Transforming urban climate governance

Capacities for transformative climate governance

Katharina Hölscher

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Transforming urban climate governance

Capacities for transformative climate governance

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Capaciteiten voor transformerend klimaat governance

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Contents

Summary

Cities provide rich opportunities for delivering effective climate action that directly acts on the sources of emissions and climate-related vulnerabilities, while also decreasing air pollution, strengthening local communities and polishing public spaces. However, despite the proliferation of urban climate governance ambitions, planning and experimentation in cities worldwide, to date these have failed to deliver the radical and effective actions necessary to reduce emissions and protect from climate impacts, let alone to create stepping stones for improving social and environmental wellbeing in the long-term.

This thesis contributes to explaining and evaluating how urban climate governance is being developed and advanced, whether these efforts manifest in capacities for *transformative* (climate) governance in cities and how such capacities can be strengthened. The current disconnect between narrated opportunities and on-the-ground practice in cities signifies a mismatch between historically grown urban governance systems and contemporary and complex problems such as climate change. The shortcomings of urban climate governance to date are symptoms of governance lock-ins, due to which urban governance arrangements have hardly changed and urban climate governance efforts run against a complex web of diverse responsibilities, ill-suited national policies and paradigms of economic efficiency. I put this problem at the heart of this thesis: how can the transformation of urban (climate) governance be supported so as to facilitate transformative climate governance in cities?

My aim is to contribute to an understanding about what *transformative* climate governance could look like and how it can be strengthened vis-à-vis existing urban governance regimes. I re-position climate governance within the broader ambition of navigating urban transformations towards sustainability and resilience. I argue that enabling transformative climate governance requires the development, and better understanding, of new governance capacities so as to create institutional space for and facilitate those actions that can purposefully contribute to the transformation required for dealing with climate change and unsustainability in cities. The contribution of this thesis is both theoretical and empirical: I develop a framework of capacities for transformative climate governance and empirically trace and compare whether, how and by whom such capacities have been created in Rotterdam, the Netherlands, and New York City, USA.

A transformative perspective on urban climate governance

I first take a step back to conceptualise and operationalise *transformative* climate governance as an ideal-type and normative approach for addressing climate change in the context of urban transformations. My central premise is that climate change needs to be viewed as a *symptom*, and an *amplifier*, of unsustainable path-dependencies and mal-adaptation in urban design, living and land use patterns: the transformative perspective draws attention to the complex dynamics, contestations and uncertainties involved in addressing climate change as a transformation challenge. The notion of urban transformation facilitates a better understanding of the diverse, endogenous and exogenous driving forces of urban transformations, as well as how these forces lead to altered urban functions,

new local needs and new interactions between cities and their surroundings. On the one hand, it exemplifies the unsustainability of current urban development pathways: activities and behaviours in cities are key contributors to climate change, propelling the urgency for radical and sustainable change. On the other hand, urban hazards brought about by climate change (e.g. changing temperature patterns, heat waves, drought, sea-level rise and heavy storms) will increase in severity and frequency, and they will fundamentally challenge urban infrastructures, the built environment, ecosystems and living patterns. Sustainability and resilience give an orientation for steering on-going urban transformation processes towards desirable directions: urban sustainability and resilience transformations are radical and structural change in urban systems that enhance and maintain urban functions for environmental integrity, social equity, human well-being and economic feasibility in the long-term, also in the face of shocks and crises and while not negatively impacting other regions.

From this perspective, climate mitigation and adaptation should be considered part of the quest for broader societal transformations to sustainability and resilience that achieve deep cuts in greenhouse gas (GHG) emissions, facilitate adaptation to non-revocable impacts of climate change and increase social and environmental wellbeing within planetary boundaries. This embedding of climate mitigation and adaptation within the endeavour to achieve urban sustainability and resilience transformations opens up opportunities for integrating mitigation and adaptation with other goals associated with societal and environmental wellbeing and to contribute to the radical changes needed to achieve these goals. This is what I term transformative climate governance: transformative climate governance allows actors to develop climate mitigation and adaptation actions in synergy with other policy priorities and goals so as to contribute to urban transformations towards sustainability and resilience.

A capacity lens to explain and evaluate the development of urban climate governance

Explaining the development of urban climate governance and assessing whether it indeed manifests in transformative climate governance involves understanding how and by whom urban climate governance is enacted, identifying the new governance conditions that emerge as a result of these activities, and evaluating whether these contribute to urban sustainability and resilience transformations. Throughout the thesis I argue that transformative climate governance requires the development of new governance capacities to take more seriously the complex, uncertain and contested dynamics of urban transformation processes that cannot be managed or predicted in conventional ways.

The perspective on governance capacity gives a simple conceptual frame that connects governance agency ('who'), interactions with governance conditions ('how') and governance outputs and outcomes ('what'). Governance capacities are manifest in the collective abilities of actors to mobilise, create and change structural governance conditions, as well as the conditions that result from these activities and enable or disable collective action. Accordingly, the capacity lens facilitates a learning-oriented view on how urban (climate) governance is changing, and to which ends, by bridging between the diverse actors and activities driving the governance shift, the governance conditions that emerge as a result, as well as whether these indeed contribute to navigating urban transformation under climate change. Governance capacity is action-oriented and empowering: by connecting actor-level activities to how they contribute to building governance conditions for transformative climate governance it is possible

to identify what opportunities were created and used, what challenges need to be accounted for, what are capacity gaps and how capacities can be strengthened.

Theoretical contribution: framework of transformative climate governance capacities

I develop a framework of capacities for transformative climate governance, which provides a systematic analytical tool to deconstruct how actors' activities create new types of governance conditions and to evaluate whether these conditions and activities contribute to transformative climate governance. The capacities framework contributes to a consistent and empowering conceptual frame to identify and strengthen conditions that need to be put in place for enabling transformative urban (climate) governance.

The capacities framework brings together different research strands concerned with climate governance and urban transformations – in particular sustainability transitions and resilience approaches – to conceptualise the capacities for transformative climate governance. In a first step, I have positioned climate change and climate governance in the context of sustainability and resilience transformations and defined distinct output functions for transformative climate governance based on a review of sustainability transitions and resilience literatures. This aided a systemic and problem-based understanding of urban climate governance to evaluate whether it delivers different output functions to address and respond to transformation dynamics. In a second step, I have defined capacities for transformative climate governance that conceptualise and operationalise an agency-based perspective on how conditions are developed for delivering the different output functions.

The capacities framework distinguishes between four critical capacities:

- **Stewarding capacity** is about enabling anticipation of and responses to disturbances, risks and uncertainty.
- **Unlocking capacity** determines what and how drivers of unsustainable path-dependencies and mal-adaptation are recognised and reduced.
- **Transformative capacity** enables the development of innovations and their embedding into structures, cultures and practices.
- **Orchestrating capacity** creates synergies between climate governance and other policy sectors across scales in line with overarching visions for sustainability and resilience.

Empirical contribution: tracing capacities for transformative climate governance in Rotterdam and New York City

The case studies of this thesis – Rotterdam and NYC – are examples of cities providing global leadership and setting a standard for climate change adaptation and mitigation with ambitious and cross-cutting climate, sustainability and resilience goals and agendas and a portfolio of innovative and systemic solutions for climate mitigation and adaptation. The case studies illustrate the applicability of the framework and generate empirical knowledge about how existing urban climate governance efforts are being developed and advanced, whether these efforts manifest in new capacities for transformative climate governance, and how the capacities can be strengthened vis-à-vis existing governance regimes.

In both cities, all capacities for transformative climate governance are emerging and manifest in novel approaches and initiatives to address climate change that are systemic, long-term, learning-based and co-creative. This has been especially driven by the integration of climate mitigation and adaptation within long-term sustainability and resilience goals and strategies. This integration reflects the recognition that climate mitigation and adaptation need to be approached as opportunities for improving liveability and wellbeing and that they are long-term concerns, thus requiring long-term perspectives.

Each capacity manifests in diverse governance conditions, which were created as a result of the activities of diverse actors and that enable delivering the transformative climate governance functions: institutional (e.g. regulatory space for experimentation), knowledge (e.g. o-created knowledge about long-term and systemic risks), network (e.g. support networks that mobilise for change, mediation structures), and social conditions (e.g. co-ownership over long-term visions). The activities provide detailed explanations and transferable lessons of how the diverse conditions were created.

- ***Stewarding capacity:*** In both cities, stewarding capacity is visible in initiatives and plans to protect from long-term risks and uncertainties related to flooding, storm and health as well as to improve equity and wellbeing. Stewarding capacity is marked by a shift towards polycentric, flexible and knowledge-based approaches that allow long-term, fit-to-context and fit-for-purpose decision-making, planning and management. Conditions for stewarding have been created by developing a vast amount of knowledge on systemic risks and uncertainties, establishing integrated, long-term and multi-level planning approaches and supporting diverse social networks.
- ***Unlocking capacity:*** Unlocking capacity in Rotterdam and NYC is visible in the identification of and awareness raising on drivers of emissions in connection with drivers of air and noise pollution, waste and inequality, and the creation of new incentives and regulations to control unsustainable practices and support alternatives. The capacity is characterised by a new view about institutional 'sun-setting' to phase-out and/or reduce the competitive advantage of business-as-usual. Conditions for unlocking are primarily created by phasing-out or disincentivising business-as-usual and creating support networks and strategic alliances with a clear mission for change.
- ***Transformative capacity:*** Transformative capacity in Rotterdam and NYC is evident in the multiple strategic, operational, institutional and organisational innovations in how climate mitigation and adaptation are addressed. It resonates the application of experimentation as a full-fledged governance approach that does not only encompass the (continuous) innovation itself but also reflection and learning about what the innovation brings about in the policy and planning mix (e.g. for replication, scaling). Conditions for transformative capacity were created by leadership that made use of opportunities for change (e.g. Hurricane Sandy), providing (e.g. regulatory, financial) space for experimentation, and by spreading the innovation story to increase legitimacy of and support for the innovations and the experimental approach.
- ***Orchestrating capacity:*** The capacity is evident in both cities in the city-wide long-term and integrated climate, sustainability and resilience goals and the large variety of nested, formal and informal institutions, networks and communication channels that were established at different levels of governance to streamline and coordinate the activities of multiple actors and

networks. Orchestrating capacity is critical for aligning and coordinating and ensuring collaboration through systemic knowledge and perspective that is brought into other departments, sectors etc. through formal and informal processes (e.g. institutionalising sustainability and resilience, cross-departmental task forces, informal spaces).

The ways the governance capacities are created and enacted in Rotterdam and NYC underlines the decidedly multi-actor nature of urban climate governance. While the local governments, in particular the Climate and Sustainability Offices in Rotterdam and the Mayor's Office for Recovery and Resiliency (ORR) and the Mayor's Office for Sustainability (MOS) in NYC, are the main actors responsible for ensuring and overseeing climate-proofing safeguarding measures, they establish and collaborate with diverse networks and partnerships to enable cross-boundary and cross-sectoral implementation. As a result, in both cities a diversity of cross-sectoral, cross-scale and public-private partnerships and networks, including regional and national knowledge programmes, research partnerships, research-industry collaborations and private stakeholder platforms, participate in the generation of knowledge, the formulation of strategies and agendas and the development of innovative solutions.

Despite the successful development of more integrated, multi-actor and experimental approaches to urban climate governance in Rotterdam and NYC, there are several shortcomings with regard to their potential to deliver the output functions. Overall, the capacities for transformative climate governance still represent niches within the overall governance architecture in both cities. This signifies a lack of mainstreaming and prioritising climate-related concerns in city-wide policy and planning processes. The majority of existing incentive structures and regulations still favour short-term economic interests and investments, pre-empting co-beneficial protection from long-term risks and decisive phase-out of the root causes of emissions and sustainability. This perpetuates counteracting investments (e.g. building developments in flood-prone areas) and undermines the contribution of innovative solutions into the policy mix as they remain disconnected from mainstream policy and planning.

So what? Lessons on and recommendations for transforming urban (climate) governance

The review and empirical analysis of urban climate governance activities and shortcomings vis-à-vis existing governance regimes raise in particular the challenge of how to mainstream the integrated, multi-actor and experimental approach to addressing climate change, sustainability and resilience. I highlight four critical lessons from my theoretical and empirical research on proactively experimenting cities. I suggest that these need further attention and investment to address existing shortcomings and proactively develop capacities for transformative climate governance and achieve effective change. The lessons are forward-looking: I stress not only the activities and conditions that have proven to work, but which are next step for research and practice in view of existing shortcomings and gaps.

- ***Lesson #1:*** Given that climate change is a cross-cutting issue it requires problem-based and fit-to-context approaches that address multiple interacting and interfering dynamics and goals. Consequently, developing the capacities for transformative climate governance will eventually make urban 'climate' governance obsolete and highlight the (need for prioritisation of and mediation between) synergies and trade-offs across policy domains and goals under the frame of urban 'transformation' governance. In other words, successful urban governance that navigates urban sustainability and resilience transformations under climate change is not

about prioritising rigid goals, but focuses on negotiation and synergies. Co-creation and social learning are shown to be key mechanisms for achieving shared alignment towards common goals.

- ***Lesson #2:*** Orchestration is critical for initiating, mobilising, overseeing and integrating urban (climate) governance processes, decisions and investments in line with long-term, systemic and inclusive objectives and across scales and sectors. While orchestrating has proven to work well as a soft governance mode relying on mediation, co-creation and inducement, the research shows that orchestration needs to be decisively enforced through 'hard' policy instruments and regulatory frameworks. Only in this way long-term climate, sustainability and resilience priorities can be mainstreamed and institutionalised in tactical and operational governance action across scales and sectors. In addition, due to the high amount of time and resources required for orchestration, cities need to invest in organisational capacity for co-creation and mediation (e.g. in terms of staff capacity, mediation skills).
- ***Lesson #3:*** Transformative urban (climate) governance requires strategically dismantling and replacing those aspects of existing urban governance regimes that favour short-term interests and siloed decision-making. This requires unlocking of existing institutions and actor networks as well as innovation and anchoring of new governance approaches. This represents a major gap in research and practice: so far, governance action shies away from making hard choices and 'taking away' what is there, which might cause considerable opposition and conflict. Eroding existing incentive structures to make novel and sustainable technologies more (financially) viable and attractive, opening up dominant actor networks towards new actors, and building political and societal support networks have shown to be critical mechanisms for unlocking.
- ***Lesson #4:*** Community engagement and participatory planning processes are increasingly employed to access local knowledge, gain support and foster resilient neighbourhoods. Awareness raising activities increase knowledge about risks and support for innovation and changing practices. However, despite the promise of the diversity of actors and networks, the interactions among actors and the effectiveness of their actions continue to be constrained by conflicts, organisational culture and structure and limited experience with, resources for and knowledge about devising effective participatory climate governance mechanisms. Strategically building alliances between local communities and local governments could be a powerful way for ensuring local knowledge and needs are accounted for and for mobilising broader societal action. This was illustrated in NYC, where neighbourhoods with strong community organisations benefited from their substantial support in the aftermath of Hurricane Sandy when local, state and federal agencies struggled with providing relief.

This thesis ultimately presents a normative 'governance vision' about how to design urban governance to tackle the urgent climate change challenge within the next decade and build a better future that opens up new opportunities for human and environmental wellbeing. Whether a (governance) vision for sustainable and resilient urban and global futures can be achieved, and more specifically whether the capacities for doing so will be created, depends to a large degree on the existing political system and the attitudes of people choosing political leaders.

Abbreviations

100RC	100 Resilient Cities Rockefeller Program
CoP	Convention of Parties
DCAS	NYC Department of Citywide Administrative Services
DEP	NYC Department of Environmental Protection
DOB	NYC Department of Buildings
DOT	NYC Department of Transport
DPR	NYC Parks and Recreation Department
EDC	NYC Economic Development Corporation
EMD	NYC Emergency Management Department
ICLEI	International Council for Local Environmental Initiatives
IPCC	International Panel on Climate Change
FEMA	US Federal Emergency Management Agency
GGBP	Greener Greater Buildings Plan
GHG	Greenhouse gas
HPD	NYC Housing Preservation Department
HUD	US Federal Department of Housing and Urban Development
MOS	NYC Mayor's Office of Sustainability
NGO	Non-governmental organisation
NPCC	NYC Panel on Climate Change
NYC	New York City
NYSERDA	New York State Energy Research and Development Authority
OneNYC	One New York: The Plan for a Strong and Just City
ORR	NYC Mayor's Office of Recovery and Resiliency
RbD	Rebuild by Design
RCI	Rotterdam Climate Initiative
SDG	Sustainable Development Goal
SIRR	NYC Special Initiative for Rebuilding and Resiliency (SIRR)
SRI@JB	Science and Resilience Institute at Jamaica Bay, New York City
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WCED	World Commission on Environment and Development

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Chapter 1

Introduction: The challenge to steer urban transformations under climate change

Chapter 1

Introduction: The challenge to steer urban transformations under climate change

Dealing with anthropogenic climate change is one of the defining issues of the 21st century with severe and far-reaching societal and environmental impacts (Carter et al. 2015; IPCC 2014; Gillard et al. 2016). Meeting the Paris Agreement's goal of holding "the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C" (UN 2015: p. 3) as well as adapting to non-revocable impacts of climate change will require fundamental changes in existing production and consumption processes, technologies, individual values and behaviours (Tàbara et al. 2018; O'Brien 2012; Steffen et al. 2018; Pelling et al. 2014). As underscored by the latest IPCC report on the 1.5°C target, these changes will have to happen quickly and decisively (IPCC 2018).

The scale of cities has become an epicentre of scientific and policy attention for tackling climate change and sustainability problems (Elmqvist et al. 2018; UN-Habitat 2016; WBGU 2016; Winnington et al. 2016). In September 2015, the United Nations (UN) adopted a city-specific Sustainable Development Goal (SDG 11), which is to "[m]ake cities and human settlements inclusive, safe, resilient and sustainable" (UN 2016: p. 24). The New Urban Agenda, which was adopted in Quito in October 2016 at Habitat III, targets the creation of sustainable and equitable cities by prompting a rethinking of how cities are planned, managed and inhabited (UN-Habitat 2016). It symbolises the UN's recognition of urbanisation as a permanent driver of development and expresses the ambition to harness the opportunities for living sustainable in an increasingly urban future (Parnell 2016; Rudd et al. 2018; Garschagen et al. 2018). The concern about the role of cities and urban areas in contributing to local and global sustainability and resilience is not only derived from recognising them as both culprits and victims of high emissions, resource depletion, inequality and climate impacts such as sea-level rise and heat waves (Seto et al. 2017; UN-Habitat 2016; Ürge-Vorsatz et al. 2018). It also epitomises the hope that cities provide rich opportunities for delivering effective climate action that directly acts on the sources of emissions and climate-related vulnerabilities while also decreasing air pollution, strengthening local communities and polishing public spaces (Rosenzweig et al. 2015; Seto et al. 2017; Bai et al. 2018; Kabisch et al. 2018).

The problem I put at the heart of this thesis is the transformation of urban (climate) governance so as to create institutional space for and facilitate those actions that can purposefully contribute to the transformation required for dealing with climate change and unsustainability in cities. So far, even the most ambitious efforts to address climate change in cities are countered by the negative impacts of urbanisation, unsustainable production and consumption, pollution and inequality (Ürge-Vorsatz et al. 2018; Rink et al. 2018; Roberts et al. 2018). The current disconnect between narrated opportunities and on-the-ground practice in cities signifies a mismatch of existing urban governance regimes and

characteristics of climate change and urban transformations, which are complex, long-term, uncertain and contested processes of radical change in urban systems (Rink et al. 2018; Romero-Lankao et al. 2018a). Therefore, significant changes of urban (climate) governance have to accompany, or, even precede effective action on climate change that is also able to radically redirect urban development pathways towards sustainability and resilience (Rink et al. 2018; Romero-Lankao et al. 2018a; 2018b).

I conceptualise the type of urban governance for addressing climate change in the context of urban transformations as *transformative* climate governance, which refers to an ideal-type and normative approach, or 'governance vision'. My central premise is that climate change needs to be viewed as a *symptom*, and an *amplifier*, of unsustainable path-dependencies and mal-adaptation in urban design, living and land use patterns: this makes clear that any attempt on climate mitigation and adaptation should be part of the quest for transformations to sustainability and resilience (Tàbara et al. 2018; Rudd et al. 2018; McCormick et al. 2013; Bartlett and Satterthwaite 2016). This is what I term transformative climate governance: transformative climate governance allows actors to develop climate mitigation and adaptation actions in synergy with other policy priorities and goals so as to contribute to urban transformations towards sustainability and resilience.

My aim is to contribute to an understanding about what transformative climate governance could look like and how it can be strengthened vis-à-vis existing urban governance regimes. Throughout the thesis I argue that transformative climate governance requires the development, and better understanding, of new governance capacities to take more seriously the complex, uncertain and contested dynamics of urban transformation processes under climate change (Kabisch et al. 2018; Rink et al. 2018; Romero-Lankao et al. 2018a; 2018b). While urban climate governance has in many cities already driven a shift towards more systemic, collaborative and learning-based approaches, and thus new capacities are developing, there are no overarching insights into how this shift is brought about, which governance mechanisms, conditions and processes manifest in this shift, and whether it contributes to navigating urban transformations under climate change. I propose a systematic and agency-based framework that identifies capacities for transformative climate governance. The framework provides a diagnostic tool to explain, evaluate and support the development of transformative climate governance in cities vis-à-vis existing urban governance regimes.

In this introductory chapter, I introduce the transformative perspective on climate change and climate governance in cities, trace the emergence and development of urban climate governance vis-à-vis existing urban governance regimes, and formulate the key research objective and research questions this thesis addresses.

1.1 Urban transformations under climate change

Climate change and cities are inextricably linked: the majority of global GHG emissions is produced by activities, behaviours and resource demands in, or driven by, cities, while urban populations, infrastructures and ecosystems (already) face severe risks as a result of climate change impacts (Carter et al. 2015; UN-Habitat 2016; Seto et al. 2017). Climate action in cities is therefore an imperative, but the drivers and impacts of climate change in cities cannot be viewed in isolation from other stresses and

pressures today's cities face (Shaw et al. 2014; Rosenzweig et al. 2015). The ways in which services and infrastructures are currently organised and designed in cities and the lifestyles of urbanites drive high-emission urban development trajectories and mal-adaptation to climate change impacts along with other sustainability challenges such as air pollution, inequality and waste (Koch et al. 2016; Ürge-Vorsatz et al. 2018).

The concept of transformation conveys a notion of fundamental, systemic, multi-dimensional and radical structural change (Brand 2016; Feola 2015; Patterson et al. 2016). On the one hand, it helps to describe and understand the various processes, interactions and dynamics manifesting in cities as complex socio-technical and social-ecological systems and shaping urban development trajectories (Frantzeskaki et al. 2018b; Wolfram et al. 2017). This also enables positioning climate change in the context of urban transformations – i.e. how climate change is driven by existing urbanisation and urban development trends and dynamics and how climate change impacts add considerable pressure, risk and uncertainty to urban transformation dynamics. On the other hand, the transformation perspective provides a normative orientation for overcoming persistent sustainability problems and purposefully moving cities towards sustainability and resilience (McCormick et al. 2013; Frantzeskaki et al. 2018b; Kabisch et al. 2018).

In the last years, the notion of transformation has been gaining ground in science and policy debates. The New Urban Agenda calls for urban transformations towards sustainability and resilience, highlighting how urbanisation and multiple local and global developments drive undesirable transformations in cities (UN-Habitat 2016). A rich research field around questions of urban transformations has started to emerge, combining multiple scientific disciplines, ontologies and methods (Wolfram and Frantzeskaki 2016; Wolfram et al. 2017; Elmqvist et al. 2018).

The diversity of urban transformation research rises to some ambiguities of concepts and meanings. For example, in the urban sustainability transitions community, 'transition' is commonly used rather than the term transformation in a similar, often interchangeable way to understand and support systemic and radical societal change (Hölscher et al. 2018a). Differences between both terms partially result from their etymological origins, transitions referring to the 'shift from one state to another' and transformation as a 'change in shape' (Brand 2014): "[t]ransitioning therefore implies significant transformations" (Moloney and Horne 2015: p. 2438). In addition, transformation has been employed in relation to more large-scale processes of social-ecological change (Rink et al. 2018). Overall, whether the terms 'transformation' and 'transition' are preferred largely relates to particular epistemic communities rather than a substantive difference in meaning: while 'transition' is the preferred term in sustainability transitions and socio-technical systems' studies, 'transformation' is adopted more widely to describe both process and outcome of changes in the conditions of urban systems (Wolfram et al. 2017). The latter is the focus of this thesis, which combines work across disciplines and addresses questions of both 'transformation of what' and 'transformation to what', for which reasons I employ the term transformation.

This section establishes the need to address climate change in the context of contemporary urban transformations and thus to embed climate mitigation and adaptation within the broader ambition to achieve urban sustainability and resilience transformations.

1.1.1 Transformations *of*, *in* and *by* cities

While cities may have been portrayed as static in the past, cities constantly undergo incremental and radical changes as a result of endogenous and large-scale factors and trends (e.g. lifestyle changes, globalisation, financial crisis) (Pickett et al. 2014; McCormick et al. 2013; Seto et al. 2012). However, the changes that are currently taking place in cities, and the concerns and implications on local and global sustainability that go along with them, are unprecedented. Contemporary urbanisation processes are unparalleled: Since 2008, more people live in urban than in rural areas (UN-Habitat 2016), and urban population is expected to grow by about 75 percent until 2050, which brings the urban population up to 6.3 billion (UN 2014). Urbanisation in its current form causes significant changes in land use and landcover, energy demand, biodiversity and lifestyles and raises questions about the contribution of cities to global environmental change, including climate change, biodiversity loss and resource depletion (Haase et al. 2018; Alberti et al. 2018; Elmqvist et al. 2013; Seto et al. 2017). Additionally, cities increasingly have to grapple with a variety of interrelated challenges, including pollution, waste, poverty and inequality, inadequate or ageing infrastructure, poor water quality, access and high quality service delivery, climate change and social tensions (Haase et al. 2018; UN-Habitat 2016; Seto et al. 2017).

The notion of urban transformation facilitates a better understanding of the diverse, endogenous and exogenous driving forces of urban transformations, as well as how these forces lead to altered urban functions, new local needs and new interactions between cities and their surroundings (McCormick et al. 2013; Wolfram et al. 2017). While the term has been used differently across urban disciplines (Burch et al. 2018), urban transformations are commonly defined in relation to an understanding of cities as complex, adaptive and open systems (Box 1.1; Wolfram and Frantzeskaki 2016; McCormick et al. 2013). As such, urban transformations relate to the complex, cross-scale and cross-sectoral dynamics between multiple dimensions (e.g. social, institutional, cultural, political, economic, technological, ecological) of urban systems, as well as how these dynamics affect such systems and other systems at multiple scales (e.g. rural hinterlands, global economy) (Wolfram et al. 2017; Chelleri et al. 2015).

I distinguish between three perspectives on urban transformations. These perspectives are closely related, but they have different implications on how to understand contemporary urban transformation processes. As such, they provide a structuring approach for studying and integrating the multi-scale, multi-issue and multi-disciplinary characteristics of urban transformations (research).

- ***Transformation in cities:*** **cities as places of transformations**

Transformation *in* cities refers to the interactions and change dynamics that are place-based in cities. Transformations in cities are driven by endogenous factors and dynamics (e.g. local economic structure, geographic location, lifestyles, population structures, governance and planning) as well as large-scale processes (e.g. national policies, globalisation, climate change) (McCormick et al. 2013; Leichenko 2011; Wolfram et al. 2017; UN-Habitat 2016). Examples of on-going transformation dynamics and driving forces in cities include the privatisation of public services, skyrocketing housing prices, the increasing complexity and reach of urban institutions and governance, and ageing urban infrastructure (Seto et al. 2017; Haase et al. 2018; Newton et al. 2017). For example, the rapid population growth in developing countries' cities, with most growth taking place in slums, puts infrastructure

Box 1.1: Understanding cities as complex, adaptive and open systems

There is no one definition of what is 'a city' or what is 'urban' (Haase et al. 2018). Cities have many varying characteristics, and are often classified in terms of administrative units with a set minimum number of inhabitants, human densities, built-up area, material and energy flows or employment proportions (Haase et al. 2018). Since the 1970s, urban studies is developing a post-structuralist view on cities that transcends from such geographical, or other, delineations: cities are understood as "local nodes within multiple overlapping social, economic, ecological, political and physical networks, continuously shaping and shaped by flows of people, matter and information across scales" (Wolfram and Frantzeskaki 2016: p. 143). Cities thus evade the prescription of immobile boundaries, but rather need to be understood based on the "topologies of actor networks which are becoming increasingly dynamic and varied in spatial constitution" (Amin 2004: p. 33).

To account this networked character of cities, urban researchers call for an integrated systems' approach that views cities as complex social-ecological-technological systems (Alberti et al. 2018; McPhearson et al. 2017; Meerow et al. 2016; Bai et al. 2017). Social systems encompass the socio-economic, political and institutional dimensions, including variables such as personal income, culture, governance, demography, justice, education and health (Meerow et al. 2016). Natural systems refer to the natural resources and physical phenomena in a city, such as air, water, biodiversity and ecosystems (Pickett et al. 2011; McPhearson et al. 2016b). Technological systems include the manmade surroundings providing services for human activities, such as shelter, transport systems, public spaces and urban form (Meerow et al. 2016; Ramaswami et al. 2012). Actors have a central position within urban systems: diverse and heterogeneous actors, at multiple scales (e.g. household members, local and national governments, real estate developers, academic institutions), influence how cities are organised and consume resources (Alberti et al. 2018).

This perspective draws attention to the complex and dynamic networks of interactions between social, ecological and technological elements of urban systems that shape urban development trajectories in adaptive, self-organising ways (Alberti et al. 2018; Ernstson et al. 2010). For example, urban segregation and inequality result from and are reinforced by interactions between residential choices, personal preferences, job markets, land and real estate markets and public policies (Alberti et al. 2018). Similarly, the privatisation and liberalisation of infrastructures and the diverse social interests involved in the functioning of infrastructure systems (e.g. of utilities, regulators, consumers) determine how infrastructures are built, operated and used (Hodson and Marvin 2010). Conversely, the built environment is usually characterised by a high degree of path dependency and opportunity costs; once built, they exist over long periods of time (Moss 2014; Loorbach et al. 2010). Natural systems are strongly influenced by the networked material and energy flows of human resource production and consumption in cities, such as water, energy, food and waste flows (Meerow et al. 2016; Pickett et al. 2011).

Moreover, cities operate as open systems that are (usually) not self-sufficient, but depend on ecosystems, resources and populations from other localities (Elmqvist 2014; Chelleri et al. 2015; Seto et al. 2012). The impacts of urban activities are therefore not contained within some local geographical boundaries. This makes cities "entities in broader 'networks' of global resources, commodities, communication, and multilevel governance" (Meerow et al. 2016: p. 45). 'Urban land teleconnections' is a recent conceptual framework in land use science to describe how the linkages between urban land use change and the resources consumed by urbanites extend their influence to distant locations (e.g. on ecosystems, migration) (Seto et al. 2012). Considering the urban scale of transformations thus helps to see how current (un)sustainability concerns and the need for societal transformations are "inherently local *and* global, and indeed, come together in urban environments" (Jhagroe 2016: p. 47).

management, service provision and governance under enormous pressures (Haase et al. 2018). At the same time, in cities worldwide diverse types of social, technological and institutional innovations are emerging in response to local and global pressures, which provide potential incubators for sustainable change (Frantzeskaki et al. 2018a).

Looking at cities as sites of transformations opens up questions about why transformations occur and are supported in some places and not others, which have been taken up in work on the 'geography of transitions' that has generated insights on how place-specific factors shape similarities and differences in transformation process and progress (Hansen and Coenen 2015; Truffer et al. 2015; Coenen et al. 2012; Hodson et al. 2017). The idea of place-specificity facilitates sensitivity to place variety and differences for example between European, 'global' cities, metropolitan cities and cities in the Global South. It also addresses the notion of socio-spatial embeddedness of agency as rooted in particular places, referring for example to how sense and meaning of place influence how individuals value and pursue change of places (Brink and Wamsler 2019; von Wirth et al. 2019; Clarke et al. 2018).

- ***Transformation of cities:*** **transformation dynamics and outcomes in urban systems**

Transformation *of* cities addresses the systems' perspective on cities and identifies and evaluates the changes of urban systems resulting from transformation dynamics in terms of new urban functions, local needs, new interactions and outcomes. Transformations of cities affect an array of urban systems (e.g. economy, energy, transport, food, healthcare, governance) (Romero-Lankao et al. 2018b; Amundsen et al. 2018). They involve changes of dominant urban structures (e.g. infrastructures, regulations), cultures (e.g. values) and practices (e.g. mobility behaviours) (Frantzeskaki et al. 2018b; Ernst et al. 2016). Examples of past transformations of cities include the industrialisation of cities in the course of the Industrial Revolution and the introduction of the automobile in the early 20th Century, which gave way to a city planning model that is dedicated to meeting the function of vehicles and that has contributed to urban sprawl and air pollution (Pickett et al. 2014; McCormick et al. 2013). Especially since the 1980s, cities are undergoing fundamental changes in terms of their demographic, cultural, economic, environmental and social structures as the result of industrialisation, globalisation and urbanisation (UN-Habitat 2016). Many cities in the Global North have become 'post-industrial', which entailed decreasing employment opportunities, investment and social cohesion (Pickett et al. 2014). In the developing world, especially rapidly growing cities of China, Brazil, India, Indonesia, Mexico and South Africa show extremely stratified development patterns, with many millions of urban residents living in informal or squatter settlements on the one hand and affluent centres of innovation on the other (Haase et al. 2018). Accordingly, recent social, environmental and technological changes bear many challenges for cities, including increasing social inequality, insufficient infrastructure systems and ineffective governance systems (Koch et al. 2016; UN-Habitat 2016).

The systems' perspective draws attention to the complex processes and feedback loops within, across and beyond urban systems and the accumulated effects on the urban system level. For example, studying social-ecological-technical infrastructure systems in cities advances understanding of urban complexity and urban structure-function relationships between green space availability, wellbeing, biodiversity and climate adaptation (McPhearson et al. 2016b). Similarly, urban metabolism analysis and ecosystem studies allows to understand the behaviour of cities – such as energy and material flows, resource depletion, self-sufficiency or external dependency, regulating mechanisms – as human-

dominated, complex social-ecological system (Bai 2016). This also addresses interactions across multiple urban systems and scales, such as energy, water and food, and how, for instance, rapid changes in electricity systems have knock-on effects for urban mobility or heat systems (Chen and Chen 2016; Chelleri et al. 2015). The relational geography perspective puts forth a more differentiated view of urban systems, zooming in on different boroughs, districts or neighbourhood and raising questions such as how innovation and change in one location affects neighbouring locations (Wachsmuth et al. 2016).

- ***Transformation by cities:*** **cities as agents of change at global scale**

The third perspective on transformation *by* cities draws attention to the changes taking place on global and regional levels (e.g. rural hinterlands) as a result of urbanisation and urban development. This perspective highlights the connectivity of cities as agents of change at global scale. On the one hand, in this perspective, cities can be viewed as culprits driving global high emissions, resource depletion and unsustainability. This raises critical questions about the relationship between current and unprecedented urbanisation and global sustainability (Seto et al. 2017; Haase et al. 2018). For example, the expansion of cities will triple land cover by 2030, compared to 2000, with severe implications on biodiversity (Alberti et al. 2018; Elmqvist et al. 2013). On the other hand, cities also have become key loci for trialling sustainable approaches and solutions to inform the global sustainability agenda (UN-Habitat 2016; Seto et al. 2017; Bai et al. 2018). Goal 11 on making "cities and human settlements inclusive, safe, resilient and sustainable" (UN 2016, p. 24) recognises the transformative role of urban areas towards building global sustainability.

This perspective on cities as agents of change at the global scale highlights how the experiences and best practices showcased in cities are knowledge to be diffused and shared. It raises questions about how transformations travel between places and across scales – for example, about how and why governance strategies such as experimentation, best practices or imaginaries have been taken up globally (Joss et al. 2013; Nagorny-Koring 2018). Notable is also the proliferation of multiple forms of transnational city networks such as the International Council for Local Environmental Initiatives (ICLEI), C40 and 100 Resilient Cities. Such networks facilitate knowledge exchange and inter-city learning, foster the creation of collective goals, lobby for international attention, and enable the transplantation of innovative, sustainable and resilient policy and planning approaches (Acuto et al. 2017; Lee 2018; Mejía-Dugand et al. 2015). This discourse is mainly focused on 'global cities', while medium-sized and middle-income cities are leaders in terms of actual sustainability performance (Vojnovic 2014).

Together, these three perspectives on urban transformation highlight that the challenges faced by today's cities find their roots in complex problems, and that there are no straightforward solutions. Such 'persistent problems'[1] cannot be solved through quick fixes, but require fundamental changes in

[1] Because of complex interdependencies between cause and effect of contemporary societal and environmental problems and crises, these are often described as persistent problems (Rotmans 2005; Schuitmaker 2012). This draws on the concepts 'wicked problem' (Rittel and Webber 1973) and 'ill-structured problem' (Hisschemöller and Hoppe 1996). There are no simple, straightforward solutions to 'solve' persistent problems, because they are deeply rooted in societal structures,

urban energy, transportation, water use, land use, consumption patterns and lifestyles (Romero-Lankao et al. 2018a; Koch et al. 2016; McCormick et al. 2013; Frantzeskaki et al. 2018b). How these changes come about and affect local, regional, translocal and global levels requires attention to transformation dynamics and outcomes in, of and by cities. Climate change is one example of a global problem driving transformations in cities, interacting with multiple other multi-scalar developments and affecting different localities, neighbourhoods and communities differently within and across cities. Transformations of cities need to be attuned to the cumulative effects of urban change dynamics including climate change on multiple urban systems.

1.1.2 Climate change as an urban transformation challenge

Climate change alters the face of cities in a dramatic way. On the one hand, it exemplifies the unsustainability of current urban development pathways: activities and behaviours in cities are key contributors to climate change, propelling the urgency for radical and sustainable change (Satterthwaite 2008; Dodman 2009)[2]. On the other hand, urban hazards brought about by climate change (e.g. changing temperature patterns, heat waves, drought, sea-level rise and heavy storms) will increase in severity and frequency, and they will fundamentally challenge urban infrastructures, the built environment, ecosystems and living patterns (IPCC 2014; Revi et al. 2014; Carter et al. 2015; Rosenzweig et al. 2015). The driving forces and implications of climate change can therefore not be understood in isolation from urban transformations.

Viewing climate change as an urban transformation challenge reveals the systemic, complex and long-term characteristics of climate change and situates the implications of climate change within the dynamics of urban transformations and allows to draw implications for urban climate governance (Table 1.1). Firstly, it helps to describe and understand what changes over the course of an urban transformation under climate change, and which factors, processes and interactions shape that development trajectory (*Transformation of what?*). Secondly, the transformative perspective draws attention to the complex, cross-scale and cross-sectoral driving forces and dynamics involved in transformations under climate change, which are long-term, produce deep uncertainties and threshold effects (*How do transformation processes occur?*). Finally, urban transformations under climate change are politically contested, because actors are affected in different ways and decisions about what direction for urban transformations is desirable touch on multiple, partially competing and contradictory, interests and goals (*Transformation for what, and whom?*). The perspective on characteristics of urban transformations helps to detangle how climate change influences and interacts with urban transformations and to derive implications for urban (climate) governance.

definitions of the problems are themselves contested and context-dependent and they affect different actors in different ways (Rotmans 2005; Schuitmaker 2012).

[2] While cities are frequently held to produce about 75-80 percent of global GHG emissions (Satterthwaite 2008), establishing appropriate calculation processes for estimating the emissions from cities remains challenging and depends on how the boundaries for emission accounting are being set and the approaches used (i.e. consumption-based or production-based approaches). Different scopes of emission accounting can yield very different estimations, depending on whether they for example include emissions embodied in electricity, products and services produced and imported from outside a city's geographical boundary (Dodman 2009; Satterthwaite 2008). For example, Castán Broto (2017) criticises the lack of data disaggregation, which obscures the differentiation of emissions within cities, the urban-rural linkages that characterise land transformations and the inaccuracies inherent to carbon accounting.

- ***Transformation of what:*** **climate change drivers and impacts in systemic perspective**

Urban transformations are generally understood as a radical change of the identity of an urban system (e.g. energy, economy, transport, health) including its functions, fundamental components, interactions and outcomes (Romero-Lankao et al. 2018b; McCormick et al. 2013; Ernst et al. 2016). This involves multidimensional changes in cultures, values, technologies, production and consumption patterns, politics and individual behaviours (McCormick et al. 2013; Frantzeskaki et al. 2018b).

This systemic perspective on 'transformation of what' enables positioning climate change in the context of urban transformations. It draws attention to the social and economic root causes driving high-emission trajectories and vulnerabilities to climate change impacts alongside other unsustainability trends in cities, including individual values, built urban structures, human behaviours, incentive structures, institutions and economic opportunity (Ürge-Vorsatz et al. 2018; Rosenzweig et al. 2015). For example, current patterns of urban land use, infrastructures, transportation systems and resource consumption drive GHG emissions (Liu et al. 2015; Sharifi and Yamagata 2015; Ürge-Vorsatz et al. 2018). Similarly, the ways cities are currently designed undermine their ability to adapt to the impacts of climate change. Many cities are located on flood-plains, in dry areas or on coasts, but existing water management systems are not able to store excessive storm water, thus exacerbating flood risk (Carter et al. 2015; Romero-Lankao and Dodman 2011; Bai et al. 2018). Vulnerabilities to climate change impacts in cities result from and are reinforced by interactions between residential choices, infrastructure policies, structural inequalities and land and real estate markets (Alberti et al. 2018; Rosenzweig et al. 2015). Risks and hazards brought about by climate change (e.g. changing temperature patterns, heat waves, drought, sea-level rise and heavy storms) will increase in severity and frequency, and they will fundamentally challenge urban infrastructures, the built environment, ecosystems and living patterns (IPCC 2014; Revi et al. 2014; Carter et al. 2015; Rosenzweig et al. 2015).

The key implications from this perspective are that climate change mitigation and adaptation need to be understood in relation to the interactions within multiple systems, which requires attention to the social and economic root causes driving high emissions, mal-adaptation and vulnerabilities (Rink et al. 2018; Seto et al. 2016). The systemic perspective suggests problem-based and systemic approaches to addressing climate change that deploy solutions that build on system insight and are fitted to specific contexts and problems (rather than scales and sectors) (Tàbara et al. 2018; Chelleri et al. 2015).

- ***How do urban transformations occur:*** **complexity, uncertainty and longevity of urban system dynamics**

Urban transformations are complex, uncertain and long-term processes of systemic change, but they follow specific patterns and mechanisms such as path-dependency, emergence and thresholds (McCormick et al. 2013; Loorbach et al. 2015). Since cities are open systems, the change dynamics and interactions take place across multiple sectors, scales and time (Alberti et al. 2018; Chelleri et al. 2015; Seto et al. 2012). The complexity of interactions and dynamics cause deep uncertainty and surprise, where long phases of relative stability can quickly shift into rapid phases of non-linear change (Frantzeskaki et al. 2018b; Wittmayer et al. 2018; Jacob et al. 2015).

The perspective on change dynamics draws attention to the complex, cross-scale and cross-sectoral characteristics of driving forces and dynamics involved in urban transformations under climate change, which are long-term, produce deep uncertainties and threshold effects. Climate change drivers and impacts interact with diverse processes in cities, such as wetland loss, ageing infrastructure and coastal development (Alberti et al. 2018). Mutually reinforcing physical, economic and social constraints – such as long infrastructure lifetimes, institutions, behaviours, large capital costs – restrain the rate and magnitude of emissions reductions and climate adaptation (Seto et al. 2016; Rosenzweig et al. 2015). In addition, a lot of uncertainties girdle climate change impacts, including how climate change affects specific regions or ecosystems (Carter et al. 2015; IPCC 2018). Hurricanes Sandy (2012) and Katrina (2005) demonstrated the threats and impacts of surprises and unexpected shocks (Alberti et al. 2018).

In the context of urban transformations, urban climate governance is not so much about controlling rather than creating the conditions for mobilising, influencing and responding to the change dynamics (Loorbach et al. 2015; Rink et al. 2018). Complex and uncertain interactions and interdependencies across scales, sectors and time cannot be addressed though short-term oriented and narrow (e.g. sectoral) approaches, but require cross-sectoral and multi-scale coordination and collaboration (Fröhlich and Knieling 2013; Hodson et al. 2018). A challenge for urban climate governance is to facilitate context-specific decision-making, in line with local needs and opportunities, and an explicit consideration of synergies and trade-offs across scales and sectors resulting from action in one particular locality or sector (Chelleri et al. 2015). Deep uncertainties require the abilities to anticipate surprises, respond to and cope with crises, and for putting in place 'safe-to-fail' (rather than 'fail-safe') responses (Tanner et al. 2019; Fröhlich and Knieling 2013).

- ***Transformation for what, and for whom:*** **contestation and co-creation of urban transformations**

What type of transformation is (un)desirable depends on perceptions, values and cognition (Patterson et al. 2016). This makes urban transformations highly contested, because they affect different actors in different ways, touch on conflicting interests and challenge existing power structures, and raise questions about who is making decisions for whom (Castán Broto 2017; Avelino and Wittmayer 2017; Burch et al. 2018; Köhler et al. 2019).

Questioning the political dimension of urban transformation under climate change highlights how climate change touches on multiple, partially competing and conflicting, policy priorities and societal goals (Koch et al. 2016). Decisions about what should change and how to deal with trade-offs require normative judgements and not everybody will benefit equally (Meerow et al. 2016). For example, transforming a city's energy system raises questions of affordability and acceptability (Rink et al. 2018). In addition, while responsibilities for climate change are unequally distributed, climate change will impact vary across different geographical locations and different groups (Castán Broto 2017; Reckien et al. 2017; Romero-Lankao et al. 2018b). There is a strong relationship between social stratification and vulnerability to climate change impacts in cities as economically disadvantaged groups and ethnic and racial minorities tend to live in more hazard-prone, vulnerable and crowded parts of cities (Rosenzweig et al. 2015; Reckien et al. 2017).

Table 1.1 Characteristics of urban transformations and climate change as a transformation challenge: implications for governance (inspired by Wittmayer et al. 2018)

Characteristics of transformations		Climate change as transformation challenge	Implication for urban (climate) governance
Transformation of what?			
Systemic	Radical changes of multiple urban systems (e.g. economy, energy, transport, food, health, governance) including their functions, interactions and outcomes (Romero-Lankao et al. 2018b; McCormick et al. 2013; Ernst et al. 2016).	Climate change affects multiple urban systems, including economy, agriculture, water, health and transport (Rosenzweig et al. 2015; IPCC 2014; Carter et al. 2015).	**Systemic perspective** Position and understand climate mitigation and adaptation in relation to interactions with multiple systems and dimensions (Rink et al. 2018; Fröhlich and Knieling 2013; Elmqvist et al. 2019)
Multi-dimensional	Multi-dimensional changes of cultural, behavioural, institutions, technologies, economic, environmental and political system elements (McCormick et al. 2013; Frantzeskaki et al. 2018b).	Climate change is propelled by and affects urban land-use, infrastructures, design and lifestyles (Ürge-Vorsatz et al. 2018; Rosenzweig et al. 2015; Burch et al. 2014).	**System insight** Generate system insight on the social and economic root causes driving high emissions, mal-adaptation and vulnerabilities to climate change impacts (Ürge-Vorsatz et al. 2018; Seto et al. 2016; Tàbara et al. 2018).
b. How do transformation processes occur?			
Complexity	Urban transformations are driven by the complex patterns of interactions between social-ecological-technological elements of urban systems, across sectors and scales (Alberti et al. 2018; Meerow et al. 2016; Chelleri et al. 2015; Seto et al. 2012).	Climate change drivers and impacts are cross-sectoral and cross-scale; e.g. they interact with diverse processes (e.g. wetland loss, ageing infrastructure, coastal development vulnerabilities) (Alberti et al. 2018).	**Cross-sectoral integration** Integrate sectoral expertise needs into climate strategies and solutions and mainstream climate issues in different sectors to make them integral aspects of sectoral policies (Wamsler 2015; Fröhlich and Knieling 2013). **Multi-scale coordination of decentralised action** Coordinate and align climate mitigation and adaptation across multiple scales of governance while developing fit-to-context and fit-for-purpose solutions through polycentric networks (Elmqvist et al. 2019; Jordan et al. 2018; Hodson et al. 2018).
Long time horizon	Urban transformations unfold over long time horizons – commonly over a minimum of 25 years (Loorbach 2010; Wittmayer et al. 2018).	Long periods of time pass between the emission of GHGs and the impacts of a changing climate (Fröhlich and Knieling 2013; Meadowcroft 2009).	**Long-term goals for short-term action** Formulate long-term climate mitigation and adaptation goals to orient short-term incremental climate action, which anticipate future scenarios and ensure intergenerational equity (Wittmayer et al. 2018; Fröhlich and Knieling 2013; Biermann et al. 2009).

Characteristics of transformations		Climate change as transformation challenge	Implication for urban (climate) governance
Co-evolution of driving forces: build-up and break-down patterns	Co-evolution leads to build-up and break-down patterns of transformation. Break-down means that established structures, practices etc. are increasingly put under pressure for change. Build-up refers to the emergence of alternatives that might replace the dominant modus operandi in a system (cf. Loorbach 2014).	Mutually reinforcing physical, economic and social constraints (e.g. long infrastructure lifetimes, institutions, behaviours, large capital costs) constrain the rate and magnitude of emissions reductions and climate adaptation (Seto et al. 2016; Rosenzweig et al. 2015).	**Dismantling path-dependencies and mal-adaptation** Existing institutions, market patterns, technologies, values and behaviours that drive path-dependencies and mal-adaptation need to be strategically phased out (Kivimaa and Kern 2016; Seto et al. 2016).
			Innovating urban systems Create space for experimentation to facilitate innovation that challenges existing assumptions and reconfigures problem solving to overcome existing path-dependencies (Wittmayer et al. 2018; Brown et al. 2013; Loorbach et al. 2015).
Uncertainty	High level of uncertainty about the effects and impacts of interactions, causing high levels of unpredictability and surprise (Frantzeskaki et al. 2018b; Wittmayer et al. 2018).	A lot of uncertainties girdle climate impacts, e.g. concerning the sensitivity of the climate system (how much warming will result from a certain increase of GHG concentrations), regional climate impacts and consequences for ecosystems (Meadowcroft 2009; Carter et al. 2015).	**Flexibility and adaptation for risk management** Support and maintain self-organisation and learning to ensure the societal ability to adapt to continuous changes and risks (Fröhlich and Knieling 2013; Tanner et al. 2009; Torabi et al. 2018).
Threshold effects	Long phases of relative stability and incremental change and rapid phases of non-linear change once critical thresholds are crossed (Jacob et al. 2015).	Climate-related uncertainties are exacerbated by the likelihood of surprises and unexpected shocks – as illustrated by Hurricanes Sandy and Katrina – which can lead to radical discontinuities (Alberti et al. 2018; IPCC 2018).	**Preparation and timing** Make use of crisis as opportunities for overcoming system inertia by immediate and effective interventions, while ensuring effective coping and incremental responses that contribute to radical change in the long-term (Wittmayer et al. 2018).
c. Transformation for what, and whom?			
Contestation	Urban transformations are highly contested because they affect different actors in different ways, touch on conflicting interests and challenge existing power structures (Castán Broto	While responsibilities for climate change are unequally distributed, climate change will impact vary across different geographical locations and different groups (Castán Broto 2017; Reckien et al.	**Normative orientation** Co-define a shared normative orientation for sustainability and resilience in the long-term that fosters social justice and allows a variety of approaches and solutions (Wittmayer et al. 2018; McPhearson et al. 2017).

Characteristics of transformations	Climate change as transformation challenge	Implication for urban (climate) governance
2017; Avelino and Wittmayer 2017; Burch et al. 2018; Köhler et al. 2019).	2017; Romero-Lankao et al. 2018b).	**Good governance and co-creation** Ensure participatory and co-creative decision-making processes that are inclusive, transparent, accountable and sensitive to existing power structures, building on discussions about the allocation of responsibilities and duties among diverse public and private actors (Rink et al. 2018; Kabisch et al. 2018; Elmqvist et al. 2019).

This requires critical interrogations about whose visions are being pursued, who bears costs and who is considered as vulnerable in view of climate change (Gillard et al. 2016; Castán Broto 2017). Critical for urban climate governance are therefore co-creative decision-making processes that are inclusive, transparent, accountable and sensitive to existing power structures, foster social justice and provide a broad variety of approaches and solutions building on discussions about the allocation of responsibilities and duties among diverse public and private actors (Rink et al. 2018; Kabisch et al. 2018).

This view on climate change as an urban transformation challenge makes clear that climate change fundamentally challenges the core of urban systems. It underscores that climate change cannot be viewed (anymore) as an isolated problem. Rather, climate change is a symptom, and amplifier, of existing urban sustainability challenges and vulnerabilities (Burch et al. 2018; Rudd et al. 2018; Reckien et al. 2017). For example, shifting from a city with high energy consumption that is primarily based on fossil fuel resources towards a city with lower consumption based on renewable energy requires technological, social and institutional innovations in terms of energy production and consumption, retrofitting of buildings and mobility behaviours and building on new forms of economic budgeting and national and international energy networks (Rink et al. 2018). In this sense, positioning climate change in the context of urban transformations re-orients urban climate governance from climate mitigation and climate adaptation towards navigating urban transformations under climate change, which requires new governance approaches that are long-term, multi-actor, learning-based and experimental.

1.1.3 Urban transformations towards sustainability and resilience

Current debates on urban transformations share the concern of how urbanisation and urban development can be navigated in a way that achieves and maintains a high level of social and environmental wellbeing in cities and reduces the negative global footprint of cities. The complex nature of social, environmental and climate challenges associated with contemporary urban transformation processes require systemic and radical changes, especially in transport, energy, water, land use, consumption patterns and lifestyles (Ürge-Vorsatz et al. 2018; Romero-Lankao et al. 2018b;

Koch et al. 2016). This has spurred an interest in urban sustainability and resilience transformations that unlock new development pathways for reinventing cities to be more sustainable, inclusive, attractive, prosperous, safe and environmentally healthy (Elmqvist et al. 2018; Kabisch et al. 2018; Frantzeskaki et al. 2018b; Rudd et al. 2018; McCormick et al. 2013).

Rather than succumbing to a pessimistic narrative of cities, the notion of urban transformations towards sustainability and resilience embodies the hope that cities can play a positive role in contributing to a sustainable and resilient global future. Cities provide a suitable scale for effective actions and responses that act directly at the problem sources of large consumption, GHG emissions, high waste production, inequality and localised effects of climate change (Amundsen et al. 2018; Khare et al. 2011; Alberti et al. 2018). There are ample opportunities for developing sustainable and low-carbon transport and energy systems, water sensitive infrastructure and decreasing inequality (Seto et al. 2017; van der Heijden 2018). The institutional proximity in cities makes it possible for innovations to cascade, integrating local knowledge and needs, directly affecting individual behavioural changes and for local synergies to happen (e.g. between air quality, biodiversity, health and climate adaptation) (Frantzeskaki et al. 2018b; van der Heijden 2018; McPhearson et al. 2016a; 2016b). City governments are able to directly design low-carbon, sustainable and resilient urban systems through the way they provide and manage services and infrastructures (e.g. waste management, health care), prepare for disasters, conduct procurement, plan land use, support and connect local businesses and showcase examples of opportunities and possibilities for other actors (Amundsen et al. 2018; Tanner et al. 2009). This shows how urban areas can be sites of innovation and production of knowledge and wealth, while providing widespread access to employment, education, sanitation and modern energy (Seto et al. 2017; Wolfram and Frantzeskaki 2016).

Science and policy communities have taken up sustainability and resilience as complementary key concepts for assessing urban transformation processes and orienting them towards desirable directions (Box 1.2 and Box 1.3; Pickett et al. 2014; Simon et al. 2018; Kabisch et al. 2018). Both concepts are enshrined in the 2030 UN SDGs (UN 2016) and the New Urban Agenda (UN-Habitat 2016), and cities employ 'urban sustainability' and 'urban resilience' as frames to inform urban planning and regeneration programmes (Elmqvist et al. 2019). While there are still some ambiguities and shortcomings in how they are defined and operationalised in practice – for instance, urban sustainability seems to be often narrowly interpreted as increased resource efficiency and resilience as the ability to recover from disasters – taken together both concepts capture and highlight important aspects for guiding urban transformations (ibid.).

Both concepts are defined in relation to (desirable and undesirable) states and processes of urban systems, and thus they provide holistic, process-oriented and normative orientations for urban transformations, which require continuous social negotations, compromises and learning (Table 1.2). Sustainability is an inherently normative and positive set of goals for achieving environmental integrity, social equity, human well-being and economic feasibility in urban systems now and in the future (Elmqvist 2014; Leichenko 2011; Pickett et al. 2014). Baselines for urban sustainability are inter- and intragenerational equity, as well as a functioning biosphere as precondition for human wellbeing and societal development now and in the future (WCED 1987; Elmqvist et al. 2019). As such, sustainability provides a skeleton to support discourse about the interaction between human societies and the environment, but decisions about what sustainability means in specific urban systems need to

Table 1.2: Attributes of sustainability and resilience in the context of urban transformations

Attribute	Urban sustainability	Urban resilience	Implication for urban sustainability and resilience transformations
Holistic perspective	Urban sustainability encompasses interlinked social, environmental and economic goals for urban systems across sectors and scales (Pickett et al. 2016; Wolfram and Frantzeskaki 2016).	Urban resilience stresses the interdependencies and dynamics in urban systems across sectors and scales (Pickett et al. 2014; McPhearson 2014; Chelleri et al. 2015; Elmqvist et al. 2019).	Urban sustainability and resilience demand holistic thinking and action that relates goals to system processes and does not export negative effects to other sectors or distant places.
Process thinking	Urban sustainability is an on-going process or trajectory rather than a fixed state or end point (Pickett et al. 2014).	As urban systems are constantly experiencing change, urban resilience draws attention to change dynamics and emergent risks and disturbances (Pickett et al. 2014; Elmqvist 2014).	Urban sustainability and resilience are future-oriented concepts and require understanding trajectories of change and long-term impacts (Pickett et al. 2013; 2016).
Normativity	Urban sustainability defines the compromises and values of people and institutions (Pickett et al. 2016), and it has different meanings in different places (Neven et al. 2013; Wittmayer et al. 2015).	Enacting urban resilience – in terms of resilience "for whom, what, when, where, and why" – is a contested process touching on different motivations, power dynamics and trade-offs (Meerow et al. 2016).	Urban sustainability and resilience are contested and context-dependent. They have to be socially negotiated, recognising the diversity of pathways towards sustainability and resilience (Meerow et al. 2016; Pickett et al. 2013).

stem from an understanding of the workings of these systems, which address biophysical hazards, social vulnerabilities and institutional inertia (Pickett et al. 2016; Elmqvist et al. 2019). Resilience keeps at its core the acceptance and management of constant change, uncertainty and surprise and focuses on the ability to evolve, adapt to and learn from change dynamics at multiple scales (Simon et al. 2018; Meerow et al. 2016; Pickett et al. 2013). Accordingly, Pickett et al. (2014) define resilience as the underlying mechanisms by which sustainability operates: resilience indicates the phenomena and interactions that determine how systems can adjust to radical and surprising change, thereby facilitating or inhibiting the achievement of sustainability. Similarly, according to Elmqvist et al. (2019), while sustainability provides a normative direction for navigating urban transformations, resilience draws attention to managing the breadth of the operating space and multiple pathways for pursuing this direction. While resilience is in essence a non-normative system property (Elmqvist et al. 2019), decisions about resilience 'for whom, what, when, where, and why' is a contested process touching on different motivations, power dynamics and trade-offs (Meerow et al. 2016).

Sustainability and resilience give an orientation for steering on-going urban transformation processes towards desirable directions by focusing collective solution finding efforts and by guiding for short-term and mid-term actions (Loorbach et al. 2015; Koch et al. 2016). In other words, sustainability and resilience in cities can be achieved through processes of transformation (Kabisch et al. 2018). I define urban transformations towards sustainability and resilience as radical and structural change in urban systems that enhance and maintain urban functions for environmental integrity, social equity, human

Box 1.2: Urban sustainability

Sustainability emerged for the first time on the global agenda in the 1970s and received increasing attention through the Brundtland report "Our common future", which was prepared in the 1980s by the World Commission on Environment and Development's (WCED) (WCED 1987), as well as the first UN Conference on Environment and Development (World Summit on Sustainable Development) in Rio in 1992. The Brundtland report defined sustainable development as meeting "the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987: ch. 2, article 27). The report also introduced the commonly used three pillars – social development, environmental protection and economic development – to describe and assess sustainability. Sustainability thus refers to a socially constructed and normative set of goals, which lays out the values and compromises of people and institutions for addressing environmental integrity, social equity, human well-being and economic feasibility now and in the future (Leichenko 2011). Later views on 'strong sustainability' position the economy as a subsystem of human society, which is itself a subsystem of the biosphere on which all human activity depends (Elmqvist et al. 2019). For example, the 'doughnut' framework introduced by Raworth (2012) implies that society must strive to attain a balanced approach to socio-economic development that is based on a strong understanding and respect for ecological systems while also taking basic human needs into account. Overall, sustainability is increasingly understood following broader conceptualisations that emphasise linkages and interdependencies between social, environmental and economic issues (O'Riordan 2009; Leach et al. 2010).

Cities, especially in Europe and North America, but also in the other regions of the world, started in the early 1990s to commit to sustainable development goals, especially through Local Agenda 21 processes that sprouted after the World Summit, and put in place long-term programmes to improve their environment and reduce resource use and waste (Satterthwaite 1997; Wittmayer et al. 2015). Urban sustainability relates to sustainability in cities – i.e. sustainable processes and outcomes – as well as to impacts on distant locations (Wolfram and Frantzeskaki 2016). According to Satterthwaite (1997), a sustainable city ensures healthy living and working environments and provides infrastructure for basic services (e.g. clean water, sanitation, waste management) while existing in an equilibrium with environmental systems by, for example, limiting environmental pollution. The New Urban Agenda identifies sustainable infrastructure as a core component of sustainable cities – referring to the interconnected physical and organisational structures, services and systems that support the daily functioning of urban societies and their economy – that has to be designed, maintained, used and operated in a way that ensures minimal strain on resources, the environment and the economy, contributes to public health and welfare, social equity and diversity (UN-Habitat 2016).

Urban sustainability includes different dimensions such as quality of life, resource efficiency, land use, urban design, transportation, food systems, environmental planning and restoration, economic development, energy and materials use, social equity and environmental justice, institutions and politics (Koch et al. 2016; Olazabal 2015; Wheeler and Beatley 2014). Lately especially issues of equity and solidary have been highlighted as central themes of sustainability (Wittmayer et al. 2015; Castán Broto 2017). The New Urban Agenda employs the notion of 'just sustainabilities' to emphasise urban environmental alongside economic welfare and social justice issues (UN-Habitat 2016).

well-being and economic feasibility in the long-term, also in the face of shocks and crises and while not negatively impacting other regions.

The notion of urban sustainability and resilience transformation is integrative: it allows connecting diverse objectives and actions and searching for systemic solutions (Frantzeskaki et al. 2016a; Burch et al. 2018). This is not to veil trade-offs. For example, in the sustainability discourse dense urban centres are desirable, however, the tight connectivity within dense urban systems (i.e. in terms of population,

Box 1.3: Urban resilience

Resilience started to gain importance as a central concept in a number of policy domains in the context of increasing environmental, socioeconomic and political uncertainty and risk (Chelleri et al. 2015; Meerow et al. 2016). Resilience has its origins in ecology, where it has been defined as the capacity of a system to "absorb changes of state variables, driving variables, and parameters, and still persist" (Holling 1973: p. 17). While meanings and applications of resilience differ (Brand and Jax 2007), it is commonly related to changes in (especially social-ecological) systems, and how those changes reflect capacities to adjust or respond to change (Folke 2016). The main premise is that complex systems' behaviour is not deterministic or predictable, but constantly changing in nonlinear and uncertain ways (ibid.).

Especially in its early applications, resilience was understood as the ability to 'bounce back' to a previous state following a disturbance, which refers to 'engineering resilience' and might be appropriate in situations with a legitimately narrow focus on a desired stable state (Holling 1996). This often correlates with understandings of 'specified resilience' (resilience "of what, to what"), i.e. a system's capacity to cope with a determinate shock or stressor (Folke et al. 2010). In contrast, 'general resilience' is the resilience of any and all parts of a system to all kinds of shocks, including novel ones (ibid.). In non-equilibrium contexts resilience cannot mean bouncing back to a fixed, stable state because of events and pressures originating from outside the system (e.g. climate change) and random internal or indirect effects that drive instability (Pickett et al. 2014). 'Social-ecological resilience' or 'evolutionary resilience' further extend the meaning of resilience as the capacity for renewal, re-organisation and development in response to shocks and disturbances through processes of learning and innovation (Folke 2006). This view shifts policies from those that aspire to control change to managing systems' capacity to cope with, adapt to, and shape change (Folke 2016). Accordingly, managing for resilience seeks to enhance "the likelihood of sustaining desirable pathways for development in changing environments where future is unpredictable and surprise is likely" (Folke 2006: p. 254).

In cities, the increase in severe weather events and natural disasters, but also of social risks and tensions, health concerns and resource dependencies raised interest in cities' ability to withstand the risks they may face (UN-Habitat 2016). Urban resilience is largely related to urban ecological resilience, disaster reduction, climate adaptation and urban institutional resilience (Leichenko 2011; Meerow et al. 2016; Torabi et al. 2018). Frequently used terms such as "climate resilient" and "climate proofing" imply that urban systems should be able to quickly bounce back from climate-related shocks (Leichenko 2011). According to Pickett et al. (2013; 2014), this focus on engineering resilience cannot serve the reality of complex urban system, because initiatives with an engineering perspective focus on rebuilding, recovery and "fail-safe" urban systems (rather than "safe-to-fail"). Instead, urban social-ecological resilience suggests that cities can incorporate, by design and by policy, more adaptive structures and processes that enable them to evolve, adapt to and learn (ibid.). This view highlights the dynamic processes and interactions between urban systems and large-scale changes (e.g. urban sprawl and loss in natural habitat, impervious surface and flood vulnerability, population displacements induced by climate change) and advocates general adaptability and transformability (Meerow et al. 2016; Pickett et al. 2013; Alberti et al. 2018). It also places urban resilience in the multi-scalar and changing regional and global context of urban systems to consider cross-scale dynamics which provide the setting, for example, for ecosystem or economic dynamics and planning practices (Pickett et al. 2014; Elmqvist 2014; Chelleri et al. 2015).

While resilience is often presented as a non-normative system property (Pickett et al. 2014; Elmqvist et al. 2019), it also has normative implications: Determining what is a desirable system state and what system elements and dynamics need to be strengthened requires normative judgements, and not everybody will benefit equally (Meerow et al. 2016; Simon et al. 2018; Bahadur and Tanner 2014). In this sense, resilience can also be undesirable and might reinforce unsustainable regimes. This is for example visible in urbanisation and urban design patterns that reinforce social stratification (Ürge-Vorsatz et al. 2018; Haase et al. 2018). Undesirable resilience is conceptualised in the form of 'traps' that cause and reinforce unsustainable

Box 1.3: Urban resilience

structures, lock-ins and mal-adaptation, for example in the way societal systems create and reproduce power imbalances and inequalities (Enfors 2013; Boonstra and de Boer 2014). Building resilient urban systems might require persistence for certain components (e.g. a building remaining intact through a storm), while for others more adaptive or transformative changes may be necessary (Meerow et al. 2016).

There are also different types of resilience, such as social resilience or community resilience, technological infrastructure resilience or ecological resilience (Elmqvist et al. 2019). While managing for ecological resilience might focus on promoting biodiversity and green space in urban planning, social and community resilience particularly draws attention to the less visible roots of vulnerability, such as social, cultural, economic and political factors (ibid.; Rink et al. 2018).

infrastructure, social ties, biogeochemical and economic flows) can both contribute to, or erode resilience (McPhearson et al. 2014; Elmqvist et al. 2019). Likewise, when designing for urban sustainability in mobility or energy systems the sustainability paradigm of maximising efficiency might result in vulnerability to natural disasters when they lack parallel or redundant back-up systems (Elmqvist et al. 2019). This underscores the importance of considering resilience and sustainability together, for example to incorporate quality and health of urban ecosystems into densification plans in cities which enhance urban resilience to climate change (ibid.). In addition, while sustainability and resilience are meant to orient urban transformations, urban transformations towards sustainability and resilience represent processes and not an endpoint (Kabisch et al. 2018). Due the variety of trends and their specific local impacts in cities, different transformation pathways are necessary, involving multiple processes that can interfere with each other at the same time and in different temporal steps (ibid.).

Climate change mitigation and adaptation have become important prerequisites of urban sustainability and resilience transformations (Rink et al. 2018). Urban sustainability and resilience cannot be met without explicitly recognising the contribution to global GHG emissions emanating from activities in cities as well as the vulnerabilities of urban populations, infrastructures, ecosystems and economic systems to the impacts of climate change (UN-Habitat 2016; Vergragt et al. 2015). Conversely, climate change cannot be addressed without understanding the larger context of urban transformation processes and how they affect sustainability and resilience. For example, climate change impacts are but one of many types of shocks and stresses that cities face, and climate change-related shocks typically occur in combination with other environmental, social and economic stresses (Leichenko 2011). As such, climate change mitigation and adaptation in cities intersect with multiple policy domains and a diverse, and sometimes contradictory and competing, bundle of goals such as air pollution, social equity and economic development (Koch et al. 2016; Shaw et al. 2014; Castán Broto 2017).

The embedding of climate change mitigation and adaptation within the endeavour to achieve urban sustainability and resilience transformations makes clear that climate mitigation and adaptation are no end goals in themselves. Rather, it opens up opportunities for integrating mitigation and adaptation with other goals associated with societal and environmental wellbeing and to contribute to the radical changes needed to achieve these goals (Simon et al. 2018; Burch et al. 2018; Shaw et al. 2014). In this way, actions to reduce GHG emissions and increase resilience can also enhance quality of life and social equity and help avoid locking a city into counterproductive infrastructures and policies (UCCRN 2015; Rosenzweig et al. 2015). For example, climate adaptation actions that aim to reduce

flood risk exposure link to goals like the protection of cultural heritage, economic development and the creation of new recreation areas (McPhearson et al. 2016; Wamsler 2015). There is also consensus that resilience and adaptation strategies should particularly address issues of structural vulnerability, justice and equity, because both the responsibility for climate change and how climate change affects people are not equally distributed (Tanner et al. 2009; Simon et al. 2018).

Despite the powerful discourse on cities as sites of opportunity, many cities all over the world are so far grossly unprepared for the multidimensional challenges associated with urban transformations under climate change (UN-Habitat 2016; Rudd et al. 2018; Castán Broto 2017). Debates on urban transformations towards sustainability and resilience draw attention to the governance dimensions of change, which is inherently implicated in any intentional effort to shape transformations (Burch et al. 2018; McCormick et al. 2013; Romero-Lankao et al. 2018b; Rink et al. 2018). Governance determines how urban environments, societies and political economies are shaped and reshaped through the diverse and interlocking activities by a plethora of actors across scales (McCann 2016; cf. Hodson et al. 2018). As such, urban governance crosses the perspectives on transformations in, of and by cities: while urban governance targets transformations in cities in terms of place-specific interventions, urban governance has implications on how transformations of cities unfold and on the opportunities for urban governance to inform and strengthen transformations by cities. However, existing urban governance are tuned to resolve problems rather than co-creating and co-implementing visions and solutions (Elmqvist et al. 2019; UN-Habitat 2016).

1.2 What shift in urban (climate) governance?

In the past years, cities have gained a high level of visibility as key arenas for battling climate change (Rudd et al. 2018; Castán Broto 2017; Acuto et al. 2018). Governance initiatives in cities to address climate change have started to proliferate in the 1990s and often go above and beyond the ambitions set by their respective nation states (van der Heijden 2018). Local governments have taken a leading role in formulating local emissions reductions and climate adaptation goals, but also actors from local communities, businesses, research institutes, regional and national governments, amongst others, generate knowledge, experiment with innovations and self-organise service provisions (Bulkeley 2010; Hughes et al. 2017; Burch et al. 2018).

This has come to be known as urban climate governance (Bulkeley 2010; Castán Broto 2017; van der Heijden et al. 2019). The 'governance'[3] element relates to the intentional coordination of social actions

[3] There exists no universally accepted definition of what governance is (Rhodes 1997). As a broad concept, governance relates to intentional actions or interventions of diverse actors to address a specific collective problem (Castán Broto 2017; Jessop 1997). On the one hand, it refers to the formal and informal structures, processes and rules that determine how people in societies make decisions and share power (Patterson et al. 2016; Biermann et al. 2009). On the other hand, it represents a recognition of the multiple actors that perform acts of governing (Moss et al. 2011; Fröhlich and Knieling 2013). Governance in this broad understanding is connected to a wide range of regulatory (e.g. spatial planning, laws), non-regulatory (e.g. communication, cooperation) and economic (e.g. taxes, subsidies) instruments that are being initiated and implemented by state and non-state actors (Fröhlich and Knieling 2013; Driessen et al. 2012).

(Kooiman 1993). In particular, it represents a recognition of the diverse types of actors (e.g. from civil society, economy, research institutes) and hybrid arrangements for partnership and collaboration that self-organise to intervene in the purposive steering of society (Jessop 1997; Rhodes 1997; Kooiman 1993). The 'urban' element draws attention to action that target the scale of cities, while recognising their multi-scalar effects as well as the complex multi-level governance structures and networks that act in urban systems (McCann et al. 2016). Finally, the 'climate' element refers to the problem that is being addressed, i.e. climate change (Castán Broto 2017). Climate governance commonly encompasses climate mitigation and adaptation – i.e. the intentional actions and interventions by which diverse actors seek to reduce emissions (climate mitigation) and to prepare for and cope with the impacts of climate change (climate adaptation) – across multiple policy sectors (e.g. water, energy, urban planning, transport) (Bulkeley 2010; Anguelovski and Carmin 2011; van der Heijden et al. 2019). In summary, I use the term 'urban climate governance' throughout this thesis to refer to the range of actors (individuals, groups, networks, organisations) who have a role in developing and implementing climate mitigation and adaptation actions in urban systems, the interactions between these actors as well as the structural contexts that influence their interactions.

This section reviews existing urban climate governance efforts, including their emerging features and shortcomings, as well as the lock-ins of existing urban governance systems that pose barriers to addressing climate change. As such, it details the central research challenge this thesis addresses: while urban climate governance in cities signify a shift towards more systemic, learning-based and inclusive governance approaches, the shortcomings of urban climate governance to date are symptoms of urban governance where service delivery goals, infrastructure and governance and decision-making processes are out-of-step with contemporary problems associated to urban transformations under climate change.

1.2.1 Features of urban climate governance

In the last decade, climate action in cities has become formally recognised as a vital part of the global response to climate change and pressing sustainability challenges (Amundsen et al. 2018; van den Heijden 2018). As national progress continues to lag, cities have taken a visible role in international climate negotiations (Gordon and Johnson 2017; Acuto et al. 2017; Lamb et al. 2018; Bulkeley et al. 2012). Climate Summits for Local Leaders were held in parallel to the Paris Conference of Parties (COP) in 2015 and to COP22 in Marrakech in 2016[4], giving local actors the opportunity to influence international climate change negotiations (van der Heijden 2018). While until recently the global climate regime focused heavily on national commitments, the Paris Agreement marks a shift towards encouraging more bottom-up, decentralised and non-state climate governance (Chan et al. 2015; van Asselt et al. 2018; Abbott 2017).

The momentum at the local scale is often driven by the desire of local governments, especially individual politicians or policy officers, to address climate change and its local impacts, as well as to put pressure on climate change policies at a national level (Moloney and Horne 2015; Bulkeley 2010). Initial efforts in cities that started in the 1990s, predominantly in North America and Europe, mainly related to climate mitigation (van der Heijden et al. 2018; Nordgren et al. 2016; Moloney and Horne 2015;

[4] At COP22 in Marrakech in 2016 it was the Climate Summit of Local and Regional Leaders.

Bulkeley 2010). By now, thousands of cities worldwide and a number of joint city initiatives have pledged substantial emissions reductions, such as the C40 network[5] and the Global Covenant of Mayors[6] (Lamb et al. 2018; Moloney and Horne 2015). The emissions reductions goals set by local governments often exceed the ambitions of the states in which they are embedded (Gordon and Johnson 2017; van der Heijden 2018). For example, the city of Sydney seeks to cut emissions by 70 percent from 2006 levels by 2030. New York City (NYC) aims to cut by 80 percent below 2005 levels by 2050. Both ambitions are more than double than those of their respective countries (van der Heijden 2018). A small number of so-called '100% communities' cities of various European countries have set the target to become CO_2-neutral (Rink et al. 2018).

The current mitigation discourse centres on the concept of a "low-carbon city", which "pursues a step-by-step approach towards carbon neutrality linked with urban resilience and energy security, supporting an active green economy and stable green infrastructure" (ICLEI 2016; cf. Simon et al. 2018). To identify sources of emissions and opportunities for reductions, many cities have created baseline GHG emissions inventories and sustainability portfolios (Simon et al. 2018). Measures to reduce municipal and residential emissions include initiatives to improve energy efficiencies in built infrastructures, encourage alternative modes of transportation, lifestyles and urban food production, and integrate green infrastructure into the urban landscape for carbon sequestration (Simon et al. 2018; Bulkeley 2010). This is largely achieved by the implementation of regulation, the provision of subsidies and the establishment of low-carbon infrastructure (Moloney and Horne 2015; Bulkeley 2010). The City Council of Vienna (Austria) adopted a Climate Protection Programme as a framework for its Eco-Business plan, which resulted in significant reductions in solid waste, toxic solid wastes, emissions and water use and which was also adopted in Chennai (India) and Athens (Greece) (McCarney et al. 2011). Regarding the transportation sector, the government of Mexico City has implemented an obligatory school transportation system to ensure that students take public transportation to school (ibid.).

Urban climate adaptation has received more recent, yet significantly growing attention in academia and policy in response to more frequent and often more severe occurrences of extreme events, including intense rains and floods, hurricanes, storm surges and heat waves (Simon et al. 2018; McCarney et al. 2011; Carter et al. 2015; Rosenzweig et al. 2015). Resilience has become a key lens to approach climate change adaptation, which is then often framed as 'climate-proofing' to protect valuable assets and reduce city's vulnerability (Box 1.3; Leichenko 2011; Torabi et al. 2018; Simon et al. 2018). The 100 Resilient Cities programme by the Rockefeller Foundation was a notable effort to support cities worldwide become more resilient in relation to physical, social and economic challenges

[5] The C40 Cities Leadership network is an example of a transnational city network focused on facilitating climate change action at the municipal level. Established in 2006, C40 currently includes 90 municipalities from 50 countries around the world (C40 2018; Lee 2018). With the support of steering committee cities, the C40 member cities organise conferences and workshops to promote partnerships and learning (Lee 2018).

[6] The European Commission launched the Covenant of Mayors in 2008 to endorse and support local and regional governments in the implementation of sustainable energy policies. Signatories of the Convenant of Mayors voluntarily commit to increasing energy efficiency and the use of renewable energy (EU Covenant of Mayors 2008). In October 2015, the Covenant of Mayors merged with the Compact of Mayors for Climate and Energy to form the Global Covent of Mayors. So far more than 9.000 cities worldwide have committed to the Global Covenant of Mayors, and thus to the goal to promote and support voluntary action to combat climate change and move to a low carbon and resilient society (Global Covenant of Mayors 2018).

and including shocks (e.g. earthquakes, floods) and stresses (e.g. high unemployment, inefficient public transport, chronic food and water shortages) (100 Resilient Cities 2018; Simon et al. 2018).

Adaptation actions include the identification and assessment of long-term risks, vulnerabilities and uncertainties, as well as generating more nuanced understandings of the drivers of these risks and vulnerabilities, for example by developing flood maps (Simon et al. 2018; Torabi et al. 2018; Tanner et al. 2009). Urban adaptation and risk mitigation responses encompass a range of approaches at multiple scales (e.g. citywide, neighbourhood) and in relation to diverse sectors (e.g. water management, health, infrastructure, transport, land use planning) (Rosenzweig et al. 2015). Adaptation measures often include either soft or hard infrastructure changes, or a combination of both (Romero-Lankao et al. 2018b; Torabi et al. 2018). For example, cool pavements and roofs are installed, urban vegetation is increased, electricity installations in flood areas are heightened and sea walls or levees are constructed to reduce the risk of floods and heat waves (Romero-Lankao et al. 2018b; Wamsler et al. 2013). Nature-based solutions or ecosystem-based adaptation, including natural wetlands restoration or river re-naturalisation, become increasingly popular as more cost-efficient, multifunctional and flexible approaches than 'hard adaptation' (Romero-Lankao et al. 2018b; Frantzeskaki and Tillie 2014; McPhearson et al. 2014). Zoning regulations and building code adaptations, which incorporate a future level of risk in planning (e.g. 1-in-100-year flood levels) are key tools for local governments to avoid high-risk areas (Torabi et al. 2018; Lonsdale et al. 2015).

While climate mitigation and adaptation initially have been addressed as isolated objectives, there is an increasing emphasis of mainstreaming mitigation and adaptation into decision-making and planning processes across sectors and scales (Runhaar et al. 2018; Aylett 2015; den Exter et al. 2014). In a way it seems that climate change as a policy priority by itself is due to its systemic and complex nature driving a change in urban governance by prompting more long-term, integrated, experimental and multi-actor approaches (Johnson et al. 2015; Castán Broto 2017). The ways in which multiple actors in cities have taken up and advanced urban climate governance signify several distinct features of urban climate governance, which affect urban governance more generally.

- **Hybridisation of actors and networks within polycentric urban climate governance structures**

While local governments often initiate, oversee and implement urban climate strategies, action and experimentation, a multifarious number of actors from local communities, businesses, transnational networks and regional and national governments contribute to delivering urban climate action (Hughes et al. 2017; Castán Broto 2017; Frantzeskaki et al. 2014; Bulkeley 2010; Homsey and Warner 2015). Citizens started to act as active innovators and self-service providers (Frantzeskaki et al. 2016b), small-medium enterprises established sustainable businesses to showcase sustainability in practice (Burch et al. 2016), research-industry collaborations develop innovative technologies (Farrelly and Bos 2018) and community-based organisations play a significant role in carbon reduction and community-based adaptation initiatives (Cowan and Hogan 2014; Chu et al. 2017; Archer et al. 2014). Additionally, as urban climate governance is inherently multi-level, regional, national and international regulatory bodies influence and at times lead and deliver urban climate governance by providing legislation, incentives and resources (Hughes et al. 2017; Fuhr et al. 2018; Keskitalo et al. 2016; Bulkeley and Betsill 2013).

This hybridisation of actors came along with a shift to a polycentric and less structured urban climate governance architecture. Polycentricity means that "multiple governing authorities at different scales" exercise "considerable independence to make norms and rules within a specific domain" (Ostrom 2010: p. 552). Public and private actors at local, regional, national and international scales come together in deliberate and partnership-based processes to jointly develop and implement climate action in cities (Bulkeley 2010; Homsey and Warner 2015; Frantzeskaki et al. 2017). Notable is also the proliferation of multiple forms of transnational city networks such as the International Council for Local Environmental Initiatives (ICLEI), C40 and 100 Resilient Cities. Such networks facilitate knowledge exchange and inter-city learning, foster the creation of collective goals, lobby for international attention, and enable the transplantation of innovative, sustainable and resilient policy and planning approaches (Acuto et al. 2017; Lee 2018; Mejía-Dugand et al. 2015).

- **Integrating climate change mitigation and adaptation with sustainability and resilience goals**

Local governments have started to frame climate mitigation and adaptation as opportunities for enhancing liveability, economic development and wellbeing in cities. This is visible in the formulation of long-term and integrated climate, sustainability and resilience goals and plans, which build on a systemic understanding of city-specific and long-term effects of climate change alongside other risks (Shaw et al. 2014; Aylett 2015). For example, in NYC Mayor Bloomberg (2002-2014) has ignited a city-wide agenda on sustainability and climate mitigation by commissioning the cross-cutting PlaNYC in 2007, which tied goals such as emissions reductions, improving air quality, managing population growth, modernising infrastructure and the city's long-term liveability and global competitiveness (NYC 2007). When Mayor de Blasio took office in 2014, he issued 'One New York: The Plan for a Strong and Just City' (OneNYC) (NYC 2015), introducing affordable housing and social equity as top priorities for resilience and sustainability. Aylett (2015) shows based on a survey of 350 cities across five continents that most cities are integrating mitigation and adaptation into other types of long-range (e.g. sustainable development, community planning) and sectoral plans (e.g. spatial development, transportation).

The integration of climate change with broader sustainability and resilience agendas facilitates the mainstreaming of climate change across policy sectors and the development of systemic climate actions (McPhearson et al. 2017; Shaw et al. 2014). Mitigation actions are often explicitly linked to environmental and social justice agendas (Castán Broto 2017; Bulkeley et al. 2013), while adaptation actions often relate to broader discourses of resilience, which highlight the systemic challenges and structural conditions that influence people's ability to cope with climate impacts and risks (McPhearson et al. 2015; Wamsler and Brink 2014; Bartlett and Satterthwaite 2016; Pelling and Manuel-Navarrete 2011). The mainstreaming of climate mitigation and adaptation through for example their integration into on-the-ground operations and the modification of formal and informal planning procedures can ensure that local sustainability initiatives are designed to also deliver mitigation and adaptation objectives – even though mainstreaming has so far been mainly limited to policy output rather than outcome (den Exter et al. 2014; Runhaar et al. 2018).

- **Experimenting with learning-based urban climate governance approaches for innovation, flexibility and collaboration**

In many instances, urban climate governance stepped away from traditional urban governance that are based on short-term and control style policy and planning approaches with limited opportunities for collaboration and participation. Local governments have created institutional space for inclusive, collaborative and learning-based approaches such as experimentation, co-creation and social innovation (Castán Broto 2017; Frantzeskaki and Kabisch 2016). For example, climate governance experimentation has been a central means for the testing of innovative and multi-functional climate solutions in out-of-mainstream governance settings that allow collaborative learning between multiple actors (Castán Broto and Bulkeley 2013; Nevens et al. 2013; Evans et al. 2016). Experimentation has been appraised as an open-ended way for trialling new, agile and responsive solutions that translate distant sustainability targets into concrete actions, enable dealing with the significant uncertainties and complexities of climate change and urban transformations and contribute to the radical changes necessary for achieving sustainability and resilience (Castán Broto and Bulkeley 2013; Karvonen 2018). Knowledge co-creation is "an effort to draw on diverse knowledge" (Wyborn 2015 p. 57). Given that in cities, knowledge about problems, needs, solutions and institutions lies in diverse actors, co-production has become a novel form of collaborative urban governance to address complex urban problems in an inclusive way, develop and scale innovations that address local needs, build new partnerships and mobilise and empower urban actors (Muñoz-Erickson et al. 2017; Frantzeskaki and Kabisch 2016; Frantzeskaki and Rok 2018; Voorberg et al. 2014).

Such governance approaches essentially seek to facilitate social learning for making urban governance a joint process of discovery for better urban futures: they allow for new types of relationships and interactions between as well as empowerment of diverse actors and the generation of innovative, multifunctional and fit-to-context solutions (von Wirth et al. 2014; Loorbach et al. 2015; Hölscher et al. 2017). Experiments facilitate the emergence and diffusion of new technologies to direct changes in the built environment and infrastructures, but experimentation also relates to broader learning outcomes in terms of changed discourses, practices, policies and institutions (Kivimaa et al. 2017; Wolfram et al. 2017). Co-creation allows for deep participation to leverage and weave together local, expert and tacit knowledge (Frantzeskaki and Kabisch 2016; Devolder and Block 2015), as well as to account for competing value systems (Gulsrud et al. 2018).

- **Coordinating structures for synergistic polycentric urban climate governance across scales and sectors**

Research shows the emergence of new governance structures and processes to facilitate cross-scale and cross-sectoral coordination, collaboration and mainstreaming of climate governance activities (Hodson et al. 2013; den Exter et al. 2014). This has become necessary because climate mitigation and adaptation do not fit neatly in existing institutional siloes and because of the increasingly polycentric urban climate governance landscape (Aylett 2015; Hughes et al. 2017). Coordination has thus started to accompany decentralised and hybrid climate governance activities to start initiatives when needed, pool resources and knowledge, and ensure monitoring (den Exter et al. 2014; Pahl-Wostl and Knieper 2014; Hodson and Marvin 2010; Frantzeskaki et al. 2014).

Urban climate governance coordination is visible in diverse new governance structures, mechanisms and processes. Local governments often lead urban climate governance coordination, establishing formal and informal structures and processes to motivate, support and mainstream climate

governance actions (den Exter et al. 2014; Frantzeskaki et al. 2014). Many cities have set up central bodies, such as climate and/or sustainability offices, that centrally coordinate climate-relevant concerns, seek to anchor responsibilities for climate action across the whole municipal body and reach out to and build partnerships across governance scales and with private actors (den Exter et al. 2014; Aylett 2015). In some cities, these bodies and offices are located within environmental departments, but stronger approaches for coordination are enabled by the cross-cutting establishment of such offices (den Exter et al. 2014). Next to local governments, intermediaries facilitate coordination by creating convening spaces for face-to-face contact, articulating expectations and visions, building social networks as well as gathering, processing and brokering knowledge (Hodson et al. 2013; Kivimaa 2014; Castán Broto 2017; Gliedt et al. 2018).

Urban climate governance scholars highlight intermediation as a key mechanism to align, motivate and support urban climate governance activities by mediating knowledge and resources, mainstreaming climate change, convening strategy formulation processes and building trust (Hodson and Marvin 2010; Frantzeskaki et al. 2014). Similarly, Dąbrowski (2017) analyses how multiple actors at different scales of governance engage in boundary spanning as a way to coordinate cooperation on climate adaptation across horizontal (boundaries between sectoral policies) and vertical (boundaries between levels of government) dimensions. Abbott (2017) analyse 'orchestration' as an indirect mode of strategic ordering in polycentric climate governance: "An orchestrator (O) works through like-minded intermediaries (I), catalysing their formation, encouraging and assisting them, and steering their activities through support and other incentives, to govern targets (T) in line with the orchestrator's goals (O-I-T)" (Abbott 2017: p. 2).

These features of urban climate governance illustrate how climate change as a systemic issue with severe and long-term implications comes along with, or even prompts, a change of urban governance. Climate mitigation and adaptation as strategic priorities touch on multiple goals and sectors and are therefore implemented in multiple tactical and operational governance arenas. However, so far there has not been a significant shift of existing urban governance that allows for the systematic delivery of ambitious action on emissions and climate impacts: while urban climate governance shows many innovative features with the potential to advance urban climate, sustainability and resilience actions, there are also still severe shortcomings in how urban climate governance is implemented in practice.

1.2.2 Shortcomings of urban climate governance

Despite the proliferation of urban climate governance ambitions and activities, urban climate governance to date has failed to deliver the radical and effective actions necessary to reduce emissions and protect from climate impacts, let alone to create stepping stones for improving social and environmental wellbeing in the long-term (Rink et al. 2018). The amount of emissions induced in cities still goes up and many adaptation actions have no effect or are mal-adaptive because they actually increase risk (Lonsdale et al. 2015; Torabi et al. 2018).

Scholars identify four major shortcomings of current urban climate governance approaches. These shortcomings manifest in the limited effectiveness of how climate change is currently addressed in cities.

- **Climate change, sustainability and resilience goals and agendas are not mainstreamed and operationalised into urban governance practice**

Climate change, sustainability and resilience goals and agendas so far remain less impactful because they are not consistently and decisively translated into institutional frameworks, financing mechanisms and operational practices that change incentive structures and organisational ways of working (den Exter et al. 2015; Wamsler 2015; Runhaar et al. 2018). For example, climate change is still communicated as an additional and separate aspect rather than as a cross-cutting issue, and is thus perceived as but one of many issues (Wamsler et al. 2013; Rosenzweig et al. 2015). As such, there is an implementation gap of the strategic goals and climate mitigation and adaptation remain merely add-on priorities to business-as-usual policy and planning practices. This concerns the local governance agenda, but also national level policies that do not consistently integrate climate change into national policy frameworks to direct urban practices (Moloney and Horne 2015).

This results in a disconnect between sectoral urban policies and those focused on climate change. Climate action still frequently draws the short straw when competing with 'pressing' urban needs (Ürge-Vorsatz et al. 2018; Gouldson et al. 2015). Rather than inspiring systemic efforts to transform urban systems the multitude of urban climate responses can be characterised as an ad hoc and patchwork mosaic (Bulkeley et al. 2012). Additionally, even the most formidable efforts for climate mitigation, climate adaptation and sustainability are continually countered by the negative effects and externalities of other policy areas. Rather than enabling synergies between different goals, the lack of mainstreaming and operationalising of climate change as a cross-cutting and systemic issue into operational planning and policy practice results in counteractive investments. For example, continued investments in mal-adaptive infrastructure such as the development of building areas in flood-prone areas are at odds with the implementation of climate-resilient building codes, flood zones and discussions on planned retreat (Torabi et al. 2018; Rosenzweig et al. 2015).

- **Climate change mitigation and adaptation actions are often developed in an incremental way that favours short-term, reactive and technocratic solution approaches**

The shortcomings of urban climate mitigation and adaptation are also reflected in how mitigation and adaptation are often still framed and approached. Transformative responses that create the required shifts in energy, water, transportation, land use regimes, production and consumption practices and worldviews target the underlying drivers of resource use, emissions and vulnerability (Romero-Lankao et al. 2018b). Examples include a shift from centralised, fossil-fuel based electricity to decentralised, rooftop solar energy, or integrating disaster risk management with a pro-poor urban development agenda (ibid.). However, research on mitigation and adaptation action in cities has shown that both are often developed building on paradigms of incrementalism and technocracy, which are unable to create stepping stones for radical and systemic change but rather perpetuate path-dependency and mal-adaptation (Moloney and Horne 2015; Torabi et al. 2018; Nordgren et al. 2016).

For example, approaches to mitigation are generally focusing on technical efficiency and market rationales (e.g. technical solutions to reduce energy use, financial incentives) (Moloney and Horne 2015). While people are typically targeted through information, training and incentives, this is not able to achieve social change in for example energy use, eating or transport patterns (ibid.; Olazabal et al. 2014). As Moloney and Horne (2015: p. 2450) illustrate, "encouraging people in greenfield areas to reduce their car use is a waste of time if we continue to plan new suburbs with little or no alternative transport options. Likewise, reducing energy use in houses with rapidly increasing floor areas driven by the latest trends in renovations and design is also challenging".

Similarly, climate adaptation in cities is primarily framed in terms of the need to protect valuable assets and vulnerability reduction (Nordgren et al. 2016; Torabi et al. 2018). Many climate adaptation measures are 'hard' technological interventions (e.g. building a seawall or levy) that aim to reduce hazard exposure and vulnerability of buildings and infrastructures without accounting for and connecting with the social, cultural, economic, political and institutional characteristics of cities (Birkmann et al. 2010; Wamsler et al. 2013; McPhearson et al. 2015). Such adaptation initiatives often fail to address issues related to the unequal distribution of climate impacts (Nordgren et al. 2016; Aylett 2015; Reckien et al. 2014). Additionally, adaptation approaches often address climate-related impacts in the short- to mid-term and are unable to manage future climate risk (Torabi et al. 2018; Lonsdale et al. 2015). For example, the incorporation of the level of acceptable risk in planning (e.g. 1-in-100-year flood level) and the upgrade of zoning regulations building codes accordingly are often inadequate for dealing with projected future climate change, incur high costs of replacement and can lock in communities in mal-adaptive pathways (Torabi et al. 2018).

- **Insufficient space for embedding learning-based governance approaches that allow to spread and institutionalise collaborative innovation**

While opening up new political spaces for governing climate change in the city, collaborative and learning-based governance approaches still remain add-ons to conventional, control-style and siloed governance approaches and are not sufficiently supported by organisational structures that provide space and resources for long-term follow-up and learning. For example, while urban climate governance experimentation implies – and does generate – some sort of learning about what the tested innovations bring about in the policy mix of cities (Luederitz et al. 2017; Raven et al. 2017), climate experiments often remain disconnected from more formalised and mainstream urban policy and planning processes. This repeatedly results in stand-alone innovations that do not inform policy and planning, rendering their impact and legitimacy contested (Ansell and Bartenberger 2016; Evans 2016; van Buuren et al. 2018).

A key challenge is to create space in a governance system that is oriented towards optimising efficiency. There is a need for new institutional structures and organisational ways of working that allow for learning from experimentation and co-creation, long-term collaboration and partnerships and the embedding of new roles and responsibilities (Ehnert et al. 2018; Hölscher 2018). As learning-based and collaborative governance approaches depart from conventional governance processes, there is also a lack of skills and resources for the design and facilitation of for example co-creation processes that are inclusive, legitimate and open, nurture trust and spark (re-)defining roles and responsibilities (Frantzeskaki and Kabisch 2016; Hölscher et al. 2017). This also includes knowledge about how to be

protective from vested interests and power imbalances: despite its stated innovative potential, urban experimentation is often criticised for not allowing all social interests to equally shape innovations and underpinning a paradigm of competitive urbanism that conforms to existing neo-liberal rationalities (Hodson et al. 2018; Evans 2016; Jhagroe 2016).

- **Urban climate mitigation and adaptation are often framed as apolitical and technical, without paying attention to underlying power structures and structural vulnerabilities**

Researchers repeatedly point out that urban climate governance interventions do not sufficiently take issues of existing power relations and equity into account (Jhagroe 2016; Matyas and Pelling 2014; Chu et al. 2017). Addressing climate change in the context of urban transformations requires far-reaching societal and political choices that have strong normative and contested content that requires profound societal deliberation (Nordgren et al. 2016; Nevens et al. 2013; Jabareen 2013). While there is a tendency within public sector authorities to treat climate change action as apolitical and technical, urban political and economic forces influence how mitigation and adaptation interventions are being framed (Chu et al. 2017; Romero-Lankao et al. 2018b; Simon and Leck 2015). For example, powerful economic actors associated with the property development industry lobby state governments on planning instrument (e.g. zoning, performance regulations) and projects (Newton et al. 2017).

As a result, initiatives do not address the source of the problem and they do not necessarily deliver optimal city-wide or community benefit (Newton et al. 2017; Simon and Leck 2015). In this vein, Chu et al. (2017) conclude that climate action must explicitly consider the powerful and often entrenched political and economic interests that constrain urban equity at large. This requires an understanding of the factors that determine structural inequalities to ensure that mitigation and adaptation burdens are not placed upon those that are least able to afford them but at the same time often bear a disproportionate level of explore and risk to climate change impacts (Simon and Leck 2015). While there has been an increased recognition for the role of the private sector and public-private partnerships, these partnerships have been accused of being anti-democratic, excluding already marginalised urban groups and reinforcing power imbalances (Tanner et al. 2009; Reckien et al. 2017).

These shortcomings of urban climate governance to date signify the multiple challenges related to changing existing urban governance regimes that are unfit to meet contemporary and complex urban problems. While urban climate governance can be found in cities worldwide, cities have different types of capacities, challenges and opportunities to address climate change and sustainability (Castán Broto 2017; Simon and Leck 2015). A common challenge everywhere is to overcome the institutional, organisational, economic, political, technological and cultural barriers – or lock-ins – associated with existing urban governance regimes (UN-Habitat 2016; Torabi et al. 2018; Bettini 2013).

1.2.3 Urban governance lock-ins

The shortcomings of urban climate governance are symptoms of a deeper running problem: they are symptoms of urban governance where service delivery goals, physical infrastructure and administration and decision-making processes are out-of-step with contemporary problems and

demands for integrated, long-term and flexible solutions and responses (Frantzeskaki et al. 2018b; Bettini 2013). As such, the shortcomings of urban climate governance are caused by different types of lock-ins, due to which urban governance arrangements have hardly changed and urban climate governance efforts run against a complex web of diverse responsibilities, ill-suited national policies and paradigms of economic efficiency (cf. UN-Habitat 2016).

Lock-ins refer to initial conditions that have developed inertial resistance to change, reinforce path-dependency in technical, institutional and behavioural systems and inhibit innovation and competitiveness of low-carbon, sustainable and resilient alternatives (Table 1.3; cf. Seto et al. 2016). These lock-ins are mutually reinforcing and create collective inertia (ibid.).

- ***Institutional lock-in:*** **siloed decision-making and jurisdictions impede horizontal and vertical coordination and collaboration**

The cross-cutting nature of climate change, sustainability and resilience exposes the institutional path-dependencies that have been created through the siloed and compartmentalised nature of decision-making (Romero-Lankao et al. 2018b; McCarney et al. 2011). While approaches to climate mitigation and adaptation need to be holistic and comprehensive, expertise required to address climate change and sustainability challenges is scattered across sectoral agencies, utilities and governance scales (Romero-Lankao et al. 2018; den Exter et al. 2014; Fröhlich and Knieling 2013). Additionally, actors across city departments, levels of government and policy sectors often have varied visions, values, interests and decision-making power (Romero-Lankao et al. 2018b). This makes it hard to mainstream and coordinate climate change action both vertically across multiple levels of governance and horizontally across the city (McCarney et al. 2011; Romero-Lankao et al. 2018b; Moloney and Horne 2015).

A main barrier for horizontal inter-jurisdictional coordination across the city to address climate change in synergy with other policy priorities and goals is the historic compartmentalisation of city services into different functional sectors (e.g. water supply waste, energy, mobility, health) (Runhaar et al. 2018; Bettini 2013; Anguelovski et al. 2014). While the compartmentalisation has grown out of the quest for efficiency, it has resulted in institutional fragmentation, unlear responsibilities and mandates, lack of communication and conflicts of interests across city departments (Bettini 2013; Pickett et al. 2014; Romero-Lankao and Dodman 2011). Environmental departments often have limited remit over and capacity to implement actions in key sectors like energy, transportation and water, and have to compete for resources from other developmental priorities (Romero-Lankao et al. 2018b; Anguelovski et al. 2014; Aylett 2015). The siloed approaches are deeply engrained in organisational cultures and determine how responses are developed, designed and maintained. Intersectoral cooperation "goes against the grain of most government systems. Councilors and officers, usually representing specific disciplinary areas and professional groups, may want to defend their sector's interests and compete" (Pradad et al. 2009: p. 69, cf. Frantzeskaki 2016). If there are mainstreaming activities these are limited to the strategic policy level, but this 'high-level-talk' does not permeate to the daily operational work (Wamsler et al. 2013).

The legal and institutional frameworks at regional, national and international scales determine the extent to which urban climate actions are legitimised, prioritised and incentivised and require vertical

coordination and collaboration across governance levels (Romero-Lankao et al. 2018b; Runhaar et al. 2018; Keskitalo et al. 2016). However, regulations and laws at national and regional levels often impede local efforts to address climate change and sustainability rather than motivate and support them (Nordgren et al. 2016; Newton et al. 2017; Moloney and Horne 2015). As illustrated by Moloney and Horne (2015), in Victoria, Australia, local energy efficiency agendas conflict with state energy policy that supports the continued growth of the fossil fuel industry. Similarly, sustainable transport policies in cities conflict with the continued support for private transport-led road construction (ibid.). Political and jurisdictional differences often interfere with a more integrative and collaborative approach to urban planning and development (Newton et al. 2017). The multi-scale implications of climate change can create jurisdictional conflicts over who can or must act on a specific initiative (Rosenzweig et al. 2015). Negative consequences or externalities of structural measures (e.g. dyke systems, relocation) manifesting not only in the city but also in the surrounding urban, peri-urban and rural areas need to be discussed and made transparent (Birkmann et al. 2010). Another underlying problem is that national and regional governments are themselves often compartmentalised in multiple ministries, each having roles and responsibilities in planning parts of urban systems (e.g. industry, housing, transport, energy, education), being unwilling to share power and resources with cities and struggling to imagine integrated, cross-sectoral decision-making and planning (Newton et al. 2017; Rudd et al. 2018).

- ***Political economy lock-in:*** **vested political and economic interests drive a focus on short-term optimisation**

Powerful economic, social and political actors often seek to reinforce a status quo trajectory that favours their interests (Seto et al. 2016; Castán Broto 2017). This impedes a long-term orientation towards radical change. Party politics and markets tend towards securing short-term interests and optimisation to provide quick fixes for short-term needs (Friend et al. 2014; Shaw et al. 2014; Romero-Lankao and Dodman 2011). The short time horizons of politicians due to political cycles make it difficult to overturn policies and institutions of any sort, for example those in favour of fossil fuels (Seto et al. 2016; Gillard et al. 2016). Decisions are often made under time pressure while institutional rules that strengthen long-term and integrative policies for climate and sustainability action are costly and often politically vulnerable (Seto et al. 2016; Rink et al. 2018). The prevalent and relatively undisputed governance paradigm in cities is still a "governance-for-growth approach", which is "relatively stable, with overarching coalitions between elected counselors and private companies whose aim is to combine resources and competences and initiated successful growth policy" (Rink et al. 2018: p. 15). According to this paradigm, growth will create (new) jobs, generate investment and increase welfare through trickle-down effects. In this context, urban regimes have emerged, defined as "informal, yet relatively stable group with access to institutional resources that enable it to have a sustained role in making governing decisions" (Stone 1989: p. 4; cf. Rink et al. 2018). These regimes have to some extent also captured the transformation idea by reproducing the economic and political status quo under the disguise of sustainability. According to Rink et al. (2018), this is exemplified by the smart city concept, which is poorly defined and mainly focus on investment in modern information and telecommunication infrastructure to generate sustainable economic development and a high quality of life, but cannot solve the challenge of achieving urban sustainability.

Table 1.3: Shortcomings of urban climate governance and existing urban governance lock-ins

Urban governance lock-ins	Shortcomings of urban climate governance			
	Operationalisation and mainstreaming in urban governance practice	*Incremental and technocratic approaches*	*No space for embedding learning-based governance approaches*	*Attention to politics and legitimacy*
Institutional lock-in	Lack of horizontal and vertical collaboration and coordination			
Political economy lock-in	Strong business-as-usual interests and short-term focus on reactive, optimisation and technocratic solutions			
Organisational lock-in	Lack of knowledge, staffing capacity and funding for urban climate governance			
Technological lock-in	Long life cycles and high investment costs of existing physical infrastructure			
Demand side lock-in	No societal awareness and agency about and take up of action			

The failure to take a long-term perspective results in solutions that address symptoms of problems rather than their root causes, reinforce investments in unsustainable lock-ins and mal-adaptation and induce higher costs in the long-term (Torabi et al. 2018; Carter et al. 2015; Romero-Lankao and Dodman 2011). As long as business-as-usual is (financially) viable sustainable business models remain thin and climate and sustainability related actions are perceived as more expensive and remain reliant on easy investments in low-hanging fruits that do not fundamentally challenge existing behaviours and interests (Ürge-Vorsatz et al. 2018; Gouldson et al. 2015). While some mitigation activities are taken by local governments because they pay off quickly, they often decide against activities that have high upfront investment costs and long payback periods (McCarney et al. 2011).

- ***Organisational lock-in:*** **limited experience with, resources for and knowledge about 'effective' urban climate governance**

A third lock-in refers to the limited experience with, resources for and knowledge about what type of urban climate governance effectively helps to address climate change, sustainability and resilience challenges, as well as how to develop this. What is clear is that urban climate governance, including for example the preparation against long-term risks or novel experimentation and co-creation approaches, require new types of knowledge, skills and organisational structures and resources. Besides having to generate detailed information about the economic and social impacts of climate change, urban climate governance requires knowledge about how to use that information and how to make a (financial, political etc.) case for why climate action is warranted (Nordgren et al. 2016; Romero-Lankao et al. 2018b). There is limited experience for making decisions in high uncertainty contexts, which are exacerbated by lack of knowledge, vagueness of climate projections and multifaceted options for action (Fröhlich and Knieling 2013). While many resources are available to support local climate mitigation and adaptation initiatives, practitioners struggle to find the resources that are the most useful given the specific context and needs (Nordgren et al. 2016; Torabi et al. 2018). Similarly, moving beyond singular experiments requires the dedication of time and resources to create space for identifying, evaluating and translating lessons from specific innovations, such as about the viability, replicability and scalability, for their broader context (Ehnert et al. 2018; Hölscher et al. 2018b).

This organisational lock-in is driven by the ways in which knowledge is created and shared and organisational capacities and resources are allocated and mobilised. For example, while a lot of scientific information is already available, it is not easily made accessible and translated for use (Nordgren et al. 2016; Romero-Lankao et al. 2018b). Increasing budget cuts of local governments and particularly limited staffing capacity and a high turnover of staff exacerbate the development of new skills, processes and knowledge (Nordgren et al. 2016; Simon and Leck 2015). Limited staffing capacity is for example visible in the lack of consistent monitoring activities to review emissions reductions and evaluating adaptation activities (Nordgren et al. 2016). Researchers also noted a trend towards a 'projectification of funding', which is reinforced by governments' focus on cost-optimisation and effectiveness, but does not enable moving beyond initial seeds of innovative initiative and sustain them in the longer-term, replicate or scale them (Ehnert et al. 2018). Similarly, Simon and Leck (2015) find that the time frame for most local participatory adaptation interventions exceeds most local election and donor funding cycles, which makes it difficult to persuade elected leaders and donor agencies to buy-in and (financially) support participatory processes.

- ***Technological lock-in:*** **long life cycles and high investment costs of existing physical infrastructure**

Technological lock-in refers to the longevity of infrastructure and technology – once in place, physical structures persist over decades or even centuries (Moss 2014; Markard 2011). Technological lock-in is in part caused by the long life of physical infrastructures, related sunk costs, and the other lock-ins that are aversive to change and long-term investments, including societal expectations and regulatory frameworks (Seto et al. 2016; Loorbach et al. 2010; Moss 2014). At the same time, the old age of infrastructures such as sewage, storm water drainage and roads increase vulnerability of many coastal cities to climate change impacts and demand radical changes (Torabi et al. 2018).

Technological lock-ins exacerbate long-term and systemic urban climate governance. The tendency of existing urban governance is to optimise incumbent technologies and infrastructures rather than to innovate novels ones, because of the uncertainty of the new technology and the high levels of upfront investment costs (Geels 2002; cf. Bettini 2013; Seto et al. 2016). For example, Seto et al. (2016) outline how energy demand patterns are locked in through large incremental investments in long-lasting built infrastructure, which inhibit energy efficiency measures.

- ***Demand side lock-in:*** **existing definitions of 'who has agency' inhibit changes in individual behaviours and social practices**

Climate change mitigation and adaptation require considerable changes in cultures, values and individual behaviours (Torabi et al. 2018; Creutzig et al. 2016). Seto et al. (2016) refer to behavioural lock-in driving high GHG emissions as related to behaviours, habits and norms associated with the demand for energy-related goods and services, including human travel, consumption, living and travel patterns. This includes both individual behaviours (e.g. habits, risk avoidance) and socially shared practices that emerge from standardised traveling, heating and dietary routines (e.g. through social norms or road and building infrastructures) (ibid.). Similarly, climate adaptation can be constrained by a community's desire to live close to the water, which exacerbates the pressure to develop low-lying waterfront land (Torabi et al. 2018).

Demand side lock-ins relate to definitions and perceptions about 'who has agency' in terms of who is responsible for implementing change. On the one hand, climate mitigation and adaptation policies and interventions tend to solely focus on technological solutions, casting aside social practices (e.g. energy efficiency over energy conservation and changes in energy practices, low-emission vehicles over changes in mobility habits) (Moloney and Horne 2015; Seto et al. 2016). This is also because of the little understanding about how behavioural patterns and routine change and consensus about the opportunities and ethical use of interventions to change habits. Since habits are followed outside of conscious cognitive processing, informational and awareness raising campaigns to change attitudes underpinning transport choices might not be effective. More successful interventions comply with the habit-discontinuity hypothesis, which posits that "behaviors are more pliable when a context change disrupts the routine" (Seto et al. 2016). On the other hand, demand side lock-ins relate to a low level of awareness or recognition about the need for *everybody* to take up action themselves. Hence, if there are demand side policies such as for better health and living, these remain rather ineffective given for example the low level of awareness about climate-related risks and the urgency for action (Tanner et al. 2009; Romero-Lankao and Dodman 2011; Seto et al. 2016).

The literature review on urban climate governance features and short-comings vis-à-vis existing urban governance lock-ins makes clear that effectively addressing climate change and contributing to urban sustainability and resilience transformations challenges existing urban governance paradigms and structures. This leads me to the central research problem I address in this thesis: how can the transformation of urban (climate) governance be supported so as to facilitate transformative climate governance in cities? While the features of urban climate governance signify a shift into the direction of addressing climate change as a transformation challenge (see governance implications in Table 1.1), the key challenge is to operationalise and mainstream transformative climate governance and make true to the promise of cities as sites of opportunities for sustainability and resilience transformations.

1.3 How to shift towards transformative climate governance in cities?

The problem I put at the heart of this thesis is the transformation of urban (climate) governance so as to create institutional space for and facilitate those actions that can purposefully contribute to the transformation required for dealing with climate change and unsustainability in cities. The positioning of climate change in the context of urban transformations makes clear that climate change is a cross-cutting issue with severe implications on human and environmental wellbeing in cities and beyond (Table 1.1; Rosenzweig et al. 2015; Koch et al. 2016; Burch et al. 2018). The current disconnect between narrated opportunities and on-the-ground practice in cities signifies a mismatch of existing urban governance systems and practices and characteristics of climate change and urban transformations, which are complex, long-term, uncertain and contested processes of radical change in urban systems (Rink et al. 2018; Romero-Lankao et al. 2018a). Indeed, as shown in the review above, urban climate governance already shows various features indicating more systemic, experimental and multi-actor approaches, but so far it has failed to deliver the radical and effective changes necessary to reduce

emissions, protect from climate impacts and improve overall sustainability (Roberts et al. 2018; Torabi et al. 2018; Castán Broto 2017).

My aim is to contribute to an understanding about what transformative climate governance could look like and how it can be strengthened vis-à-vis existing urban governance regimes. I employ the term transformative climate governance to conceptualise an ideal-type and normative approach to urban governance that allows actors to develop climate mitigation and adaptation actions in synergy with other policy priorities and goals so as to contribute to urban transformations towards sustainability and resilience. Transformative urban governance has generally been introduced to denote the necessary shift "away from incremental approaches which are driven by short-time requirements to transformative changes with a strategic long-term perspective to the natural livelihood of mankind" (WBGU 2016: p. 9). However, how this governance should be structured and arranged, which actors will be involved and how the necessary governance shift can be achieved so far remain unanswered questions (Rink et al. 2018). The features of urban climate governance signify new governance approaches, and there is already a lot of knowledge about specific mechanisms and configurations (e.g. polycentric governance, intermediation, experimentation, see Section 1.2.1). Yet there are no overarching and structured insights into how the corresponding governance shift is brought about, which governance mechanisms, conditions and processes manifest in this shift, and whether the shift contributes to navigating urban transformations under climate change.

This section introduces the key concepts and research approaches that this thesis builds on to develop and empirically ground the transformative perspective on urban climate governance. It introduces the concept of governance capacity as a lens to explain and evaluate the governance shift in view of transformative urban climate governance. The capacity lens facilitates a learning-based view on how urban (climate) governance is changing, and to which ends, by bridging between the diverse actors and activities driving the governance shift, the institutional and organisational governance conditions that emerge as a result, as well as whether these indeed contribute to navigating urban transformation under climate change (cf. González and Healey 2005). In order to conceptualise and operationalise capacities for transformative urban climate governance I turn to transformation research that covers multiple research strands and approaches providing knowledge about what urban transformation governance could look like. While urban transformations cannot be controlled, they can be influenced by mobilising and responding to the driving forces and dynamics characterising transformations (Loorbach et al. 2015; Rink et al. 2018). In other words, I posit that different sets of conditions and processes – i.e. different governance capacities – are needed for accomplishing distinct governance functions that respond to and mobilise transformation dynamics and achieve change at the system level.

1.3.1 A perspective on governance capacity: connecting 'what', 'who' and 'how'

Understanding the development of urban climate governance vis-à-vis existing urban governance regimes and whether it results in transformative climate governance requires new frameworks and concepts that bridge between the diverse actors and activities driving the governance shift, the institutional and organisational governance conditions that emerge as a result, as well as whether these indeed contribute to navigating urban transformation under climate change. The notion of

governance capacities provides a learning and agency-based view on how, and by whom, urban climate governance is enacted, what conditions emerge as a result, whether these conditions mark a shift towards transformative climate governance, what are capacity gaps, as well as how capacities can be supported.

Governance capacity is as ambiguous a concept as governance; for example, it has often been related to the power of the state or quality of government (Christensen et al. 2016). At the most general level, it refers to the effective organisation of collective action, which draws attention to the interactions among diverse governance actors who solve problems or complete complex tasks by working together (Innes and Booher 2003; Rama et al. 2009). In public administration, policy analysis and planning literatures, scholars have been introducing different concepts and understandings related to the capacity for governance in an effort to address the question of which skills, instruments and institutions help to govern in a complex society. It encompasses the individual capacity of governance actors, the organisational capacity of governance organisations and institutions, and relational capacity for collaboration between individuals and organisations (Foster-Fishman et al. 2001; Innes and Booher 2003). Yet governance capacity goes beyond individual, organisational and relational capacity to describe how these manifest in the capacity of the governance system as a whole, including actors, their positions, roles and strategies, networks and coalitions, discourses, governance cultures and institutional arenas, to operate as a collective actor (Innes and Booher 2003; González and Healey 2005).

Central to the idea of governance capacity is that it is an emergent property of governance systems: governance capacity is emergent through the formal and informal collaboration and learning processes between multiple governance actors and how they interact with their institutional and organisational contexts – including governmental institutions, politics and other social worlds – to solve collective problems (Innes and Booher 2003; Koop et al. 2017). This is what I call the 'structuration perspective' on governance capacity: This understanding shifts attention from the design of projects and policies and their impacts to the co-constitutive design of the institutional infrastructure, expressed in formal rules and structures, informal norms and practices, which determines what projects and policies emerge, and what impacts are on identities, knowledge, resources, interactions and cultural assumptions as well as material outcomes (González and Healey 2005). Governance capacity is then "the ability of institutional relations in a social milieu to operate as a collective actor" (ibid.: p. 2056). This perspective on governance capacity and how it is evolving is agency-based: governance capacity ultimately depends on the ability of multiple actors to navigate their structural contexts by mobilising, creating and removing governance conditions.

The emergent characteristic of governance capacity makes it a contingent, context-dependent and relational – not an absolute – quality (ibid.; González and Healey 2005). Given its broad conceptual scope, governance capacities can hardly be assessed for a governance system as a whole (González and Healey 2005; Wolfram 2016). It is characterised by the micro-politics of interactions between specific actors in particular arena embedded in the political economy of a concrete time and space, including sense of identity and place, urban narratives, spatial imaginations and geographical contexts (González and Healey 2005).

I identify four dimensions of governance capacity that manifest in the ability of a governance system to effectively organise collective action and thus allow to trace how urban governance is changing and assess whether the new emerging forms allow for transformative climate governance.

- **Governance capacity is enabled and constrained by knowledge, organisational and relational conditions that allow to mobilise skills, knowledge, resources and collaboration for collective action.**

While urban governance actors are capable of purposive decisions, deliberate actions and strategic choices, their actions and interactions are shaped by the more or less institutionalised working arrangements (e.g. organisational settings, rules, regulations) as well as the broader socio-economic and political contexts (e.g. available resources, discourses) (Hodson et al. 2018; Koop et al. 2017). Governance capacity therefore requires attention to and investment in mobilising networks, organisational resources, skills, knowledge and institutions that allow actors and organisations to collaborate, to analyse, assess and act on information and to deliver joint action in practice (Christensen et al. 2016; Rama et al. 2009).

Personal skills and knowledge have to be developed on a collective level including how to plan, design and evaluate programmes, to provide technical assistance, as well as how to communicate, cooperate and resolve conflicts (Foster-Fishman et al. 2001). Organisational conditions such as organisational structures, administration, leadership, communication systems and financial resources enable and constrain collective action (ibid.; Rama et al. 2009; Christensen et al. 2016). Collective action in distributed governance systems also needs well-networked working relationships among multiple actors that allow actors need to act independently on the basis of their own local knowledge but in ways that will be beneficial also to the system as a whole (Innes and Booher 2003; Foster-Fishman et al. 2001). Moreover, it is important to build strong working relationships based on a shared vision, an inclusive culture and trust (Foster-Fishman et al. 2001; Rama et al. 2009). This also extends to citizens' attitudes and trust in central governmental institutions that influence organisational and policy decisions and judgements about their success (Christensen et al. 2016).

This perspective allows to identify the diverse governance conditions enabling or constraining collective action for transformative climate governance. Urban climate governance scholars have identified key sets of governance conditions related to constitutional, legal and regulatory frameworks across multiple levels, local and domestic financing and inclusive governance arrangements (Castán Broto 2017; Rudd et al. 2018). For example, urban climate governance can be both enabled and constrained by the institutional contexts of their nation states (Bulkeley and Betsill 2013; Moloney and Horne 2015; Keskitalo et al. 2016). International and national discourses on for example renewable energy influence energy production and consumption patterns in cities (Bulkeley 2015; Rink et al. 2018).

- **Governance capacity is enacted by diverse governance actors who mobilise, create and change governance conditions for collective action.**

Governance capacity has often been reduced to the institutional contexts, organisational structures and resources that enable actors to collaborate and address shared problems (Koop et al. 2017; Amundsen et al. 2018). However, this is unable to explain how governance capacity is made to be. In

light of the problem of institutional inertia, organisational and political lock-ins regarding urban climate governance described above, it fails to address questions about how structural barriers and opportunities can be removed, utilised or created (cf. Bettini 2013). For example, Rama et al. (2009) discuss how collaborative capacity is determined by framing processes, i.e. "the collective processes of interpretation, attribution, and social construction" (McAdam et al. 1996, p. 2, cf. Rama et al. 2009) that involve strategic efforts to generate shared understandings for legitimating and motivating collective action.

Scholars concerned with policy change have developed understandings about institutional or policy entrepreneurship (Huitema et al. 2011; Boasson and Huitema 2010; Bakir and Jarvis 2017). The term institutional entrepreneurship refers to the "activities of actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones" (Maguire et al. 2004: p. 657; cf. Garud et al. 2007). The emphasis here lies on the actions of entrepreneurs, how they generate policy and institutional changes (such as in distribution of authority and information, norms and cognitive frameworks), and how they are influenced by context-dependent, dynamic interactions among interdependent structures, institutions and conditions (Bakir and Jarvis 2017; Boasson and Huitema 2017). For example, Huitema et al. (2011) identify set of strategies by which policy entrepreneurs affect water policy change, including idea development, coalition building, the detection and exploitation of windows of opportunity and network management. The authors also highlight how policy change is a political game, requiring for instance strategic issue framing and by-passing formal policy forums.

While a focus on how governance capacity is shaped by institutional and organisational forces helps to explain continuity and conformity, privileging agency emphasises how organisational processes and institutions themselves are shaped by creative entrepreneurial forces (cf. Garud et al. 2007). An agency-based perspective on governance capacity facilitates an understanding about who shapes governance priorities, why actors become active, which factors they consider when selecting strategies and how their activities relate to the emergence of governance innovations (Hodson et al. 2018; Koop et al. 2017; Rama et al. 2009). Along these lines, transforming urban (climate) governance ultimately depends on the ability of multiple actors to mobilise and remove existing and create new governance conditions, including formal and informal institutions, networks and knowledge, in order to establish alternative approaches to existing urban governance regimes (cf. Bettini 2013; Koop et al. 2017). A useful step forward has been to relate the institutional factors that enable effective climate action with drivers and motivations, including external shocks and endogenous drivers (e.g. actors' motivations) for innovations for climate change action (Castán Broto 2017). For example, Seto et al. (2016) illustrate how in Germany the feed-in law for renewable energy was created by political actors who responded to exogeneous shocks (e.g. Chernobyl). This helped to overcome institutional carbon lock-in: the created feed-in law incentivised investments in renewables, contributed to expanding markets, fostering learning networks and strengthening renewables lobby groups (ibid.).

- **Governance capacity is constantly mediated through the collective activities by which urban governance actors respond to, mobilise, create and change governance conditions.**

The combined view on governance conditions and governance agency engenders an understanding of governance capacity as "located in the collective practices through which governance relations are

played out and not only in the formal rules and allocation of competences for collective action as defined by governmental laws and procedures" (González and Healey 2005, p. 2059). While individual policy or institutional entrepreneurs contribute to governance change, they do so in collectives, and the ways in which they are able to affect change depends on the institutional settings they operate in (Huitema et al. 2011). Capacities for urban (climate) governance are thus constantly mediated through complex configurations of urban governance and institutions: this mediation is "a moving process of ideological framing, institutional restructuring, political struggle and social adaptation" (Peck 2016: p. 11; cf. Hodson et al. 2018) that becomes manifest in the formation of institutions to influence social behaviour and interaction.

In order to approach this interaction of governance conditions and agency to innovate and change these conditions, scholars concerned with governance capacity draw on institutionalist perspectives that probe the governance relations, including embedded cultural practices, routines and strategic interactions, leading to specific actions as well as the relations developing as a result of a specific action (González and Healey 2005). Along these lines, Giddens' (1984) structuration theory views actors as enabled and constrained in their actions by the structural frameworks in which they operate. However, actors are also able to adapt to and change their structural contexts, thus making structure both the medium and outcome of social practices (ibid.; Garud et al. 2007). The 'paradox of embedded agency' raises the question how actors can escape the structural contexts they are embedded in and create new visions and practices (DiMaggio and Powell 1983; Garud et al. 2007). This paradox is solved by viewing agency as being "distributed within the structures that actors themselves have created" (Garud et al. 2007: p. 961). Critical here is that agency presupposes an interactive response: it is "the temporally constructed engagement by actors of different structural environments — the temporal-relational contexts of action — which, through the interplay of habit, imagination, and judgment, both reproduces and transforms those structures in interactive response to the problems posed by changing historical situations" (Emirbayer and Miche 1998: p. 970). Governance capacity is thus the result of collective and reciprocal processes, through which multiple governance actors deliberate between contested solutions (rather than promoting individual actor interests) and navigate their structural contexts (Adger and Jordan 2009; Kooiman and Jentoft 2009; Huitema et al. 2011).

The focus on how governance capacity is constantly mediated makes is variable and contingent, and "inherently situated in a specific institutional space, with concrete manifestations of power and possibility, and with a particular pattern of 'moments' which could allow for transformational trajectories to get established" (González and Healey 2005: p. 2058). Governance capacity emerge through collaborative learning: "learning by individuals about which of their own actions is effective, by organizations about the results of their actions, and by the larger economic and political systems in which they are embedded about how to respond creatively and adapt in the face of change, crises and simply new information" (Innes and Booher 2003: p. 8). This perspective thus helps to explain the emergence and execution of governance capacity in terms of what governance conditions enable or hinder transformative climate governance and how actors, create, change or mobilise these conditions. For example, leadership from a Mayor or senior officials is a fundamental enabler of climate action, but how it must be complemented by legal and regulatory changes and institution building (Romero-Lankao et al. 2018b).

- **Governance capacity is normative because it is about structuring collective action that contributes to socially desirable and legitimate outcomes.**

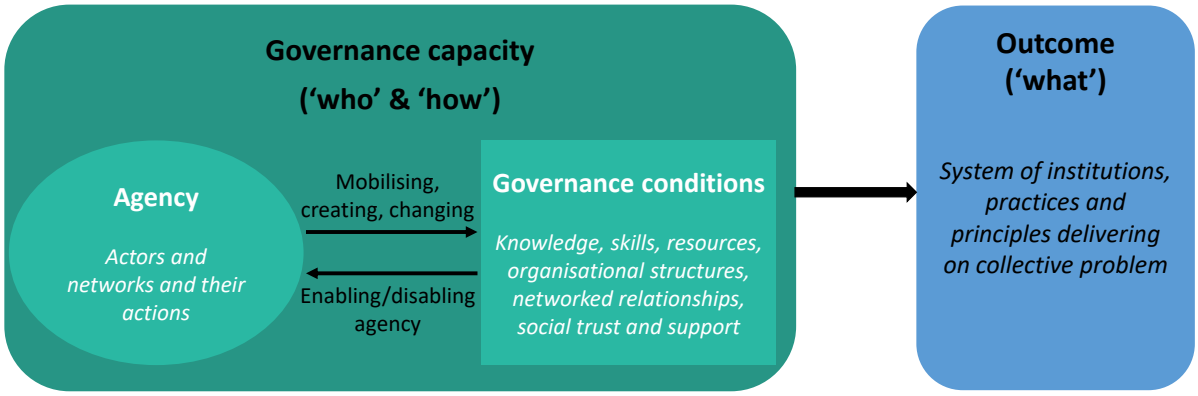
While governance capacity literature is primarily descriptive, it also harbours the potential for prescriptive and normative approaches (Innes and Booher 2003; González and Healey 2005; Koop et al. 2017). Crucially, governance capacity by itself does not lead to efficacious change – "it is a precondition or enabler for effective change" (Koop et al. 2017: p. 3439). Governance capacity and how it is changing needs to be evaluated based on whether it allows for generating socially desirable and legitimate outcomes and whether it is likely to spread and become institutionalised in a governance system (cf. González and Healey 2005).

Especially when seeking to strengthen governance capacity it is pivotal to understand what type of capacity is an effective means to achieve desired ends rather than solely looking at how governance capacity is emerging and changing. In urban transformation and climate governance research, scholars started to employ the capacity notion to identify conditions and agency attributes and strategies for responding to stresses and disturbances and for innovating system conditions. For example, Wolfram (2016, p. 126) defines urban transformative capacity as "the collective ability of the stakeholders involved in urban development to conceive of, prepare for, initiate and perform path-deviant change towards sustainability within and across multiple systems that constitute the cities they relate to". From this, he derives ten components related to governance, agency processes and relations, which are meant to facilitate insights into the strengths and weaknesses present in a given place to effectively achieve transformative change towards sustainability. Gupta et al. (2010) identify institutional characteristics that promote the adaptive capacity of society to climate change, focusing on conditions for redundancy, stability and flexibility such as learning, leadership and fair governance.

Embracing the normativity of governance capacity allows to identify which activities and conditions manifest in capacities for transformative climate governance. Many diverse types of conditions, actions and strategies will be needed to trigger transformative climate governance, including coordinated actions by local governments, innovation in the private sector, experimentation and pressure from civil society (Romero-Lankao et al. 2018b). The normative view also helps to raise political concerns about who takes up what roles in urban climate governance, with which agenda and what are implications for (changing) roles and relationships between actors (Hodson et al. 2018; Avelino and Wittmayer 2017; Hölscher et al. 2017). Positive views of the proliferation of actors in urban governance contrast with perspectives that "see this profusion of actors as the root cause of a dilution of responsibilities" (Castán Broto 2017: p. 9).

In summary, I employ the perspective on governance capacity as a simple conceptual frame that connects governance agency ('who'), interactions with governance conditions ('how') and governance outputs and outcomes ('what') (Figure 1.1). Accordingly, governance capacities are manifest in the collective abilities of actors to mobilise, create and change structural governance conditions, as well as the conditions that result from these activities and enable or disable collective action.

Figure 1.1: Governance capacities: connecting 'what' to 'how' and 'who'



The concept of governance capacity facilitates explanation and evaluation of how and whether and whose capacities for transformative climate governance are developing. In first instance, the concept provides a frame for conceptualisation transformative climate governance as a normative approach that builds on multiple capacities for delivering different governance functions for navigating urban transformations under climate change. Secondly, and consequentially from the first point, governance capacity helps to trace the activities by which actors create conditions for delivering these functions. This understanding makes use of governance capacity an "action-oriented and empowering concept", which helps "to identify requirements, design policies and devise purposive interventions" (Wolfram et al. 2017: p. 24): by connecting actor-level activities to how they contribute to building governance conditions for transformative climate governance it is possible to identify what opportunities were created and used, what challenges need to be accounted for, what are capacity gaps and how capacities can be strengthened.

1.3.2 Theoretical approaches to conceptualise capacities for transformative climate governance

In order to conceptualise and operationalise capacities for transformative urban climate governance I turn to transformation research literature that covers multiple research strands and approaches providing knowledge about what urban transformation governance could look like. In recent years, different types of work related to urban climate governance have converged within the loosely connected field of urban transformation research (Wolfram et al. 2017; Wolfram and Frantzeskaki 2016; Elmqvist et al. 2018). Urban transformation research has been driven by the recognition of the need for radical change towards sustainable and resilient urban systems (Wolfram and Frantzeskaki 2016). The diverse approaches enmeshed in the field start from the shared assumptions that urban systems are in permanent non-equilibrium state and that change in urban systems is complex, uncertain and contested (Wolfram et al. 2017; Pickett et al. 2014; Loorbach et al. 2015; Frantzeskaki et al. 2017). Highlighting the inherent tension between the self-organisation properties of complex urban systems and the idea of planning towards a desirable societal goal, transformative approaches to urban governance advocate a 'transformation of urban governance', which shifts away from steady-state approaches that control change towards creating the conditions for mobilising and responding to the driving forces and dynamics characterising transformations (cf. Patterson et al. 2016; Loorbach et al. 2015; Rink et al. 2018; WBGU 2016).

Two research approaches have come of age in informing conceptual approaches and empirical studies on (climate) governance in the context of urban transformations: sustainability transitions (Loorbach et al. 2017; Frantzeskaki et al. 2018) and resilience approaches (Olsson et al. 2014; Folke 2016; Meerow et al. 2016). Both approaches have developed from a general interest in understanding change in complex adaptive systems and have developed a distinct set of concepts, frameworks and models for deepening understanding about the role of agency and governance in supporting (or hindering) desirable transformative change (Loorbach et al. 2017; Olsson et al. 2014; Rauschmayer et al. 2015; Westley et al. 2013; Patterson et al. 2016). They offer complementary insights on urban transformations and transformative urban (climate) governance.

Sustainability transitions research views urban systems as deeply entrenched both within socio-historical processes of inter-urban space-making and within inter-spatial and cross-national dynamics (Coenen et al. 2012; Hodson and Marvin 2010; Jhagroe 2016). Urban transitions thus take place "within cross-scale spatial and institutional contexts that produce enabling and constraining effects for socio-technical transitions in terms of identity, legitimacy, actor coalitions and resources" (Wolfram and Frantzeskaki 2016: p. 144). Urban sustainability transitions' research focus on persistent institutional, technological and socio-cultural constraints underlying shifts towards more sustainable urban systems of service provision and lifestyles and thus the need for fundamental changes in the way such systems are organised and operate (e.g. physical and economic infrastructures, institutions, individual behaviours) (McCormick et al. 2013; Loorbach et al. 2015; Wolfram et al. 2017). It also addresses explicitly spatial and geographical questions of system innovation and transitions: for example, where do transitions take place, and why do transitions take place in one place and not in another (Raven et al. 2012; Coenen et al. 2012; Coenen and Truffer 2012; Jhagroe 2016; McCormick et al. 2013)? Urban ustainability transitions' studies also reveal how urban development is shaped by the political ecology of resource flows and the need to pay attention to existing power relations and vested interests (Monstadt 2009; Jhagroe 2016; Avelino 2011).

Urban sustainability transitions studies approach transformative urban (climate) governance by focusing on specific sub-sectors and transitions (e.g. low-carbon energy transitions, mobility transitions) (Wolfram and Frantzeskaki 2016; Gavin et al. 2013; Hodson and Marvin 2010). They particularly emphasise the need for urban governance innovation and new types of roles and strategies – towards more innovative and collaborative etc. approaches, which has led to studies about critical enablers and barriers of climate governance innovation (Burch et al. 2014), as well as how governance innovation helps to institutionalise new approaches for climate-sensitive management (Brown et al. 2013; Bettini et al. 2015). Shared interest in urban climate experimentation as a new governance mode has proven an especially fertile ground for cross-fertilisation between sustainability transitions and urban climate governance literatures, for example focusing on Urban Living Labs for co-creating and testing innovative and sustainable ways of doing, thinking and organising (Castán Broto and Bulkeley 2013; Nevens et al. 2013; von Wirth et al. 2019; Schäpke et al. 2018). Transition management, which has been developed as a practice-based and operational governance approach, identifies several tenets for transition governance, including long-term thinking, learning-by-doing and broad participation (Loorbach 2010; Frantzeskaki et al. 2012). Transition management has been adapted and applied to various urban contexts (Nevens et al. 2013; Loorbach et al. 2016; Frantzeskaki et al. 2018). This has shown that governance activities such as participatory foresight, visioning, experimentation and new forms of network-building support capacity building for transition governance processes in urban

contexts through generating shared visions, opportunities for learning and on-the-ground innovation (Loorbach et al. 2015; Hölscher 2018; Nevens et al. 2013; Brown et al. 2013). Recently, more attention has highlighted the role of intermediaries and meta-governors to coordinate urban climate governance across scales and sectors and network-building (Moloney and Horne 2015; Hodson and Marvin 2010; Frantzeskaki et al. 2014).

Urban resilience studies view cities as social-ecological systems, placing a strong emphasis on ecological system functions and services for enhancing the self-organising capacity of cities (Pickett et al. 2013; McPhearson et al. 2016; Wolfram and Frantzeskaki 2016). Resilience approaches root in ecology and stress the strong connection between humans and the environment in social-ecological systems and the collective capacities for enhancing the ability of such systems to respond to uncertainty and disturbance (Berkes and Folke 1998; Berkes et al. 2003; Folke 2016; Olsson et al. 2014). A recent thread puts forth transformability as the ability to innovate and build a new type of resilience "when ecological, economic, or social (including political) conditions make the existing system untenable" (Walker et al. 2004). Building on resilience theory, dynamics in and shaped by cities are coupled within social-ecological systems at the global scale, which produce emergent changes, disturbances, risks and thresholds (Anderies et al. 2014; Chelleri 2015). This has facilitated the identification of emergent vulnerabilities and dynamics of change (Wolfram and Frantzeskaki 2016).

Resilience approaches are especially visible in urban climate governance studies that focus on urban ecology (Pickett et al. 2014; McPhearson et al. 2014; Elmqvist et al. 2014) and climate adaptation (Meerow et al. 2016; Torabi et al. 2018; Chelleri et al. 2015). Implications for urban climate governance are drawn from the concept of resilience (Jabareen 2013; Desouza and Flanery 2013). Resilience refers to the characterisation of urban systems as being in permanent non-equilibrium state (see Box 1.3; Pickett et al. 2013; Meerow et al. 2016). Risk governance and climate adaptation interventions therefore need to address the short-term and long-term disturbances, risks and uncertainties implied in urban systems' change and enable both adaptability and transformability (McPhearson et al. 2014; Torabi et al. 2018; Chelleri et al. 2015). Adaptive governance describes and guides multi-actor processes for responding to change, disturbances and vulnerabilities (Berkes 2017; Koop et al. 2017).

Resilience approaches highlight the roles of governance institutions in facilitating self-organisation, learning and flexibility in the face of change and analyse the shift towards adaptive water management approaches through processes of learning, multi-level interactions and institutional change (Pahl-Wostl 2009; Bettini et al. 2015; Rijke et al. 2013). Resilience scholars also analyse the polycentricity of urban climate governance as a result of the nestedness of urban social-ecological systems (Anderies et al. 2014). Effective polycentricity requires both coordination, alignment and steering to achieve joint objectives across multiple governance networks and decentral and independent management at local levels (Pahl-Wostl and Knieper 2014; Anderies et al. 2014; Galaz et al. 2011). Similar to sustainability transitions research, resilience studies discuss the role of leadership, social learning and experimentation in building, maintaining and renewing resilience (Boyd and Gosh 2013; Ernstson et al. 2010; Childers et al. 2015). Another critical theme emerging in urban resilience studies are related to questions of social and environmental justice, which draws attention to community processes and participatory governance (Matyas and Pelling 2014; Bahadur and Tanner 2014).

Sustainability transitions and resilience approaches bring new insights to the challenge of reconfiguring urban (climate) governance through new forms of governance. They recognise that urban transformations can due to their inherent complexities not be predicted and managed in a traditional way; 'governance for transformation' requires long-term approaches that give special attention to learning, participation, knowledge co-production, long-term thinking, experimentation and flexibility (Wolfram et al. 2017; Loorbach et al. 2015; Wittmayer et al. 2018). Due to their different entry points and research foci, sustainability transitions and resilience approaches provide complementary perspectives on conceptualising and supporting capacities for transformative urban climate governance. So far, however, debates about complementarities and cross-pollinations are limited to few scholars (Wolfram and Frantzeskaki 2016; Chelleri et al. 2015; Olazabal 2015).

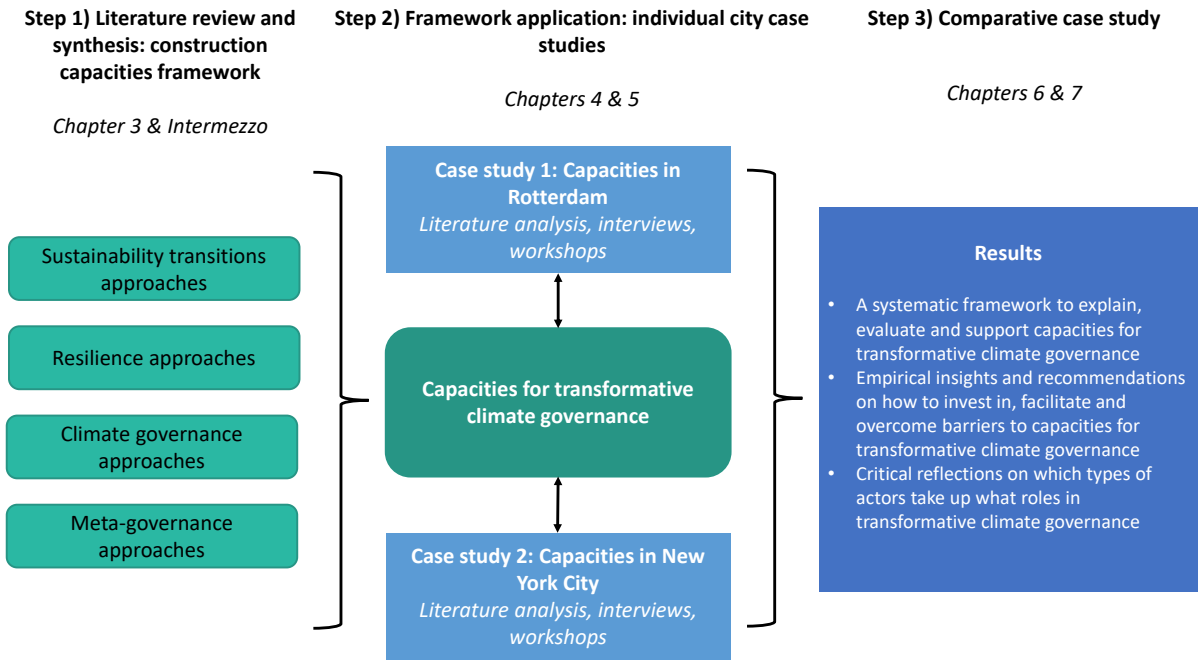
1.4 Research objective: explaining, evaluating and supporting capacities for transformative climate governance

The main aim driving this thesis is to explain the development of urban climate governance and to assess whether it indeed manifests in capacities for transformative climate governance. This involves understanding how and by whom urban climate governance is enacted, identifying the new governance conditions that emerge as a result of these activities, and evaluating whether these contribute to urban sustainability and resilience transformations. This research thus contributes to an agency-based understanding of whether and how transformative climate governance is developed vis-à-vis existing urban governance regimes, and enables the formulation of recommendations for strengthening the capacities. In particular, the results of this thesis contribute practical insights into which kinds of governance conditions facilitate transformative climate governance in cities, as well as by which activities, and by whom, they are created and strengthened.

I address this research aim by (a) developing a conceptual framework that identifies and operationalises capacities for transformative climate governance, and (b) conducting a comparative qualitative case study on capacities for transformative climate governance in Rotterdam, the Netherlands, and NYC, USA (Figure 1.2). The theoretical framework brings together different research strands concerned with climate governance and urban transformations – in particular sustainability transitions and resilience approaches – to conceptualise the capacities for transformative climate governance. The framework thus provides a systematic analytical tool to deconstruct how actors' activities create new types of governance conditions and to evaluate whether these conditions and activities contribute to transformative climate governance. The framework is applied to explain how and what types of capacities in Rotterdam and NYC are emerging. This involves identifying the actors and activities involved in urban climate governance and the conditions that emerge as a result in both cities. Rotterdam and NYC are examples of cities providing global leadership and setting a standard for climate change adaptation and mitigation with ambitious and cross-cutting climate, sustainability and resilience goals and agendas and a portfolio of innovative and systemic solutions for climate mitigation and adaptation (Solecki et al. 2016; Forgione et al. 2016; McPhearson et al. 2014; McPhearson and Wijsman 2017; Ernst et al. 2016; Frantzeskaki and Tillie 2014; Hölscher et al. 2018b; c; Depietri and McPhearson 2018). The comparative case study of capacities for transformative climate

governance in Rotterdam and NYC illustrates the utility of the framework for understanding how urban climate governance activities spur new types of capacities and enables drawing lessons on the how urban (climate) governance is transforming.

Figure 1.2: Research framework



In line with the above-identified research gap and the aim of this thesis, my main research question is as follows:

> ***What governance capacities are developing as a result of urban climate governance activities? To which extend and how do these capacities enable transformative climate governance in cities?***

This central question can be further specified in a number of sub-questions:

1. How can capacities for transformative climate governance be conceptualised, explained and evaluated?
2. What actors, activities and structural conditions manifest in capacities for transformative climate governance?
3. What are capacity gaps, barriers and opportunities for transformative climate governance in cities?

The contribution of this thesis is both theoretical and empirical. The main results of this thesis are:

I. A systematic agency-oriented framework to explain, evaluate and support capacities for transformative climate governance.
II. Empirical insights and pragmatic knowledge on how to invest in, facilitate and overcome barriers to capacities for transformative climate governance.
III. Critical reflections on which types of actors take up what roles in transformative climate governance and how capacities for transformative climate governance can be supported.

1.5 Thesis structure

This is a thesis-by-publication, i.e. it has been mainly written in scientific papers. Table 1.4 provides an overview of the paper publications.

This introductory chapter has provided the framing of the study within the real-world problem of urban climate governance and the challenge to move towards transformative climate governance in cities. Chapter 2 presents the methodological approach to the comparative case study of transformative climate governance capacities in Rotterdam and New York City. Chapter 3 includes the synthesis of sustainability transitions and resilience approaches to inform transformative climate governance. This is followed by an Intermezzo that presents the full-fledged – and final – framework of capacities for transformative climate governance. Chapters 4 and 5 present the illustration of the applicability of the framework by individual case studies of capacities for transformative climate governance in Rotterdam and NYC. The Rotterdam case study positions the framework in the context of climate governance under high-end scenarios (i.e. climate change beyond 2°C), while the NYC case study presents the framework within literature on urban transformation governance. Chapter 6 encompasses the comparative analysis of what type and how capacities for transformative climate governance emerge in Rotterdam and NYC as examples of two pioneering cities. Chapter 7 concludes the thesis by synthesising the insights, responding to the research questions and reflecting on the contributions and implications of the research.

A thesis-by-publication entails overlap between individual chapters that have been submitted as separate papers – for example, the capacities framework is presented in multiple chapters and therein is positioned in different research strands. In addition, due to the iterative nature of this research, the capacities framework has changed throughout the thesis writing process. Therefore, I have included the Intermezzo to present the final version of the framework to explain and evaluate capacities for transformative climate governance in cities.

Table 1.4: Overview of papers compiled in this thesis

Chapter	Paper titles, authors and journals
Chapter 3	**The 'how' and 'who': a transformative structuration perspective on transforming climate governance** *Katharina Hölscher, Niki Frantzeskaki, Derk Loorbach* *Journal: submitted to Climatic Change*
Chapter 4	**Steering transformations under climate change: capacities for transformative climate governance and the case of Rotterdam, the Netherlands** *Katharina Hölscher, Niki Frantzeskaki, Derk Loorbach* *Journal: published in Regional Environmental Change*
Chapter 5	**Capacities for urban transformations governance and the case of New York City** *Katharina Hölscher, Niki Frantzeskaki, Timon McPhearson, Derk Loorbach* *Journal: published in Cities*
Chapter 6	**Tales of transforming cities: Transformative climate governance capacities in New York City, U.S. and Rotterdam, Netherlands** *Katharina Hölscher, Niki Frantzeskaki, Timon McPhearson, Derk Loorbach* *Journal: published in Journal of Environmental Management*

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Chapter 2

Research design and methodology

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Lincoln and Guba (1985a) fittingly view all social research as by nature emergent, with research outcomes originating through iterative processes of negotiation and interpretation of meaning. This of course does not pre-empt the need for a clear research plan, which ensures research is conducted in accordance with the stated intent. This chapter concretises my research design and methodology to answer my research questions.

My research focus and approach have been informed by various choices and inspirations. In particular, I position myself within transformation research as a research perspective to study and support societal transformations towards sustainability and resilience (Wittmayer and Hölscher 2017; Hölscher et al. 2018a; Loorbach et al. 2017; Patterson et al. 2016). This has implications on my interpretative framework and the 'quality criteria' I set for myself as a researcher.

After introducing the transformation research perspective (Section 2.1), I present how it has informed my research logic (Section 2.2) and research strategy (Section 2.3). Finally, I detail the qualitative comparative case study approach I used in this thesis, including the methods employed for case selection, data collection and data analysis (Section 2.4).

2.1 Embedding this thesis in transformation research[7]

This section introduces transformation research as a research perspective within which this thesis is positioned. This perspective has guided the learning processes resulting in this thesis and influenced my self-positioning as a transformation researcher.

The burgeoning scientific and political consensus that business-as-usual is insufficient for keeping humanity within a safe operating space has nourished 'transformation research' as a lens to study and scientifically support transformations towards sustainability and resilience (Wittmayer and Hölscher 2017; WBGU 2011; Future Earth 2014; Patterson et al. 2016). Because of the multiplicity of research foci, approaches and methods converging in transformation research, a colleague and I have dubbed it a "joint research perspective to study complex and pervasive societal problems and to search and support long-term and fundamental societal change processes and dynamics towards sustainability" (Wittmayer and Hölscher 2017: p. 13). As such, it brings together insights, frameworks and approaches from a diversity of research strands that share a common interest in radical societal change. Recently,

[7] This section is in particular informed by the report a colleague and I wrote on transformation research for the German Environment Agency (Wittmayer and Hölscher 2017).

also an explicitly urban focus appeared within transformation research, considered as urban transformation research (Wolfram et al. 2017; Wolfram and Frantzeskaki 2016; Elmqvist et al. 2018a). Also (urban) climate governance research has started to draw on perspectives, concepts and insights from transformation research, while climate governance has simultaneously been a topic within transformation research (Gillard et al. 2016; Kivimaa et al. 2017; Patterson et al. 2016).

2.1.1 Introducing the transformation research perspective

Perspectives on and applications of transformation research have sprouted across various research fields concerned with sustainable societal change. Definitions as well as overviews of research foci and methods of transformation research are still in their early stages (Wittmayer and Hölscher 2017). At the most basic level, the concept of 'transformation' (and 'transition') still requires more decisive definitions. While transformation, as a kind of change, is generally conceived of as radical and systemic, the implications of this remain ambiguous (Duncan et al. 2018). The conceptual ambiguity and openness of transformation bears the risk of making transformation a buzzword to put forth actions and policies that actually perpetuate the status quo rather than acting as a metaphorical vehicle for condensing discourses and actions towards desirable and radical change (Brand 2016).

It is difficult to precisely grasp transformation research because it joins many societal issues (e.g. economy, health, equity, mobility, energy, climate change) as well as a variety of research strands, including their concepts, frameworks and methods, that are (at least partially) concerned with radical societal change (Markard et al. 2012; Loorbach et al. 2017; Patterson et al. 2016; Köhler et al. 2019). Transformations are conceived as highly complex, uncertain, context-dependent, multi-layered and contested, and there are no straightforward approaches or solutions for navigating transformations towards desirable directions (Loorbach et al. 2017; Hölscher et al. 2018a).

Transformation research requires new types of research that have an integrative nature, both in terms of addressing problems and issues from systemic perspectives and in terms of involving various disciplines (interdisciplinarity) and societal actors (transdisciplinarity) (Wiek et al. 2012; Wittmayer and Hölscher 2017). Starting from a complex and uncertain reality, in which we cannot afford to "choose sides between positivist approaches and interpretative approaches to science" (Wittmayer 2016: p. 57), transformation research is interparadigmatic: It combines different research paradigms, including positivistic and interpretative ones (Avelino 2011; Wittmayer 2016). Nonetheless, there is a more or less implicit recognition of the need to accept uncertainty and complexity and that knowledge will always remain incomplete (Avelino 2011).

Transformation research is normatively oriented towards societal problems by studying and actively supporting societal transformations towards some sustainable direction (Wittmayer and Hölscher 2017; Loorbach et al. 2017; van der Hel 2018). Sustainability here refers to a generic vision about how everyone can live happily, safely and in accordance with environmental protection – such a vision has to be co-created and shared (Wittmayer et al. 2015; Hölscher et al. 2017a). Transformation research is ascribed a central role in structuring and facilitating societal learning processes for co-creating and achieving sustainability visions (Haum and Pilardeaux 2014; WBGU 2011). Accordingly, scientists are not only responsible in "the scientific arena where they belong", but they are "active in other arenas as well, which makes them responsible and accountable for other activities, such as their role in societal

change processes" (Rotmans 2005: p. 20; cf. Avelino 2011). This is why transformation research encompasses both a descriptive-analytical approach to increase our understanding of transformations and generate mostly scientific knowledge as well as a transformative approach to actively support sustainability transformations and generate actionable knowledge (Wittmayer and Hölscher 2017; WBGU 2011; Wiek et al. 2012).

The normative orientation has implications on what might be termed 'quality criteria' to judge the merit of transformation research (Wittmayer 2016). Rather than being outside of society, researchers should ask themselves about their roles in the system, how they affect the system and how they can improve their contribution to societal transformation (Avelino 2011). As such, quality criteria need to encompass the societal impact of the research in addition to the research process and methods (Wittmayer and Hölscher 2016; 2017; Wiek et al. 2012). These implications of transformation research – in terms of normativity, societal impact and multiple research approaches – also draw attention to the playing field of the 'politics of science'. Taking transformations research seriously requires a reform of the science system itself in terms of curriculum development (e.g. integrating sustainability and systems thinking, interdisciplinarity, transdisciplinarity), research funding (e.g. action research) and quality criteria (e.g. shifting from quantitative measurements of publications to measuring societal impact) (Wittmayer and Hölscher 2017; Schneidewind 2015).

2.1.2 Transformation research approaches

Transformation research serves as a "catchment basin and integrator of diverse angles on societal change towards sustainability" (Wittmayer and Hölscher 2017: p. 14). It does so by converging around questions of societal transformations, including questions about the objects of change (i.e. *what* changes over the course of a transformation), the change dynamics of transformation processes and emerging transformation pathways (i.e. *how* do transformation processes occur), and the drivers of transformation processes – particular towards sustainability (i.e. *by whom/how* are transformation processes supported) (ibid.). This differentiation serves to structure the theoretical approaches and conceptual frameworks and models developed and applied in transformation research. It therefore aids in the careful translation between different research approaches to remain attentive to the approaches' different ontologies and epistemologies and to not inadvertently compromise fundamental assumptions (Redman 2014; Olsson et al. 2014).

The theoretical work of this thesis is inspired by and builds upon two research approaches that have come of age in studying and theorising how governance and agency can support and deal with transformative societal change: sustainability transitions and resilience approaches (Hölscher et al. 2018a; Loorbach et al. 2017; Olsson et al. 2014; Folke 2016). Both approaches provide rich theoretical models, frameworks and concepts that explicitly address societal transformation. Sustainability transitions and resilience approaches have developed with the recognition of continuous societal changes and the need to navigate these towards desirable directions. Both draw on a synthesis of broad theories of change in complex adaptive systems that describe rhythms of stability, collapse and renewal following complex interactions and feedbacks producing systemic uncertainties, persistence, thresholds and surprise (Olsson et al. 2014; Smith and Stirling 2010). They also share an interest in deepening understanding about the role of agency and governance in supporting (or hindering)

desirable transformative change (Loorbach et al. 2017; Rauschmayer et al. 2015; Chaffin et al. 2016 Westley et al. 2013).

Due to the different entry points of transitions and resilience approaches they offer complementary insights for agency and governance (Table 2.1; Chaffin et al. 2016; Patterson et al. 2016). Over the past years, both approaches have moved closer together through their shared interest in studying and supporting transformative change towards sustainability and resilience. There have been constructive debates between both approaches to explore whether and how their system ontologies, concepts and frameworks can enrich each other's explanations of and governance propositions for navigating desirable system change (Olsson et al. 2014; Smith and Stirling 2010; Pereira et al. 2015). For example, Foxon et al. (2009) and van der Brugge and van Raak (2007) explore how transition management can support shifts to adaptive governance. Other researchers show how adaptive capacity for resilience differs from, and in parts contradicts, transformative capacity, which becomes necessary to build new resilience to extreme environmental degradation (Marshall et al. 2012; Wilson et al. 2013).

Table 2.1: Overview of sustainability transitions and resilience approaches (partially based on Wittmayer and Hölscher 2017; Hölscher et al. 2018a)

	Sustainability transitions research	Resilience research
Origins and context	Sustainability transition research developed in the late 1990s in the Netherlands to support the development of new national framework for environmental policy (Grin et al. 2010; Loorbach et al. 2017; Markard et al. 2012).	Resilience approaches root in ecology and stress the connections between humans and the environment in social-ecological systems (Holling 1986; Folke 2016).
Goals	The starting point is the recognition of social, technological and institutional path-dependencies and lock-ins that create persistent sustainability problems (Rotmans et al. 2001). Goals are to describe and anlyse historical and contemporary (sustainability) transitions in societal (sub-)systems (e.g. economic sectors like energy and mobility, cities) and exploring possibilities for influencing the speed and direction of change in these systems (Loorbach et al. 2017).	A central premise is that human need to proactively and flexibly respond to continuous changes to avoid crossing thresholds detrimental to wellbeing (Walker et al. 2004; Folke et al. 2010). Goals are to describe, analyse and support social-ecological systems to avoid and deal with tipping points and navigate desirable transformations by building adaptive capacity and resilience (Folke 2016; Walker et al. 2004; Olsson et al. 2014).
Objects of change ('What changes over the course of a transformation?')	Sustainability transitions are defined as radical non-linear changes in the structures (e.g. market structures, infrastructures, institutions), cultures (e.g. values, expectations) and practices (e.g. production routines, individual behaviour) of a societal (sub-)system that shifts the system from its current unsustainable state towards a sustainable one (Rotmans and Loorbach 2010; Loorbach et al. 2015).	Resilience approaches focus on social-ecological systems and highlight how human societies (including economic, political, institutional and cultural dimensions) are embedded and interact with environmental resources and ecosystems (Berkes 2017; Anderies et al. 2004).
Change dynamics (How do	Frameworks and models characterise transitions as multi-phase, multi-level, multi-actor and multi-pattern processes and identify	Frameworks and heuristics serve to understand risks and vulnerabilities that emerge from change dynamics and social and ecological

	Sustainability transitions research	Resilience research
transformations occur?)	key driving forces and supporting and hindering activities from diverse actors (Rotmans and Loorbach 2010; de Haan and Rotmans 2011; Geels and Schot 2007). The multi-level perspective (MLP) helps analysing how regime build-up and break-down co-evolve from three main driving forces at landscape, regime and niche levels (Geels and Schot 2007; Loorbach 2014). The multiphase model depicts how innovative niches grow and become valid alternatives until a new regime is established (Rotmans and Loorbach 2010).	abilities to respond to disturbances (Chaffin et al. 2016; Folke 2016). The adaptive cycle chronicles four phases during which a system moves between long periods of optimisation in the 'front loop' and short periods of crisis and lock-in leading to reorganisation and renewal in the 'back loop' (Holling and Gunderson 2002). Adaptive cycles are nested in a panarchy across time and space (Holling et al. 2002).
Drivers of transformations (By whom/how are transformations supported?)	Focus on innovation processes including visioning, experimentation and coalition building, as well as the destabilisation of existing regimes to facilitate radical change (Loorbach et al. 2017; Kivimaa and Kern 2016). Governance approaches like transition management and strategic niche management provide analytical and operational tools to understand and develop niches, actors or transformative innovations at a relatively small scale (Loorbach et al. 2015; Frantzeskaki et al. 2018; Raven et al. 2010).	Adaptive capacity and resilience are concepts to describe, assess and strengthen the collective capacities (of e.g. individuals, communities, regions) in social-ecological systems to preserve a desirable state in the face of continuous change and uncertainty (Berkes et al. 2003; Folke 2016; Folke et al. 2005). Adaptive governance/(co-)management describe and guide multi-actor processes for responding to change, disturbances and vulnerabilities (Berkes 2017; Chaffin et al. 2014; Plummer 2013; Folke et al. 2005; Chapin et al. 2010).

This thesis advances the dialogue between sustainability transitions and resilience approaches – in particular regarding the question of how to position climate change and climate governance in the context of transformation. Both approaches are also applied to studying urban transformations and (urban) climate governance (see Chapter 1, Section 1.3.2; Gillard et al. 2016; Wolfram et al. 2017; McCormick et al. 2013).

2.1.3 My experiences with transformation research

My work at the Dutch Research Institute for Transitions (DRIFT), a research institute at the Erasmus University Rotterdam in the Netherlands, has greatly influenced the way I define myself as a transformation researcher. In the first instance, my institutional embedding at DRIFT has challenged me on whether I should not better call myself a 'transition' researcher rather than 'transformation' researcher. Some colleagues employ the term 'sustainability transition research' more or less synonymously to 'transformation research' (Loorbach et al. 2017). However, as a result of how I have come to know the sustainability transitions research and related fields (e.g. resilience, sustainability science, climate governance), I find transformation is more widely employed in relation to resilience and climate change studies – and I consider myself part of all these fields (Hölscher et al. 2018a; Wolfram et al. 2017).

What is more important for my self-positioning and learning process than this mild identity crisis is that DRIFT is still one of the few institutes that explicitly and solely addresses questions of radical societal change and that quite literally 'lives' these questions in research practices. Through the multiple ways of exchange, including informal talks and more formal sessions and research exchanges at DRIFT, I was incessantly inspired and had access to a large pool of knowledge. During the research for this thesis I have worked in diverse research projects, which allowed me to increase my knowledge and experience with theories and practices of transformation research. This knowledge and experience have entered this thesis – even if not explicitly being part of it.

In particular, my research was embedded within the European Union FP7 project IMPRESSIONS (Impacts and Risks from High-end Scenarios: Strategies for Innovative Solutions, www.Impressions-project.eu). In IMPRESSIONS we have developed socio-economic and climate scenarios for climate change beyond 2°C as well as visions and transformation pathways to respond to these scenarios and shift to a sustainable and resilient Europe (Tàbara et al. 2018; Hölscher et al. 2017c; Kok and Pedde 2016; Frantzeskaki et al. 2019). My involvement in this project has influenced this research in many ways, including my view on re-framing climate change as a symptom and an amplifier of existing unsustainability and the conceptualisation of transformative climate governance. It has enriched my knowledge on urban climate governance with global, European, national and multi-level climate governance perspectives. I was also able to apply and test my framework of capacities for transformative climate governance to different research questions – to understand agency-based and institutional opportunities and constraints in the socio-economic scenarios as well as in the pathways to derive recommendations for decision-making (Hölscher et al. 2017c; Pedde et al. 2019). To some extent this also came along with another identity crisis: working at the boundaries of many fields, including sustainability transitions, resilience and climate change I often had to remind myself (or be reminded) that I take an explicit transformation perspective, which also includes being critical about how for example climate change scholars adopt concepts and frameworks related to transformation.

Other projects have allowed me to further refine and advance the conceptual framework that I have developed in this thesis. For example, parts of the framework were applied to nine case studies of coupled infrastructure innovations to identify the actors and activities driving innovation processes (Hölscher and Wittmayer 2018; Hölscher et al. forthcoming). I also used the framework to analyse in retrospect whether and how transition management supports the development of new kind of governance capacities (Hölscher 2018; Hölscher et al. 2017b).

2.2 Research logic

This section introduces the logic behind this research, establishing the "logical sequence that connects the empirical data to a study's initial research questions and, ultimately, to its conclusions" (Yin 2009: p. 26, cf. Bettini 2013). The research paradigm determines every choice in the research process, including methodological choices and interpretations, paradigmatic choices (logic of inquiry to answer my research questions), the use of theory and the position and quality criteria adopted towards the researched (Blaikie 2007; Guba and Lincoln 1994; Denzin and Lincoln 2000).

The embedding of this thesis within transformation research influenced how I formulated the research problem and my research question as well as how I sought to address them. Firstly, the transformation research perspective has prompted me to critically address the question of urban climate governance in light of how and whether urban climate governance contributes to sustainability and resilience transformations. This suggests taking complexity and uncertainty seriously – not only in terms of my theoretical and empirical questions but also in terms of the assumptions underlying my research paradigm and resulting implications for quality criteria. Transformation research generally subscribes to the complexity paradigm, which views society as consisting of various complex adaptive systems (Avelino 2011; Loorbach 2017). Accordingly, issues such as 'transformation', 'climate change', 'sustainability', 'cities' and 'governance' can due to complexity, uncertainty and subjectivity hardly be fully understood and definitely not known from the outside but require in-depth description and contextualisation of local experiences (Jhagroe 2016; Loorbach 2007; Coenen and Truffer 2012).

Secondly, the explicitly normative orientation of transformation research is perhaps the most important implication for how I define my identity as a transformation researcher embedded in society. I embrace the normative orientation of transformation research: In my view, in a world in which society seems to be lost with regard to the fundamental values about how to structure the co-existence between people and between people and nature it is pivotal to always make normative questions explicit. I therefore consider the outspoken normativity a strength of transformation research, because it allows making assumptions, values and interests explicit. Critiques on transformation research rightfully highlight the risk of a dedifferentiation between society and research and of entering de-politicised 'solutionism', which evaluates research based on utility for a normative goal rather than scientifically sound principle and which hollows out democratic decision-making (Stock 2014; Strohschneider 2014). I contend that these risks are challenges that transformation research needs to address consciously and decisively – just like any other research endeavour (Grunwald 2015; Rohe 2015). In this regard, Grunwald (2015) argues convincingly that research is always influenced externally by political and economic forces – also so-called non-normative technological research on for example smart phones, genetic engineering or infrastructure provisioning. Rather than predefining solutions this opens up space for societal discussions about where we want to go collectively as a society. Transformation research can thus act as mediator of knowledge in a societal searching and learning process (Wittmayer 2016).

2.2.1 Research paradigm

Thomas Kuhn (1962) coined the contemporary meaning of research paradigm when he adopted the term to characterise any philosophical way of thinking that defines problems and solutions for a scientific discipline at any particular period of time. As a philosophical way of thinking, a research paradigm reflects the researcher's worldview – i.e. the abstract beliefs and principles that shape how a researcher sees, interprets and acts within the world (Lather 1986; Guba and Lincoln 1994). A research paradigm makes explicit the basic beliefs about the form and nature of reality (ontology), the creation of knowledge (epistemology) and how valid and legitimate knowledge can be acquired (axiology) (Denzin and Lincoln 2000; Lincoln and Guba 1985a).

I take up a critical realist research paradigm in this research. Realism has generally been defined by Phillips (1987: p. 205) as "the view that entities exist independently of being perceived, or

independently of our theories about them". However, despite this idea about a single external reality, critical realists acknowledge that all theories about the world are grounded in individual perspectives and worldviews, and that all knowledge about reality is partial, incomplete and fallible. This makes it impossible to obtain objective or certain knowledge of the world, and requires accepting the possibility of alternative and equally valid accounts of any phenomenon (Lakoff 1987; Bhaskar 2008). This contrasts with a positivist paradigm that views reality as independent of the observer: according to the critical realist perspective all reality is perception and generalisations are impossible because individual views of the world "create a world of multiple constructed realities" (Sobh and Perry 2006: p. 1195; Lakoff 1987). It also contrasts with an interpretive or constructivist paradigm, which neglects the existence of an objective reality (Denzin and Lincoln 2008; Guba and Lincoln 1989). Critical realists do not subscribe to the constructivist concern that invoking the term 'reality' implies that there is only one ultimately correct description of reality and that research thus proclaims such a description is possible. Rather, they emphasise that

> "our words and life are constrained by a reality not of our own invention [which] plays a deep role in our lives and is to be respected. The source of puzzlement lies in the common philosophical error of supposing that the term 'reality' must refer to a single superthing instead of looking at the ways in which we endlessly renegotiate – and are *forced* to renegotiate – our notion of reality as our language and our life develop" (Putnam 1999: p. 9; cf. Maxwell 2012).

The critical realist paradigm is appropriate for my research, because it enables me to design research to build knowledge about (elements, perceptions of) the external reality of urban climate governance in cities by collecting and analysing observed experiences of societal actors about the nature of some of this reality's underlying structures and mechanisms through theory (cf. Bettini 2013). In other words, this paradigm enables combining theory with empirical observations without pretending to find the ultimate truth. Theory in the critical realist perspective helps referring to "real features in the world. 'Reality' here refers to whatever it is in the universe (i.e. forces, structures, and so on) that causes the phenomena we perceive with our senses" (Schwandt 1997: p. 133). The aim of the critical realism paradigm is to show how the empirical findings of a research project nestle within theories about the underlying social structures and mechanisms that produce both observed experience and unobserved phenomena and, in this way, try to generate a more complete picture of reality (Yin 2009; Blaikie 2007). This helps making sense of the common reality of a system in which many people operate interdependently, yet critical theorists maintain that our knowledge of the real world is inevitably a construction from our perspectives and standpoints and thus interpretative and provisional (Sobh and Perry 2006; Bhaskar 2008; Guba and Lincoln 1994).

While positivism is often found to only provide incomplete accounts of social phenomena, constructivism makes it difficult to compare multiple constructed realities (Sobh and Perry 2006). Regarding the latter, governance can be viewed as ultimately aiming to manage many constructed realities. Research to understand urban climate governance therefore can be viewed "like a court room trial where evidence is sought about the external reality of 'guilty or not guilty' that exists independently of what did or did not drive a person to commit the crime, even though that external reality can only be known imperfectly" (ibid.: p. 1199).

The critical realist paradigm is congruent with the complexity paradigm that underlies transformation research (Avelino 2011; Loorbach 2017). The complex adaptive systems perspective is the basic starting

point for comprehending the characteristics of societal complexity, "such as heterogeneous agents and artifacts, dualism and structures, emergence, surprise and uncertainty" (Loorbach 2007: p. 64). Cities, in this perspective can be perceived of as contingent categories, or assemblages, i.e. a constellation of "socio-material processes imbued with uneven developmental directions and velocities" (Jhagroe 2016: p. 69), rather than geographical entities (see also Box 1.1 in Chapter 1). This understanding of cities implies that attention needs to be paid to the processes taking place within networked and nested hierarchies, which produce constant change. Urban climate governance, then, is referring to the complex set of actors and networked interactions that, while individual and collective actors may have divergent perceptions of the reality of urban assemblages, seek common ways to intervene in that reality. The interactions take place within existing structures (e.g. organisational settings, rules, regulations) and broader socio-economic and political contexts (e.g. available resources, discourses) that unfold within urban assemblages (cf. Hodson et al. 2018; Koop et al. 2017). These conditions are 'real' in the sense that they enable and constrain actors, but the ways they (are perceived to) enable and constrain can again differ across different actors.

Following from this view, the epistemological standpoint of this research is that understanding reality relies on capturing and understanding the perspectives and meaning of the social actors who experience it. This is in line with the interpretive-constructivist epistemology, according to which knowledge is always situated, local and contextual, and social reality depends on how one interprets that reality (Schwartz-Shea and Yanow 2012). The central research challenge in this thesis is to approach the notion of urban climate governance in terms of *capacity*, i.e. the collective ability of actors to intervene in, mobilise and change their structural contexts in relation to what they think ought to be (cf. Avelino 2011). As this involves understanding about how and by whom urban climate governance is enacted and evaluating whether new structural conditions emerge as a result of these activities, my epistemology is agency-based: I use actors' activities as the main epistemological device to approach the constructed reality of urban climate governance practitioners and how their meanings combine to describe, explain and evaluate the empirical domain of urban climate governance. Drawing on the work done by Bettini (2013: p. 37), who pursued a similar line of research on the structuration of urban water governance, my study is based on the premise that "compiling social actors perspectives will provide a more comprehendible (though not comprehensive) idea" of how urban climate governance is accomplished through the activities of actors and their interactions with their structural contexts.

The recognition in critical realism that while reality is 'real' it can only imperfectly and probabilistically apprehended (Sobh and Perry 2006) has implications on the axiology of this research. On the one hand, the critical realist ontology tends towards the belief also underlying transformation research that "greater insight into the dynamics of a complex adaptive system leads to improved insight into the feasibility of directing it" (Rotmans 2005: p. 34). On the other hand, critical realism holds that theories, concepts and perceptions held by the people we study as well as by researchers themselves are part of the world that is sought to understand (Maxwell 2012). In this regard, the constructivist epistemology problematises science and knowledge generation as neutral and objective practices that take place outside of societal learning processes and transformations (Jhagroe 2016; Wittmayer and Schäpke 2014). Therefore, researchers need to be critical and reflexive of how their understanding of complexity "affects and should affect our ideological basis for governance" (Strand 2002: p. 164; cf. Avelino 2011).

Resulting from this research paradigm my study has several limitations. Given its broad conceptual scope, urban climate governance capacities can hardly be assessed for urban areas as a whole, which in fact are complex systems of systems (cf. Wolfram et al. 2016). In addition, capacity is not an absolute, but a relative quality, and it is difficult to explain and evaluate where governance capacity might stem from because it is a continually evolving social dynamic, developing through innovation and struggle in all kinds of institutional sites and encompassing a range of levels of power and consciousness (Innes and Booher 2003; González and Healey 2005). Finally, capacity is context-dependent: an action which may promote capacity in one context may produce a different outcome in another. Consequently, there are serious limitations in the use of 'best practice' models for strengthening governance capacity, as these are never fully transferable (ibid.).

2.2.2 Logic of inquiry

This research follows abductive and retroductive research logics as described by Bettini (2013). Similar to her research, my research question is hardly explored, seeks to devise a (new) model of the 'reality' of urban climate governance (in a specific city) in terms of structural governance conditions and agency, and the formation of knowledge in my research relies on accessing the tacit knowledge of actors. Accordingly, the use of theory in this study contrasts both with traditions of theory building (inductive reasoning) and theory testing (deductive reasoning) that represent more linear research processes (De Vaus 2001; Blaikie 2007; cf. Bettini 2013).

Bettini (2013) follows Layder's (1998) idea of adaptive theory, "in that prior theoretical inroads are used to organise empirical data, while simultaneously adjusting these theories to reflect the patterns emerging from the data" (Bettini 2013: p. 39). This combination of retroductive and abductive research logics allows the empirical testing and refinement of existing theories and concepts (Bettini 2013).

By 'retroductive' I mean that I develop, make use of and extend a conceptual framework of capacities for transformative urban climate governance. Retroductive logic enables matching prior theory with empirical data as a way to manage multiple perspectives and devise a model of the 'real' domain of urban climate governance (Bettini 2013). In contrast to deductive logic, the initial model of reality that is developed based on theoretical sources does not intend to provide definite causal mechanisms and test theories but rather serves to reveal the structures and mechanisms and thus to *explain* reality (Blaikie 2009; cf. Bettini 2013).

By 'abductive' I mean that I use empirical observations to inform, reconsider and extend my conceptual framework. Abductive logic enables interpreting data by diving deep into the tacit knowledge of actors (e.g. interpretations, rules, intentions) and to thus provide the data for the model subsequently developed (Blaikie 2009). This helps to create a best fit between what is found in the empirical research domain and the researcher's interpretations. Abductive research is a "puzzling-out process", in which "the researcher tacks continually, constantly, back and forth in an iterative-recursive fashion between what is puzzling and possible explanations for it, whether in other field situations […] or in research-relevant literature" (Schwartz-Shea and Yanow 2012: p. 12; cf. Wittmayer 2016).

2.2.3 Ensuring research quality

I sought to ensure that my research process and results adhere to a set of quality criteria (Schwartz-Shea 2006). This is to do justice to my agentic role as a researcher, which I understand "not merely academic in this context, but also public or political" (Jhagroe 2016: p. 64). Overall, criteria for judging research quality are – to some extent fervently – debated and generally depend on the chosen research paradigm (Smith and Hodkinson 2008; Lincoln and Guba 1985b). Since this study is embedded in transformation research I particularly draw on quality criteria identified for transformation research. These are informed by post-normal science, which recognises that "facts are uncertain, values in dispute, stakes high and decisions urgent" (Funtowicz and Ravetz 1993: p. 744). They provide a good basis, because they combine criteria for scientific soundness with societal relevance and impact in relation to both research outcomes and research process (Section 2.1.1; Wittmayer and Hölscher 2017; Wittmayer 2016; see also Cash et al. 2002; Belcher et al. 2016). They are also in line with criteria that were formulated for critical realist research, which diverge from more conventional criteria for positivism (Lincoln and Guba 1985b).

Stance on normativity and subjectivity

As stated at the outset of this section, with my research I aim to not only study but also to support societal transformations towards sustainability and resilience. This study reflects my idea that there is a way to devise urban climate governance more effectively so that it becomes transformative. In particular, I hope that my results provide knowledge and recommendations about what conditions enable transformative climate governance and about what actors can do to develop these conditions – both regarding the cities that I have studied as well as, with limitations (see Section 2.2.1), knowledge transfer to other cities.

However, I am aware that my understanding of what is 'sustainable' and 'resilient' is not necessarily the same as the understanding that other people have. There are many different perceptions about what is desirable – and some of these might not even be compatible. I have in particular experienced that during my work in the IMPRESSIONS project, where I was confronted with many different visions for a desirable world not only by the workshop participants whom we asked to develop visions for a world in 2100, but also by my project colleagues with whom I have discussed them. While I believe that transformative climate governance has the potential to improve sustainability and resilience, I cannot predefine what these goals are but only emphasise that understandings of sustainability and resilience need to emerge from inclusive and participatory deliberation between actors (Wittmayer et al. 2015; van der Hel et al. 2018).

In addition, the critical realism paradigm recognises that science and knowledge generation are subjective, also drawing from the subjective perspectives of social actors, and there is no way to know the full truth (Section 2.2.1). Thus, within this paradigm, it is more important to manage subjectivity and normativity rather than to challenge or deny them (Bettini 2013). In the end, I can only present my own explanations of what I have learned from the literature and experienced by witnessing and talking to people and which I cannot fully dissemble from my own perceptions and constructions of reality.

Finally, normativity and subjectivity also enter the actual writing up of the research: there is "no innocent or a-political way to communicate research results; rather it is about crafting a convincing text with sound argumentation according to standards of a specific epistemic community" (Wittmayer 2016: p. 68). In writing up this study my subjectivity and normativity become 'real' in the sense that they become 'black-and-white' text that people can read. This also holds when I talk about my research at conferences or in informal settings – my thoughts and views become 'words'.

I have tried to address these issues of normativity and subjectivity by ensuring that my research meets a set of quality criteria. Apart from those, I find it important to leave room for debate and disagreement, which is a critical dimension of doing science.

Scientific soundness of research results: trustworthiness

Criteria for scientific soundness facilitate the generation of useful and transferable knowledge (Creswell 2009; Yin 2009). Traditional positivist-oriented criteria – including internal and external validity, generalisability, reliability and objectivity – do not sit well with a constructivist epistemology (Wittmayer 2016; Guba 1990). Lincoln and Guba (1985b) suggest to replace these criteria by credibility, transferability, dependability and confirmability to show the trustworthiness of research results. Trustworthiness can be met through consistency of the approach, ability to be reproduced and transparency about data collected, research approach and methods (Creswell 2009; Yin 2009; Sobh and Perry 2006; Wittmayer 2016). Triangulation is particularly crucial in critical realist research: as the data relies on social actors' perceptions, any perception that is collected needs to be triangulated (Sobh and Perry 2006). Additionally, member check helps to not misrepresent my collected data and to safeguard the observations I made (Jhagroe 2016). For example, I tested initial research findings and observations from earlier literature review and interviews with later interviewees. I also shared my research results with my interviewees to receive their feedback.

Soundness of the research process: inclusivity and reflexivity

Inclusivity and reflexivity in the research process are key quality criteria for researchers with a critical realist paradigm and constructivist epistemology and the ambition to provide knowledge that supports sustainability and resilience transformations. Inclusivity refers to the selection of interviewees so that they show a diversity of perspectives, interests and power positions (Jhagroe 2016). I explicitly included critical voices as well as critically reflected on unequal relations of power and how they affect urban climate governance realities. Reflexivity relates to how consciously I treated my own biases due to my experiences, involvement and values as well as how I communicate my research (Schwarz-Shea & Yanow 2011). Reflexivity helped me to situate myself in the research and reflect on my findings. In writing up this study, I did not exclude any observations and results in order to conform to academic standards or to not antagonise any person (e.g. supervisor, interviewee).

Societal relevance of research results: social impact

Transformation research identifies social impact as criterion for societal relevance based on the ambition to address societal problems and to support societal change towards sustainability (Wittmayer and Hölscher 2016; Wiek et al. 2012; Reale et al. 2018; Belcher et al. 2016). In addition to advancing scientific concepts, publishing scientific articles and presenting at scientific conferences I

aim to translate my insights into actionable knowledge that supports actors making choices and act in specific contexts (Wittmayer and Hölscher 2016). Specifically, I sought to generate recommendations about how to develop capacities for transformative climate governance. Making my results actionable will continuously challenge me to engage in a wider public dialogue, make my research relevant for decision-making bodies and the public and discuss my results with my interviewees but also other actors.

2.3 Research strategy

While this is a thesis-by-publication, the overall research strategy built upon a qualitative comparative case study of capacities of transformative climate governance in Rotterdam, the Netherlands, and New York City (NYC) in the USA. The strategy includes three general steps: 1) the development of a conceptual framework through the use of theory, 2) individual case studies, and 3) the comparative analysis of both case studies. This section outlines the rationale for and approach to these steps as well as how they were conducted in a consecutive and iterative research process. The detail on the comparative case study method, including case selection, data collection and data analysis is given in Section 2.4.

2.3.1 Use of theory for framework construction

As stated above (Section 2.1.1), theories help referring to the external reality as "consisting of structures that are themselves sets of interrelated objects, and of mechanisms through which those objects interact" (Sobh and Perry 2006: p. 1199). For realism researchers, there is an external reality that other people have usually researched or experienced before. A preliminary conceptual framework at the outset of the research and based on literature and people with experience of the phenomenon helps to access and structure existing knowledge about the underlying structures and mechanisms of the phenomenon under study (ibid.; Miles and Huberman 1994). Realist research can thus be considered as theory-driven empirical research (Pawson 2000; cf. Bettini 2013).

This thesis builds on theoretical understandings of sustainability transitions, resilience and (urban) climate governance approaches (see Sections 1.3.1 and 2.1.1) in order to construct a conceptual framework about capacities for transformative climate governance. These scientific approaches were chosen because they provide a wealth of insights on (climate) governance and agency in the context of urban transformations. Their insights are both consistent and complementary. Sustainability transitions approaches focus on persistent structural and cultural constraints underlying shifts towards more sustainable systems of service provision and lifestyles and thus on facilitating radical change (Rotmans and Loorbach 2010; Markard et al. 2012). Resilience approaches stress governance institutions and activities for enhancing the ability of social-ecological systems to respond to uncertainty and disturbance (Folke 2016; Pulver et al. 2018). Urban climate governance literature provides empirical knowledge about governance structures and activities in the context of climate change (Castán Broto 2017).

Scientific interests on sustainability transitions, resilience and climate governance studies started to converge over the past ten years (see Gillard et al. 2016 for an overview). Over the past years, there have been constructive debates about whether and how the system ontologies, concepts and frameworks of sustainability transitions and resilience approaches can enrich each other's explanations of and governance propositions for navigating desirable system change (Olsson et al. 2014; Smith and Stirling 2010; Pereira et al. 2015; Chaffin et al. 2016). However, so far these debates do not offer an integrated perspective on facilitating radical change for sustainability and building resilience in the face of uncertainty and risk. What is needed is the operationalisation of these approaches into a joint framework that can help diagnose climate change as a systemic problem and develop integrated and innovative solutions that address the drivers, risks and opportunities of climate change, sustainability and resilience in the context of transformation. As such, this research also contributed to future theory development by producing synthesised and generalised propositions about capacities for transformative climate governance, which can be further expanded and tested.

My research objective, which is to explain the development of urban climate governance and to assess whether it indeed manifests in new capacities for transformative climate governance, involves understanding how and by whom urban climate governance is enacted and evaluating whether new structural governance conditions emerge as a result of these activities. Therefore, the starting point for reviewing and synthesising the different research approaches is structuration theory, which views actors as enabled and constrained in their actions by the structural contexts in which they operate and as able to adapt to and change these contexts (Giddens 1984; see Section 1.3.3). Structuration theory enables disentangling how the research approaches explain governance agency in terms of the diverse actors and their activities in urban climate governance, as well as evaluating whether and how governance agency creates, changes and is enabled or disabled by conditions for transformative climate governance.

In other words, the conceptual framework of capacities for transformative climate governance is agency-based: In a first step, I reviewed sustainability transitions and resilience approaches regarding their ontologies, concepts and frameworks to position climate change and climate governance in the context of transformations. This enabled defining transformative climate and identifying functions for transformative climate governance in terms of different types of system-level outputs. The functions provided a systematic structure for reviewing how the research approaches conceptualise agency and for formulating agency-based propositions for transformative climate governance. The synthesis of research approaches into a framework of transformative climate governance capacities is reported in Chapter 3 and Intermezzo A.

After identifying and defining functions and capacities, I turned to an additional research strand: meta-governance. Meta-governance literature addresses questions related to the coordination of multiple and fragmented self-organising governance networks to facilitate goal alignment and concerted actions (Jessop 1997; 2011; Kooiman and Jentoft 2009; Sørensen 2006). Meta-governance literature helped to further conceptualise and operationalise orchestrating capacity. Sustainability transitions, resilience and climate governance approaches increasingly point to the need for coordinating and intermediating self-organising and polycentric governance networks and actors across scales and sectors in line with common and overarching goals (Pahl-Wostl and Knieper 2014; Hodson and Marvin 2010; Loorbach et al. 2015; Galaz et al. 2011). However, I found that their agency-related

conceptualisations about how to ensure such coordination were still in their early stages and that meta-governance literature due to the specific focus on this provided important additional insights.

In summary, the conceptual framework contributes to an agency-based understanding of transformative climate governance, and how transformative climate governance can be supported. While governance capacities are context-dependent – i.e. they relate to specific local issues and underlying processes – investigating governance capacities aids a deeper, integrated and empirically-based understanding of the most important enabling and limiting conditions that determine governance capacity as well as how conditions are created and changed (Koop et al. 2017). I hope that the framework of capacities for transformative climate governance also helps comparing cities and identifying transferable lessons.

2.3.2 Qualitative comparative case study research

The empirical research of this study encompasses a qualitative comparative case study to explain and evaluate whether climate governance activities in Rotterdam and NYC manifest in capacities for transformative climate governance. This also served to test and refine the conceptual capacities framework. The approach included individual case studies to provide detailed explanations and insights about the complexity and depth of climate governance activities and resulting conditions in both cities (Yin 2009; Gerring 2004). The comparison of governance activities and resulting capacity conditions in Rotterdam and NYC enabled interpreting similarities, differences and patterns manifest in capacities for transformative climate governance in two different urban contexts (Eisenhardt and Graebner 2007; Yin 2009). The comparative analysis thus served to abstract from the individual case study contexts and derive more generalised insights about activities, conditions and influencing factors because the insights are more deeply grounded in varied empirical evidence (Eisenhardt and Graebner 2007; Collier 1993).

A case study strategy requires boundaries to be drawn around the case, which essentially represents a theoretical category about a phenomenon, or an event, and is conceptualised and analysed empirically as a manifestation of a broader class of phenomena or event (Yin 2009; Vennesson 2008; King et al. 1994). In critical realism research, 'case' refers to the unit of analysis, i.e. an example of the 'real' structures and mechanisms that are being investigated (Sobh and Perry 2006). The conceptual framework of capacities for transformative climate governance elucidates the units of analysis of my case studies: I identified the climate governance activities in Rotterdam and NYC (independent variable) to explain and evaluate whether these have resulted in new governance conditions for transformative climate governance (dependent variable). My case studies thus focus on Rotterdam and NYC as geographical places and on urban climate governance activities in terms of the strategies and actions to address climate mitigation and adaptation in both cities. Based on the understanding of urban climate governance as multi-level, multi-sector and multi-actor (see Section 1.2), urban climate governance activities in both cities were not limited to actors and activities *from* both cities but rather to activities and actors *exerting influence in* both cities – including for example also actors from regional and national governments. Additionally, as urban climate governance is of multi-sector nature, relating to diverse sectors (Rosenzweig et al. 2015), multiple sectors were studied, including water, transport, energy, health, housing and emergency management.

The individual case studies and the comparison have been guided by the conceptual framework of capacities for transformative climate governance. According to Yin (2009), this type of theoretical generalisation (i.e. of case study findings to theory) is to the domain of case study what statistical generalisation is to the true experiment. The use of theory also enhances the comparative merit of case studies by providing a structured way to compare phenomena across cases (ibid.; Jahn 2013). While the individual case studies dive deeply into the contextual factors and dynamics, the comparison seeks to establish co-variance, i.e. to trace general regularities of explanations (Jahn 2013; King et al. 1994). The approach for analysing and comparing the case study data in line with the framework is in more detail explained in Section 2.3.3.

While the main goals of my comparative case study were to empirically test and refine the conceptual capacities framework as well as to explain and evaluate urban climate governance, the generalisability from two qualitative case studies is still very limited. Additionally, while my comparative case study design is explanatory – i.e. I seek to explain how capacities for transformative climate governance were developed – I still consider my research ultimately exploratory, because such capacities have not yet been studied in detail (Yin 2009). Particularly, in relation to the question of urban climate governance cities have very different contexts and thus face different types of enabling and disabling conditions (Castán Broto 2017). As there are no blueprint solutions for transformative climate governance, guidance must be developed from case study specific evidence (Chaffin et al. 2016).

2.3.3 Overview of research process

Without pretending that every step in this research has been meticulously planned, I can retrospectively reconstruct three – both consecutive and parallel – research steps: (i) development and enrichment of the conceptual framework of capacities for transformative climate governance; (ii) individual case studies of Rotterdam and NYC; and (iii) comparative case study of transformative climate governance capacities in Rotterdam and NYC. Within each of these steps I undertook different types of activities, including for example desk research, interviews and data analysis (Table 2.2). These steps have enabled me to respond to my research objective, i.e. to explain the development of climate governance activities in Rotterdam and NYC and to evaluate whether they manifest in capacities for transformative climate governance.

Following my logic of inquiry (Section 2.2.2), the research steps were conducted in a highly iterative way. At first, the framework was constructed to operationalise agency-based propositions of transformative climate governance capacities. The case studies enabled the detailed study of these conditions and how they manifest in the capacities. These empirical insights were used to further inform, adapt and sharpen the framework.

Table 2.2: Overview of research process

Step	Which activities did I do?	Results
(i) Conceptual framework	• Review of sustainability transitions, resilience, urban transformation, (urban) climate governance and meta-governance literatures • Development of draft conceptual framework • Revision of conceptual framework based on new insights from literature, discussion and empirical work	Scientific paper on synthesis of literatures for defining transformative climate governance (Chapter 3) Development and enrichment of conceptual framework of capacities for transformative climate governance (Intermezzo A)
(ii.a) Rotterdam case study **(ii.b) New York City case study**	• Data collection (literature review, interviews, workshops); interviews were conducted between March and June 2015 (Rotterdam case study) and between October 2015 and January 2016 (NYC case study) • Data analysis	Scientific papers on the identification, explanation and evaluation of transformative climate governance capacities in Rotterdam and NYC (Chapters 4 and 5) Testing of conceptual capacities framework
(iii) Comparative case study Rotterdam and NYC	• Comparative analysis of capacities for transformative climate governance in Rotterdam and NYC	Scientific paper on patterns of transformative climate governance capacities, including capacity gaps and challenges, based on comparative case study (Chapter 6) Synthesis and conclusions on conceptual framework and capacities for transformative climate governance (Chapter 7)

2.4 The 'how' and 'who' of the comparative case study: learning from experimenting cities

This study builds in particular on the comparative case study of capacities for transformative climate governance in Rotterdam and NYC. The comparative case study responds to the following questions: (i) what climate governance activities can be identified in both cities to explain whether these have resulted in new governance conditions for transformative climate governance?; (ii) do the conditions manifest in capacities for transformative climate governance and what are capacity gaps and challenges?; and (ii) what can be learned for the theoretical conceptualisation of capacities for transformative climate governance?

This section outlines the rationale for selecting Rotterdam and NYC as case studies for my research as well as the methods used for data collection and analysis.

2.4.1 Rationale for case selection: sneak peek at Rotterdam and NYC

Comparative case studies are analogous to multiple experiments, i.e. they follow a sampling logic to select cases for theoretical reasons, such as elaboration of an emergent theory, replication of findings, elimination of alternative explanations and contrary replication (Yin 2009; Eisenhardt and Graebner 2007). Contrary to large-N research that employs sampling logic to avoid selection bias, the selection

of cases in comparative case study research follows some replication logic so that cases are comparable and represent conditions where the phenomenon under study can be expected to be found (Yin 2009; Della Porta 2008). Cases are selected based on the dependent variable (i.e. capacities for transformative climate governance) because these cases are particularly suitable for illuminating and extending relationships and logics among theoretical constructs (Eisenhardt and Graebner 2007).

I follow a literal replication logic, i.e. I selected my case studies to predict similar results (Yin 2009). Selecting case studies with respect to similar outcomes of the phenomenon under investigation (dependent variable) helps to illuminate an issue when little is known about it and to explain and evaluate the impact of independent variables (Della Porta 2008). This is suitable for my research objective, because I intend to explain and evaluate the shift in urban climate governance. This requires selecting cities in which urban climate governance shows features of the shift, i.e. it is likely that I find activities and emerging conditions for transformative climate governance capacities and that I can identify activities that have contributed to developing these conditions.

While the case study selection of Rotterdam in The Netherlands and NYC in the USA as case studies also followed some practical considerations (e.g. proximity to Rotterdam due to location of myself as a researcher, institutional contacts to NYC), both cities match the key criteria for the literal replication logic:

- In both cities the city governments had formulated integrated, long-term and ambitious climate mitigation, climate adaptation, sustainability and resilience goals;
- Both cities are undergoing significant formal and informal institutional changes (e.g. the creation of new and cross-cutting sustainability and resilience offices, establishment of new types of actor networks and partnerships);
- In both cities, innovative solutions have been trialled through processes of experimentation;
- Both cities are members of the same transnational city networks to facilitate knowledge exchange on climate mitigation and adaptation (e.g. C40, 100 Resilient Cities).

In summary, Rotterdam and NYC are examples of cities providing global leadership and setting a standard for climate change adaptation and mitigation with ambitious and cross-cutting climate, sustainability and resilience agendas and a portfolio of innovative solutions for climate mitigation and adaptation (Solecki et al. 2016; Forgione et al. 2016; McPhearson et al. 2014; Ernst et al. 2016; Frantzeskaki and Tillie 2014; Depietri and McPhearson 2018). This offers insights into the emerging features of urban climate governance vis-à-vis existing urban governance regimes, including how and by whom urban climate governance is driven and constrained, what governance conditions emerge as a result, and whether these conditions indeed enable transformative climate governance. Boxes 2.1 and 2.2 give a sneak peek of both cities.

Next to these section criteria that are based on the dependent variable, the cities have both similar but also diverging contextual conditions (Sobh and Perry 2006). These need to be considered in the comparison and explanation of transformative climate governance capacities.

- ***City location and position:*** Rotterdam and NYC are both delta and port cities, mark important economic centres in their region and face a diversity of climate change impacts and broader socio-

Box 2.1: Sneak peek at climate governance in Rotterdam

In Rotterdam, climate change was introduced in the city government's agenda in 2007 with the Mayor's goal to reduce CO_2-emissions by 50% in 2025 compared to 1990 and the launch of the Rotterdam Climate Initiative (RCI). Concomitantly, water policy entrepreneurs formulated the goal to become climate-proof by 2025. This involved reframing the perception of water as a threat towards recognising climate adaptation as opportunity for improving the city's social and economic attractiveness (RCI 2009; de Greef 2005; van der Brugge and de Graaf 2010). Until today, the climate change focus was successively expanded towards sustainability, liveability and, most recently, resilience (Gemeente Rotterdam 2012; 2015; 2016). However, the official CO2-reduction target was removed for political reasons. This strategic approach was institutionalised in the city government's cross-cutting Sustainability and Climate Adaptation Offices that coordinate climate, resilience and sustainability-related actions and collaborate with other city departments, levels of government (e.g. national government, water boards (regional government bodies charged with managing water barriers, waterways, water quality) and private actors. The city gained international recognition particularly through its high-profile proof-of-concept experiments that deliver co-benefits for climate adaptation, greening, recreation, community-building and economic development. Examples include the Benthemplein water square, which combines rainwater management with area development (Figure 2.1), the multifunctional underground water storage facility at Museumplein car park and the Floating Pavilion in the City Ports area.

Figure 2.1: The Benthemplein water square in use as a community square during a church service in May 2015 (source: private 2015)

Box 2.2: Sneak peek at climate governance in New York City

In NYC, Mayor Bloomberg (2002-2014) ignited the city-wide agenda on sustainability and climate mitigation by commissioning a cross-cutting sustainability and climate mitigation plan. Released in 2007, PlaNYC tied goals such as emissions reductions, improving air quality, managing population growth, modernising infrastructure and the city's long-term liveability and global competitiveness (NYC 2007). Following Hurricane Sandy in late 2012, the Special Initiative for Rebuilding and Resiliency (SIRR) was convened to develop a programme for reducing the city's vulnerability to coastal flooding and storm surge and for rebuilding communities (NYC 2013). When Mayor de Blasio took office in 2014, he issued 'One New York: The Plan for a Strong and Just City' (OneNYC) (NYC 2015), introducing affordable housing and social equity as top priorities for resilience and sustainability. The cross-departmental Mayor's Offices of Sustainability (MOS) and Recovery and Resiliency (ORR) were established to spearhead the city government's efforts on climate change, resilience and sustainability. MOS, ORR and city departments closely work together with business networks, community organisations and they participate in cross-sectoral and cross-scale knowledge platforms and partnerships. These efforts resulted in diverse measures, including green infrastructure projects and designs (Figure 2.2), regulations (e.g. on energy efficiency in buildings) and community resilience building. For example, the NYC Cool Neighbourhoods programme was launched in 2017 to protect citizens from extreme heat by combining green infrastructure, health training and supporting low-income households (NYC 2017). The Federal Department of Housing and Urban Development (HUD) initiated the Rebuild-by-Design (RbD) competition to develop and implement innovative projects for rebuilding, community resilience and sustainability in the region affected by Sandy. This is resulted in three innovative projects located in NYC: The BIG U integrates green infrastructure and liveability for flood protection in Lower Manhattan, the Living Breakwaters project envisions living reefs along Staten Island's south shore to accommodate flooding, and the Hunts Point Lifelines project in the Bronx integrates flood protection, recreation, health, local livelihood development and emergency management (RbD 2016; Grannis et al. 2016).

Figure 2.2: View from Brooklyn Bridge Park that has revitalised 2.1 km of Brooklyn's post-industrial waterfront (source: Katharina Hölscher 2015)

economic challenges. Rotterdam is located in the South-West of the Netherlands. NYC is located at the east coast of the US.

- ***City size:*** While Rotterdam is the second largest city in The Netherlands, it's population of over 650.000 inhabitants is considerable smaller than that of NYC – the most populous city in the USA. The municipal city NYC accommodates an estimated population of over 8.55 Million people in the five boroughs Bronx, Brooklyn, Manhattan, Queens and Staten Island (US Census Bureau 2015).
- ***Expected climate impacts:*** Expected climate impacts in Rotterdam and NYC include sea level rise, rising river and groundwater levels, increasing severity of heavy downpours and storms, coastal and storm surges and heat waves (Molenaar et al. 2013; NPCC 2015). Both cities have already experienced climate extremes that highlighted numerous risks for the cities' population and infrastructure. Rotterdam has experienced severe flood events in the 1990s. Hurricane Sandy's landfall in October 2012 marked a key event in NYC; it caused an estimated $19 billion in damage, killed 43 people, flooded the city's sewer systems, roads and subway stations, paralysing vital transport networks, provoked power and water outages and revealed the heightened vulnerability of low-income communities in the city (NYC 2013).
- ***Socio-economic conditions:*** Rotterdam and NYC face several social, economic and environmental challenges such as social stratification, air and noise pollution, the economic downturn since the late 2000s, and – especially in the case of NYC – escalating housing prices (Wals and van der Waal 2014; Wittmayer 2016; McPhearson et al. 2014). In addition, both cities are international business hubs, and as such continuously work on urban regeneration due to the flux of population that the businesses aim to attract.
- ***Political and institutional contexts:*** Being located in The Netherlands and in the USA, respectively, Rotterdam and NYC have very different institutional contexts. This is not only evident from President Trump's withdrawal from the Paris Agreement, but also from the long-standing difficulty to put climate action on the agenda of the New York State government.

It is important to note that while the selection of cases resonates some a priori assumption that both cities are 'doing well' with regard to addressing climate change, sustainability and resilience, this does not mean the analysis was deterministic in the sense that it did not critically reflect on the effectiveness of urban climate governance. As established in the introductory chapter to this thesis, also so-called frontrunner cities show many shortcomings and challenges (Sections 1.2.2 and 1.2.3). The case selection epitomises the hope that while both cities still face many challenges, they offer ample grounds for learning about how actors can create and use opportunities for moving towards a more integrated, flexible and inclusive approach to address climate change, sustainability and resilience.

2.4.2 Data collection

Data collection has been based on a combination of document reviews, attending workshops, conducting interviews and fieldnotes. These methods provided complementary insights to provide rich empirical description, explanations and assessments of urban climate governance activities in both cities through triangulation (Section 2.2.3).

Desk research

I reviewed policy documents (strategies, visions and programmes from 2007 to 2017, including Gemeente Rotterdam 2015; 2016; RCI 2012 for Rotterdam and NYC 2007; 2010; 2015 for NYC), media articles, public videos (e.g. about conferences and meetings) and scientific papers about climate, resilience and sustainability governance in Rotterdam and NYC. This provided insights about how climate change, resilience and sustainability are 'officially' addressed and reported on and debated in both cities. In particular, I could trace the development of strategic documents (e.g. from a focus on climate mitigation and sustainability towards one that also added and in parts integrated climate adaptation and resilience). It also helped to consider more critical voices – in particular through the scientific and media articles on both cities. For both cities, extensive literature and media reports are available that critically engage with the approaches to and effectiveness of climate governance.

Interviews

I conducted semi-structured interviews with a mix of informants from local, regional (in Rotterdam referring to water boards, in NYC from the New York State government), national governance scales as well as from government, market and civil society that are involved in climate governance in the context of the respective city and in different sectors (e.g. transport, water, health, ecology). In total, I conducted 28 interviews for the Rotterdam case study and 38 interviews for the NYC case study. These interviews provided me with the most critical insights about 'how' climate governance in both cities is exercised – i.e. how do the actors engaged in climate governance develop strategies and projects, how do they engage with other actors, which challenges do they face etc. All interviews were transcribed. Detailed overviews of interviews held (including the sampling method and interview guides) are provided in Appendices A and B.

Workshops and conferences

I attended several workshops and meetings related to strategy formulation and knowledge exchange. Representatives from both cities are present at international scientific conferences on climate change, such as Adaptation Futures and the European Climate Change Adaptation (ECCA) conference. This provided me with additional insights about how actors in both cities present and communicate what they are doing, in particular in terms of 'lessons learned'. In Rotterdam, it was primarily not myself attending vision and strategy formulation workshops but rather colleagues of mine who were involved in the re-development of the City Ports area (Frantzeskaki et al. 2014) and the formulation of the resilience strategy (Gemeente Rotterdam 2016; Lodder et al. 2016). In NYC, I attended workshops and informal meetings about how to bring forward the visions for sustainability and resilience. I also attended community meetings on questions about the rebuilding of the area around Jamaica Bay, which was heavily affected by Hurricane Sandy. In addition, my supervisor at The New School in NYC has been a member of the NYC ORR's Urban Heat Island Task Force, advises on research and implementation for multiple city agencies, and co-leads the integrated NYC Stormwater Resiliency research together with ORR and NYC Department of Environmental Protection (DEP) to deliver recommendations for significant city investments to enable short- and long-term flood resiliency.

Fieldnotes

During my empirical research I 'immersed' myself in my case study contexts and the topic of urban climate governance to get a sense of who 'the urban climate governance community' is in both cities and how climate change is addressed. I kept all my observations in the form of field notes, in which I tried to distinguish between what was said or what I had observed and what were my reflections about this.

My 'immersion' in the context of climate governance in Rotterdam took various forms and was in particular supported by my work at DRIFT. Some of my colleagues have been working on projects related to climate governance in Rotterdam and on local case studies (e.g. Happy Streets, developing the strategy 'Pathways to Paris' for Rotterdam). I have taken field visits to several of the innovative 'icon projects' for climate adaptation in Rotterdam, such as the Floating Pavilion, the Benthemplein water square and the DakAkkers – but also to local community gardens such as Essenburg Park. This has given me the opportunity for many informal talks and insights about perceptions of how climate change and sustainability are addressed in the city.

For my case study on climate governance in NYC I spent 3.5 months in the city between October 2015 and January 2016. This has given me the opportunity to get acquainted with the city and the region. For my interviews I travelled to many places all across NYC and also to some extent across New York State, which also gave me a sense of space and place – for example, how different neighbourhood have very different features and challenges.

2.4.3 Data analysis

My data analysis was done in two steps: First I analysed the data with respect to the individual case study. In a second step, I compared the results for both case studies.

For each case study, the collected data was analysed in reference to the conceptual capacities framework (see Intermezzo A). Coding was done to reduce, cluster and summarise the very diverse and vast amounts of data (Saldana 2009). I followed a step-wise coding process resembling axial coding to make connections between the activities, conditions and capacity functions – i.e. to connect actors ('who'), activities and conditions ('how') and output functions ('what') (Strauss and Corbin 1998). I coded the data in five consecutive and iterative steps to describe, explain and evaluate how the capacity functions of the framework are fulfilled in each city, what conditions facilitate the fulfilling of the functions that manifest in the existence of the capacities, by which activities these functions were created and what drives capacity gaps (Table 2.3). The steps were iterative because insights gained from further analysis in step three could add or differentiate insights gained from the initial analysis in step one. Appendix C provides a detailed overview of the coding of the case studies.

Firstly, I analysed how the capacity output functions stewarding, unlocking, transforming and orchestrating are addressed in climate-related policy and planning practice in Rotterdam and NYC. It was not my aim to meticulously assess some sort of value for how the functions were fulfilled, nor to analyse the outcomes and impacts for example in terms of amount of renewable energy produced, emissions reduced and risks avoided. Rather, this step generated a qualitative assessment and

overview of how the functions of transformative climate governance were fulfilled and that could be related to capacities for transformative climate governance.

Secondly, for each function I identified the conditions (e.g. knowledge, resources, networks, organisational structures) that support the fulfilment of the capacity functions. From my data and across capacity functions, I identified four types of conditions: knowledge conditions (e.g. knowledge

Table 2.3: Analysis steps for single case studies

Step	Questions addressed	Results
(1) Assessment of capacity output functions	What strategies, programmes, actions, regulations etc. exist for stewarding, unlocking, transforming and orchestrating?	Qualitative assessment and overview of how the capacity functions of transformative climate governance were fulfilled
(2) Identification of governance conditions	What conditions (e.g. knowledge, networks, partnerships, resources) were created for stewarding, unlocking, transforming and orchestrating?	Description of conditions that support fulfilment of capacity functions and manifest in transformative climate governance capacities
(3) Identification of urban climate governance activities and actors	What activities are being undertaken in both cities to develop and implement strategies, networks, programmes, actions, knowledge etc. for stewarding, unlocking, transforming and orchestrating? Which actors engage in these activities?	Explanation of how, and by whom, the conditions for transformative climate governance were created
(4) Identification of capacity gaps and challenges	What are challenges, shortcomings, conflicts, gaps etc. for stewarding, unlocking, transforming and orchestrating?	Description and explanation of capacity gaps and challenges for transformative climate governance
(5) Relationships between capacities	How do the conditions and activities of capacities support or hinder each other?	Identification of relationships between capacity conditions and activities

about risks), institutional conditions (e.g. regulatory space, goals), network conditions (e.g. partnerships, connection nodes) and social conditions (e.g. social capital, support). I coded the conditions in reference to the capacity function and sub-function they support. This provided insights into the conditions that manifest in the different capacities.

In the third step I identified the activities by which multiple actors have created the capacities conditions. This enabled me to explain how, and by whom, the conditions were developed and to formulate recommendations for strengthening capacities for transformative climate governance.

Fourth, I identified challenges, conflicts, shortcomings etc. that reflect capacity gaps with respect to fulfilling the functions. These gaps could be related to existing or missing conditions and challenges actors experienced when engaging in activities. This provided insights about gaps, barriers and challenges and about recommendations to address these.

In the final step of the single case study analysis, I addressed the potential interrelationships between conditions and activities across capacities. This served to identify how strengths or gaps in one capacity can relate to strengths or gaps in another capacity.

The comparative analysis of transformative climate governance capacities in Rotterdam and NYC sought to identify similarities, differences and patterns with regard to how the functions are fulfilled, conditions created, actors and activities creating the conditions and capacity gaps (Eisenhardt and Graebner 2007). The comparison differentiated between case-specific characteristics and cross-case characteristics. Similarities and differences were reflected upon in relation to the specific city contexts and capacity gaps to explain causal relations (Jahn 2013).

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Chapter 3

The ‘how’ and ‘who’: a transformative structuration perspective on transforming climate governance

Abstract

The emerging paradigm of climate change as transformation challenge in policy and science discourses recognises that more transformative approaches are needed to avoid the most dangerous impacts of climate change, build the capacities to respond to such impacts and create opportunities beneficial for social and environmental wellbeing. This raises questions about why, how, by whom and with what effects climate governance takes place. We propose a change of perspective in evaluating and even surfacing climate actions. We employ the term transformative climate governance to conceptualise climate change in the context of transformations towards sustainability and resilience. By synthesising insights from sustainability transitions and resilience approaches we define transformative climate governance and identify four distinct transformative climate governance functions – transforming, unlocking, stewarding and orchestrating. Drawing on a perspective of governance as structuration process we formulate agency-based propositions for creating the conditions for delivering the transformative climate governance functions. The functions thus bridge between the conditions that emerge from climate governance activities, who is driving these activities, and whether the conditions facilitate transformative climate governance. They provide a starting point for understanding the on-going changes in the climate governance landscape at multiple levels and for guiding the development of conditions for transformative climate governance.

Status

This paper has been submitted to the journal Climatic Change and is currently under review.

Fit with overall thesis

This paper develops the transformative perspective on climate change and climate governance and defines ´transformative climate governance. The framework is positioned within global climate governance debates and is thus not restrained to the urban climate governance focus of this thesis. It builds on a synthesis of sustainability transitions and resilience approaches to derive agency-based propositions for developing the conditions for delivering transformative climate governance functions. This provides the theoretical foundation for defining and operationalising capacities for transformative climate governance, which are presented in the Intermezzo following this chapter.

Chapter 3

The 'how' and 'who': a transformative structuration perspective on transforming climate governance

3.1 Introduction

Climate governance by now builds on an extensive international regime centred on the United Nations Framework Convention on Climate Change (UNFCCC) and the ambitious Paris Agreement's 1.5-2°C target. Around this regime new forms of governance are emerging, including diverse bottom-up action stemming from multiple actors from cities, businesses and civil society, which produce dispersed, multi-level and polycentric climate governance patterns (van Asselt et al. 2018; Hoffman 2011; Jordan et al. 2018; Ostrom 2014). The Sustainable Development Goals formulate a climate-specific goal (SDG 13), thus embedding climate change within the broader discourse on sustainable development. Yet, while the pledges made by national governments are thus far insufficient to stay well below 2° (Rogelj et al. 2016), also the most formidable efforts to climate mitigation and adaptation to date are countered by negative impacts of globalisation, economic growth and urbanisation (Roberts et al. 2018).

In light of the changing global climate governance landscape, what governance of climate change is and how climate governance is accomplished are scrutinised (Bulkeley 2015; Jordan et al. 2018a). In the most generic sense, climate governance refers to the intentional actions and interventions by which actors seek to reduce emissions (climate mitigation) and prepare for and cope with the impacts of climate change (climate adaptation) (Fröhlich and Knieling 2013). The term governance draws attention to diverse types of actors (e.g. from civil society, economy, government, research) and their interactions to deliberate between contested solutions (rather than promoting individual actor interests) and navigate their institutional, socio-economic and political contexts (Kooiman 1993). What climate change is as the 'object' to be governed is defined in reference to the configuration of interactions between actors and the contestation of problem definitions, solutions, interests and power relations (Bulkeley 2015; Gillard et al. 2016). This raises questions about why, how, by whom and with what effects climate governance takes place (Bulkeley 2015; Huitema et al. 2018).

We propose a change of perspective in evaluating and even surfacing climate actions. We develop a transformative perspective on climate governance that positions climate change within societal transformations. This implies a shift from framing climate change as a clear-cut environmental problem to one of climate change as *a symptom*, and *an amplifier*, of unsustainable path-dependencies, lock-ins and mal-adaptation (Steffen et al. 2018; Hermwille 2016). Climate governance in this perspective should be considered part of the quest for broader societal transformations to sustainability and resilience that achieve deep cuts in greenhouse gas emissions, facilitate adaptation

to non-revocable impacts of climate change and increase social and environmental wellbeing within planetary boundaries (Tàbara et al. 2018).

Our goal is to define transformative climate governance and formulate agency-oriented propositions for creating the conditions for transformative climate governance. We employ the term transformative climate governance to conceptualise climate change in the context of transformations towards sustainability and resilience. The transformative perspective draws attention to the complex dynamics, contestations and uncertainties involved in addressing climate change as a transformation challenge (Gillard et al. 2016; Hölscher et al. 2018a; Loorbach et al. 2017). Transformative climate governance thus implies a shift away from steady-state approaches that control climate change through singular policies and solutions: transformations under climate change can due to their inherent complexities not be predicted and managed in a traditional way but require long-term and integrated thinking, learning, participation and experimentation (Loorbach 2014; Tàbara et al. 2018; Patterson et al. 2016).

We define transformative climate governance and derive agency-oriented propositions by reviewing and synthesising insights from two research approaches that have come of age in studying and theorising how governance and agency can support and deal with transformative societal change: sustainability transitions and resilience approaches (Loorbach et al. 2017; Olsson et al. 2014; Folke 2016; Patterson et al 2016). There have been constructive debates about complementarities of both approaches (Olsson et al. 2014; Smith and Stirling 2010; Patterson et al. 2016; Pereira et al. 2015; Chaffin et al. 2016), and both approaches have also started to permeate climate governance literature (Gillard et al. 2016). However, so far these debates hardly extend beyond a fairly uncritical comparison of both approaches and shy away from identifying concrete and synthesised governance implications.

3.2 Transformative perspectives on climate governance: sustainability transitions and resilience approaches

The burgeoning scientific and political debate on the need for radical societal shifts towards sustainability and resilience has nourished an appetite for theorising and empirically scrutinising transformations and searching ways to support desirable transformations (Patterson et al. 2016; Wittmayer et al. 2017). Sustainability transitions and resilience approaches have developed with the recognition of continuous societal changes and the need to navigate these towards desirable directions. Both draw on a synthesis of broad theories of change in complex adaptive systems that describe rhythms of stability, collapse and renewal following complex interactions and feedbacks producing systemic uncertainties, persistence, thresholds and surprise (Olsson et al. 2014; Smith and Stirling 2010; Chaffin et al. 2016). They also share an interest in deepening understanding about the role of agency and governance in supporting (or hindering) desirable transformative change (Loorbach et al. 2017; Rauschmayer et al. 2015; Chaffin et al. 2016; Westley et al. 2013).

3.2.1 Sustainability transitions approaches

Sustainability transitions research developed in the late 1990s and integrates insights from complexity science, innovation studies, sociology, governance and environmental science to understand systemic

change in societal (sub-)systems (e.g. economic sectors like energy and mobility, cities) and explore possibilities for influencing the speed and direction of change in these systems (Grin et al. 2010; Markard et al. 2012; Loorbach et al. 2017). The starting point of sustainability transitions research is the recognition of social, technological and institutional path-dependencies and lock-ins that create persistent sustainability problems (Rotmans et al. 2001). Sustainability transitions are defined as radical non-linear changes in the structures (e.g. market structures, infrastructures, institutions), cultures (e.g. values, expectations) and practices (e.g. production routines, individual behaviour) of a system that shifts the system from its current unsustainable state towards a sustainable one (Rotmans and Loorbach 2010; Loorbach et al. 2015).

Sustainability transitions approaches include a variety of frameworks and models that help to analyse transitions as multi-phase, multi-level, multi-actor and multi-pattern processes and to identify key driving forces and supporting and hindering activities from diverse actors (Rotmans and Loorbach 2010; de Haan and Rotmans 2011; Geels and Schot 2007). The multi-level perspective (MLP) helps analysing how regime build-up and break-down co-evolve from three main driving forces: increasing societal pressure for change on the landscape level (e.g. climate change, new social movements); growing internal tensions within incumbent regimes; and alternatives (e.g. technologies, lifestyles, business models) emerging and maturing in niches (Geels and Schot 2007; Loorbach 2014). In the multiphase model of an ideal-type transition innovative niches grow in the pre-development phase, become valid alternatives during the take-off and acceleration phases as the incumbent regime becomes destabilised, until in the stabilisation phase a new regime is established (Rotmans and Loorbach 2010). Approaches like transition management and strategic niche management were developed to provide analytical and operational tools to understand and develop niches, actors or transformative innovations at a relatively small scale (Loorbach et al. 2015; Raven et al. 2010).

3.2.2 Resilience approaches

Resilience approaches root in ecology and stress the connections between humans and the environment in social-ecological systems (Holling 1986; Folke 2016). A central premise is that human need to proactively and flexibly respond to continuous changes to avoid crossing thresholds detrimental to wellbeing (Holling and Gunderson 2002; Walker et al. 2004). Adaptive capacity and resilience are central concepts to describe, assess and strengthen the collective capacities (of e.g. individuals, communities, regions) in social-ecological systems to preserve a desirable state in the face of continuous change and uncertainty (Berkes et al. 2003; Folke 2016; Folke et al. 2005). A recent thread puts forth transformability as the ability to innovate and build a new type of resilience "when ecological, economic, or social (including political) conditions make the existing system untenable" (Walker et al. 2004; Olsson et al. 2014).

Frameworks and heuristics serve to understand risks and vulnerabilities that emerge from change dynamics and social and ecological abilities to respond to disturbances (Chaffin et al. 2016; Folke 2016; Pulver et al. 2018). The adaptive cycle chronicles four phases during which a system moves between long periods of optimisation in the 'front loop' and short periods of crisis and lock-in leading to reorganisation and renewal in the 'back loop' (Holling and Gunderson 2002). While a social-ecological system is located at a particular scale and adaptive cycle, it is embedded within lower/faster as well as higher/slower cycles – i.e. adaptive cycles are nested in

a panarchy across time and space (Holling et al. 2002). Radical changes can result from coinciding developments at different scales: there is a risk of undesirable transformations being imposed from larger scales (e.g. disease outbreak, forest fires), while desirable transformational changes can be deliberately initiated at smaller scales (Carpenter et al. 2001; Folke et al. 2010). Adaptive governance/(co-)management describe and guide multi-actor processes for responding to change, disturbances and vulnerabilities (Berkes 2017; Plummer 2013; Folke et al. 2005; Chapin et al. 2010).

3.2.3 The need for a synthesised perspective on the structuration of climate governance in transformation contexts

Scientific interests on sustainability transitions, resilience and climate governance studies started to converge (see Gillard et al. 2016 for an overview). Work on transformative adaptation addresses the growing likelihood of crossing tipping points due to climate impacts, which requires fundamental changes of economic systems, management strategies, technologies, behaviours and values (Wilson et al. 2013; Wise et al. 2014). Other scholars stress the need for overcoming social, institutional and technological lock-ins to shift towards low-carbon pathways (Seto et al. 2016; Rockström et al. 2017).

However, these works do not yet make the use of the full potential of the respective contributions of transitions and resilience approaches. Due to their different entry points to understanding and intervening in system change, both approaches offer complementary insights for agency and governance of system transformation. Sustainability transitions approaches focus on persistent structural and cultural constraints underlying shifts towards more sustainable systems of service provision and lifestyles and thus on facilitating radical change (Rotmans and Loorbach 2010; Markard et al. 2012). Resilience approaches stress capacities for responding to uncertainty and disturbance (Folke 2016; Pulver et al. 2018). Over the past years, there have been constructive debates about whether and how the system ontologies, concepts and frameworks of sustainability transitions and resilience approaches can enrich each other's explanations of and governance propositions for navigating desirable system change (Olsson et al. 2014; Smith and Stirling 2010; Pereira et al. 2015). However, so far these debates do not offer an integrated perspective on facilitating radical change for sustainability and building resilience in the face of uncertainty and risk.

To fathom climate change within societal transformations underscores the need for deep structural changes to overcome the socio-economic root causes, including individual values, incentive structures, institutions and technologies, driving unsustainability and (vulnerability to) climate change impacts (Tàbara et al. 2018; Seto et al. 2016). This makes clear that climate governance needs to converge insights on how to address risks, vulnerabilities and deep uncertainties amplified by climate change, as well as on how to overcome the structural drivers of climate change, unsustainability and mal-adaptation. It therefore does not seem useful to distinguish between adaptive and transformative governance (Chaffin et al. 2016), or to apply sustainability transitions approaches to questions of climate mitigation as a social and technological problem and resilience approaches to the search for responses to climate impacts through building adaptive capacity (Gillard et al. 2016). For example, adaptation to climate change requires combinations of short- and mid-term adaptive and coping responses and more radical innovations and disruptions of existing institutional, value and technological systems (Termeer et al. 2017; Chelleri et al. 2015).

Key questions for understanding and supporting transformative climate governance is what kind of governance conditions facilitate transformative climate governance, and how these conditions are created. While new types of governance conditions and processes are partially emerging in existing climate governance approaches across scales, so far a consistent approach to understand, support and evaluate the shift in climate governance is missing (Jordan et al. 2015; Huitema et al. 2018). Sustainability transitions and resilience approaches understand governance as resembling a structuration process: According to structuration theory actors are both enabled and constrained in their actions by the structural frameworks in which they operate, but actors are also able to adapt to and change their structural contexts (Giddens 1984; Garud et al. 2007). This draws attention to the institutional logics of how decision-making processes are structured and how actors can challenge and shift these logics for enabling addressing climate change in the context of transformations (Termeer et al. 2017). The structuration perspective allows bridging between the diverse actors that exercise agency in urban climate governance, the conditions that emerge as a result, and whether these conditions enable delivering the transformative climate governance functions. It enables connecting actors ('who'), context and strategies ('how') and output functions ('what') (Figure 3.1). This enables asking questions about how a transformation *of* governance can be supported to enable governance *for* transformation (Patterson et al. 2016).

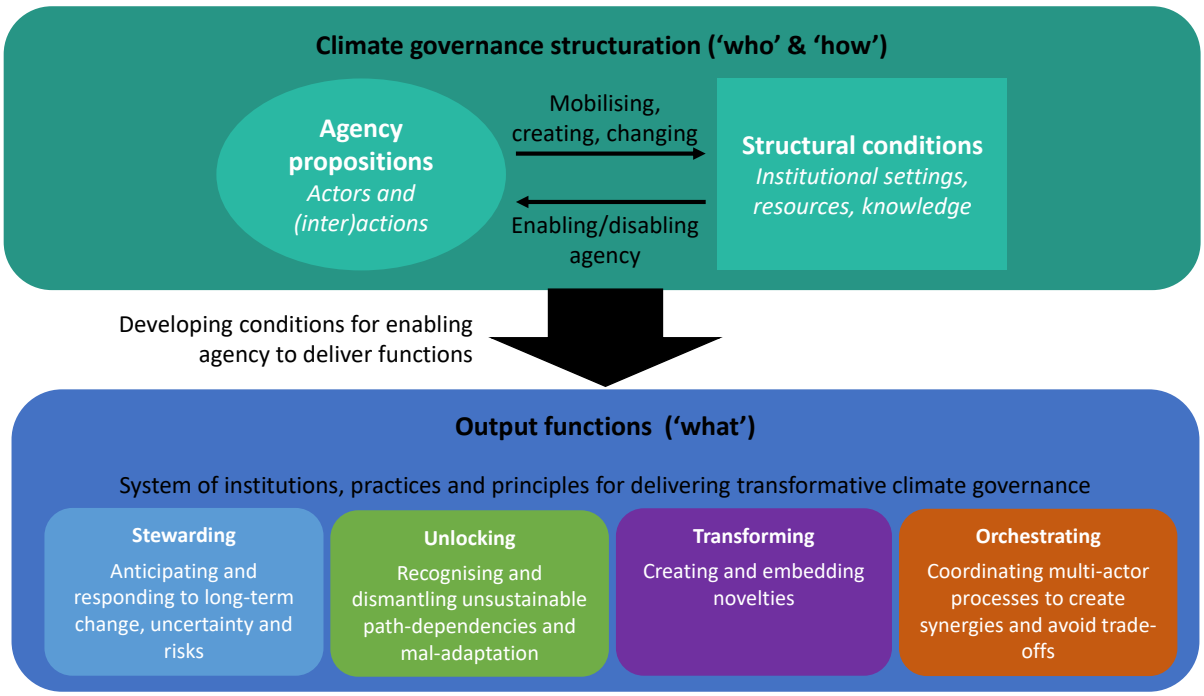
Our synthesised perspective on the structuration of transformative climate governance builds on a review of sustainability and resilience approaches regarding their ontologies, concepts and frameworks to position climate change and climate governance in the context of transformations. This enabled us to define transformative climate governance tenets and functions (Section 3.3). The functions provide a systematic structure for reviewing how sustainability transitions and resilience approaches conceptualise agency and for formulating agency-based propositions for transformative climate governance (Section 3.4).

3.3 Reframing the 'climate problem': steering transformations under climate change

This section reviews sustainability transitions and resilience approaches to position climate change in the context of transformations and define transformative climate governance. Transformations are processes of radical, non-linear and structural change involving cultural, economic, technological, political, institutional and ecological dimensions of complex societal systems such as economic sectors or regions (Feola 2015; Hölscher et al. 2018a)8. A transformative perspective thus draws attention to the systemic nature of climate change, how high emission pathways and vulnerabilities to climate impacts are driven by the unsustainable ways in which we currently organise services and produce and

[8] 'Transition' and 'transformation' are often used interchangeably to understand and support systemic, radical and non-linear societal change (Hölscher et al. 2018a). Whether the terms 'transformation' and 'transition' are preferred largely relates to epistemic communities rather than a substantive difference in meaning (ibid.; Feola 2015). We employ transformation because it is adopted more widely to describe both process and outcome of changes.

Figure 3.1: The structuration of transformative climate governance: connecting 'what' to 'who' and 'how'



consume resources as well as how climate impacts affect multiple systems and dimensions related to human and environmental wellbeing (Tàbara et al. 2018; Hermwille 2016).

Along key descriptors of system change, sustainability transitions and resilience approaches provide a comprehensive understanding of what changes in the course of transformations, how change dynamics occur and towards which directions such dynamics can be influenced (Hölscher et al. 2018a; Feola 2015). This generates synthesised implications for transformative climate governance, which addresses climate change in the systemic context of transformations towards sustainability and resilience (Table 3.1). Our definition of transformative climate governance responds to three questions: Transformative climate governance develops problem-based and systemic climate mitigation and adaptation policies (governance of what) that contribute to sustainability and resilience across sectors and scales (governance for what and whom) by creating the conditions for mobilising and responding to different types of transformation dynamics (climate governance processes).

3.3.1 System model: climate governance of what?

The starting point for understanding transformative societal change is a systemic perspective, which means an encompassing view on the interrelated and interdependent parts of a given system (Loorbach et al. 2017; Folke 2016; Hölscher et al. 2018a). A key difference is the nature of systems transitions and resilience approaches concentrate on, which influences what system elements and feedbacks they analyse and recognise as requiring attention of agency and governance (Smith and Stirling 2010).

Table 3.1: Synthesis of sustainability transitions and resilience approaches and implications for transformative climate governance

Descriptor of system change	Sustainability transitions approaches	Resilience approaches	Implications for transformative climate governance
System focus *How is the system defined? What are key elements of the system?*	*Focus on complex adaptive and open systems (interactions across scales and sectors)*		**Problem-based system insight: climate governance of what?** Develop fit-to-context and fit-to-purpose climate strategies and actions that address social, institutional, technological, economic and ecological drivers and impacts of climate change across scales, sectors and policy priorities.
	Societal (sub-) systems (e.g. energy, mobility, cities) including social, institutional, political, economic and technological system elements	Social-ecological geographical (sub-)systems (e.g. global, regional, local) including social, institutional and ecological system elements	
Models of system change *How does the system change over time?*	*Complex and uncertain system patterns and mechanisms including path-dependency, emergence, thresholds*		**Mobilising transformation dynamics in tune with opportunity contexts: climate governance processes** Mobilise and respond to different types of transformation dynamics by facilitating disruptive innovation, destabilising unsustainable regimes and safeguarding from disturbances, risks and uncertainty. This requires staying tuned to opportunity contexts to make use of crisis as opportunities for overcoming system inertia while ensuring effective coping and incremental responses that contribute to radical change in the long-term.
	'How' non-linear change occurs focusing on dialectics between path-dependency, emergence and radical innovation	'What' are emergent patterns of change and how do these evoke surprises, risks and crossing of thresholds	
	System change involves long phases of incremental change and short phases of rapid, radical change		
	Different phases of a transition with different speeds of change and opportunity contexts for navigating transitions	Different system change phases with different speeds of change and opportunity contexts	
Normative system properties *What properties are used to assess and orient systems' development pathways?*	*System change is contested and can be desirable and undesirable*		**Co-creating sustainability and resilience goals: climate governance for what and for whom?** Ensure collaborative and inclusive decision-making processes to position climate mitigation and adaptation within sustainability and resilience goals across sectors and scales.
	Focus on shift from unsustainable to sustainable system state	Resilience as a non-normative performance measure of the ability of a system to withstand disturbances without changing its identity	

Sustainability transitions research focuses on societal (sub-)systems (e.g. energy, mobility, urban), which emphasises the interdependence and co-evolution of material and social structures, including technologies, institutions, politics, culture and markets (Markard et al. 2012; Loorbach et al. 2017). Resilience approaches focus on social-ecological systems, which are often situated in spatially specific contexts, e.g. a region or watershed, and highlight how humans societies (including economic, political, institutional and cultural dimensions) are embedded and interact with environmental resources and ecosystems (Berkes 2017; Anderies et al. 2004). Both approaches acknowledge the

arbitrariness of system boundaries because of multiple cross-scale and cross-sectoral interactions between resource flows and institutional contexts creating interdependencies, synergies and trade-offs (Berkes 2017; Coenen et al. 2012).

The systemic perspective suggests problem-based and systemic approaches to transformative climate governance that deploy solutions that are fitted to specific contexts and problems (rather than scales and sectors) (Tàbara et al. 2018; Chelleri et al. 2015). Transformative climate governance thus starts from an understanding of climate change as a symptom of unsustainability and mal-adaptation and an amplifier of vulnerabilities and risks, including building developments and place attachment in flood-prone areas, ageing infrastructure and social stratification (Wilson et al. 2013; Seto et al. 2016). For example, vulnerabilities to climate change impacts in cities result from and are reinforced by interactions between residential choices, infrastructure policies, structural inequalities and land and real estate markets (Alberti et al. 2018; Rosenzweig et al. 2015). As systemic drivers and impacts of climate change, sustainability and vulnerability interact across scales and sectors, the challenge for transformative climate governance is to ensure context-specific decision-making, implementation and evaluation and an explicit consideration of synergies and trade-offs across scales and sectors resulting from action in one particular locality or sector (Chelleri et al. 2015). This is why sustainability transitions and resilience approaches highlight polycentric governance as a way to ensure a diversity of input, exchange of resources and compatibility between knowledge and context needs (Galaz et al. 2011; Moloney and Horne 2015).

3.3.2 Models of system change: climate governance processes

Sustainability transitions and resilience approaches have developed various concepts and frameworks to analyse, explain and intervene in patterns and mechanisms of system change such as path-dependency, emergence and thresholds resulting from the co-evolution of interdependent system elements (Feola 2015; Hölscher et al. 2018a). The starting point is how a prevailing modus operandi is embedded in regimes (e.g. dominant social practices, technologies; societal expectations, market structures) and the dynamics influencing regime change (Rotmans et al. 2001; Folke et al. 2010).

Transitions approaches' MLP and resilience approaches' panarchy both distinguish between three driving forces: innovation to provide alternatives to regimes; tension and destabilisation within the regime as a result of path-dependency and lock-in; and pressures from 'above' that create opportunities for change or risks of crossing thresholds (Loorbach 2014; Folke et al. 2010). While sustainability transitions focus on the path-dependencies and lock-ins resulting from regime structures (Rotmans and Loorbach 2010), resilience approaches address how emerging changes, disturbances and risks pressure existing regimes (Anderies et al. 2004; Folke 2016). The multi-phase model (transitions) and adaptive cycle (resilience) nuance how and when these dynamics can be supported or mobilised through agency and governance: The first phase of a transition or of shifting towards the backloop of the adaptive cycle can be supported by problem structuring, envisioning and experimentation, followed by leadership, coalition building, linking niche-innovations and utilising opportunities for change (Olsson et al. 2006; Westley et al. 2013; Fath et al. 2015; Biggs et al. 2010). A new regime becomes stabilised through policy, legislation and institutionalisation.

The perspective on different types of transformation dynamics highlights different types of intervention points for transformative climate governance. Sustainability transitions and resilience approaches provide a complementary perspective on how agency and governance can, and should, mobilise and respond to dynamics: by supporting disruptive innovation and strategic phase-out of existing regimes driving path-dependencies and lock-ins driving high-emissions, unsustainability, mal-adaptation and vulnerability (transitions approaches; Bosman et al. 2018; Loorbach et al. 2015; Raven et al. 2010) and by strengthening self-organisation to respond to the outcomes of change dynamics in terms of disturbances and uncertainty (resilience approaches; Folke 2016; Berkes 2017). Transformative climate governance is then not so much about controlling rather than creating the conditions for influencing the transformation dynamics by unsettling unsustainable regimes, enabling innovation and coping with surprise and disruption (Loorbach 2014; Folke 2016). The temporal dimension shows that these adaptive and transformative strategies need to co-exist to account for different time horizons and make use of opportunities for change (Chaffin et al. 2016; Anderies et al. 2013).

3.3.3 Normative system properties: climate governance for what and for whom?

Sustainability transitions and resilience approaches employ different concepts to assess whether transformations take desirable or undesirable directions. Sustainability transitions research characterises a desired system state based on its sustainability, contrasting the unsustainable state in the present and the inability to continue along the dominant development pathway indefinitely with envisioned sustainable, far-away future states (Loorbach et al. 2017). Resilience approaches employ (social-ecological or evolutionary) resilience as a way to measure the capacity of systems to absorb disturbance, reorganise, develop and renew while undergoing change in non-equilibrium contexts (Folke 2016).

Sustainability and resilience guide long-term transformative climate governance. Embedding climate governance within broader ambitions for sustainability and resilience reconciles long-term perspectives for a desirable future with short-term and mid-term win-win solutions that address the question of climate mitigation and adaptation 'for what', and 'for whom' (Tàbara et al. 2018). Sustainability provides a normative performance metrics identifying specific desirable outcomes of any policy or intervention, e.g. zero emissions, equity, safety (Anderies et al. 2013). Integrating climate and sustainability goals does not only demand more systemic climate solutions that are defined in synergy with other priorities and goals: it also implies the need to integrate climate change into all sectoral decision-making and planning at all scales (den Exter et al. 2014). Resilience draws attention to the operational context, including thresholds and uncertainty, for making decisions about synergies and trade-offs between different priorities and goals (e.g. between urban densification for emission reduction and increased flood vulnerability) (Anderies et al. 2013; Ürge-Vorsatz et al. 2018). Approaches to specified resilience 'of what, to what, and for whom', which also recognise undesirable resilience in the form of traps, address questions about what system conditions are to be made resilience and what should be allowed to change (Carpenter et al. 2001; Boonstra and de Boer 2014). The identification of (un)desirable resilience in line with sustainability goals informs decisions about how to address transformation dynamics: it helps identifying what (parts of) regimes to destabilise, what innovations to support and what values and assets to protect. This resonates the distinction in climate governance

literature between incremental and transformative adaptation, which recognises that incremental steps may be necessary to achieve transformation – as long as it is on the same path towards sustainability and resilience (Wilson et al. 2013; Patterson et al. 2016).

Sustainability and resilience are both normative concepts in governance, because identifying sustainability goals and determining what is to be made resilient and what should change requires normative judgements, and not everybody will benefit equally (Meerow et al. 2016; Avelino 2017). Transitions and resilience approaches generally emphasise notions of participatory and 'good' governance and the collective co-definition of sustainability and resilience (Folke et al. 2010; Hölscher et al. 2017). However, transformative climate governance, especially in instances where pre-emptive and transformative actions become necessary, requires a much more politicised theory of change: whose vision are we pursuing, who bears costs etc. (Gillard et al. 2016).

3.4 Towards 'who' and 'how': agency propositions for transformative climate governance

From our literature review above, we identify four distinct functions for transformative climate governance. Transformative climate governance requires systemic and problem-based approaches that integrate climate change with sustainability and resilience goals and are attuned to transformations dynamics (Table 3.1). The functions are output-oriented, i.e. they help to address different types of transformation dynamics to build and maintain sustainability and resilience. They provide a systematic structure for formulating agency-oriented propositions that facilitate the creation of conditions for delivering the functions (Figure 3.1).

Both approaches recognise that all kinds of actors – individual and organisational, from different societal spheres (e.g. government, market, civil society) and sectors – consciously or unconsciously act to influence transformative change (Rauschmayer et al. 2015; Folke et al. 2005). The ways in which they approach agency strategies resonates their entry points on innovation of new and sustainable regimes (transitions approaches) or adapting to continuous system change and uncertainty (resilience approaches). This provides complementary concepts and insights about agency for delivering the transformative climate governance functions. We reviewed both literatures and the activities they identify in relation to the distinct functions and clustered these into different types of conditions for delivering the functions (Table 3.2).

Table 3.2: Transformative climate governance functions and agency propositions for building the functions' conditions

Governance functions	Sustainability transitions approaches	Resilience approaches	Agency propositions for building transformative climate governance conditions
Stewarding *Ability to anticipate, protect and recover from uncertainty and risk while exploiting opportunities beneficial for sustainability*		Adaptive governance and adaptive capacity (Folke et al. 2005; Dietz et al. 2003; Chaffin et al. 2014); resilience (Chapin et al. 2010; Folke et al. 2010)	**a. Generate knowledge about how systems respond to change and disturbance** Generate integrated knowledge based on models of societal systems as dynamic social-ecological-technological systems to identify long-term impacts, uncertainties and synergies and trade-offs across scales, sectors and time. **b. Strengthen self-organisation at multiple scales to respond to risks and uncertainty** Establish decentralised, multi-level and flexible governance institutions to facilitate self-organisation between multiple actors and problem-oriented and fit-to-context solution approaches. **c. Ensure monitoring and continuous learning** Strengthen social and institutional memory and reflexive learning mechanisms for continuous monitoring how the system responds to change and the effects of management.
Unlocking *Ability to recognise and dismantle structural drivers of unsustainable path-dependencies and mal-adaptation*	Regime destabilisation (Geels 2014; Turnheim and Geels 2013; Kivimaa and Kern 2016; David 2017; Bosman et al. 2018); phase-out (Loorbach 2014)		**d. Reveal unsustainable path-dependencies and mal-adaptation** Develop models and mechanisms to identify sources and responsibilities for unsustainability and vulnerability (e.g. system and vulnerability analyses). **e. Undermine regime structures** Withdraw support create disincentives and control policies for, and divest from regime structures, cultures and practices (e.g. technologies, actor networks) that perpetuate unsustainability and vulnerability. **f. Break open resistance to change** Foster political willingness and public awareness for change, create awareness for alternatives and diminish support for business-as-usual.

Governance functions	Sustainability transitions approaches	Resilience approaches	Agency propositions for building transformative climate governance conditions
Transforming *Ability to create and diffuse novelties that contribute to sustainability and resilience and to embed these novelties in structures, practices and discourses*	Niche experimentation and leadership (Raven et al. 2010; Brown et al. 2013); embedding, scaling and replicating (Ehnert et al. 2018); transition arenas to create guiding visions and agendas (Loorbach et al. 2015)	Experimentation and leadership (Westley et al. 2013; Olsson et al. 2006; Biggs et al. 2010)	**g. Enable novelty creation** Create (institutional, financial) space and connect actors for the development and testing of novelties (e.g. new paradigms, practices, solutions, framings, targets). **h. Increase visibility of novelty** Create alliances and support networks and showcase novelties to gain visibility, traction and support. **i. Anchor novelty in context** Enable learning from experimentation and translate 'proof-of-concept' lessons to align strategic, organisational and institutional processes and structures with the novelty.
Orchestrating *Ability to coordinate multi-actor governance processes and foster synergies and minimise trade-offs and conflicts across scales, sectors and time*	Intermediation, boundary spanning and brokering (Hodson and Marvin 2010; Frantzeskaki et al. 2014; Kivimaa 2014; Smink et al. 2015)	Polycentric governance (Galaz et al. 2011; Anderies et al. 2016)	**j. Strategic alignment** Co-create systemic and long-term visions for sustainability and resilience to align priorities towards common goals and identify synergies and trade-offs. **k. Mediating across scales and sectors** Create formal and informal communication channels and connection nodes through intermediation, knowledge brokering and boundary spanning for knowledge gathering, processing and exchange, connecting actors and resources, and building strategic alliances. **l. Create opportunity contexts** Set (political, financial, institutional etc.) incentives and conditions that integrate long-term and multi-scale thinking to provide a framework for cooperation and long-term win-win situation within good governance principles.

3.4.1 Stewarding: anticipating, protecting and recovering from uncertainty and risk

Stewarding means strengthening and protecting desirable resilience in social-ecological systems to flexibly respond to and recover from on-going changes, uncertainty and emerging risks, stresses and surprises to protect critical societal and ecological values and create opportunities beneficial for sustainability and resilience (Folke 2016; Chapin et al. 2010). This relates to resilience approaches'

notions of adaptability and adaptive governance that help governing complex systems when knowledge is incomplete and surprise is likely (Folke et al. 2005; Chapin et al. 2010; Chaffin et al. 2014).

The (g) *generation of knowledge about how systems respond to change and disturbance* enables anticipating emergent long-term risks and uncertainties and to attune governance and management systems and development practices to societal and ecological processes and dynamics (Folke 2016; Chapin et al. 2010). Social knowledge generation networks combine multiple knowledge systems and facilitate co-production and dissemination of knowledge (Folke et al. 2005; Chaffin et al. 2016; Berkes 2017). Inclusive (h) *self-organisation between multiple actors across scales* enable dynamic responses to change, risks and uncertainty (Chaffin et al. 2016; Berkes 2017; Folke et al. 2005). Polycentric institutions, open and simple institutions and rules (e.g. rules-of-thumb) and social networks facilitate decentral, problem-oriented and fit-for-context action and responses and enhance awareness and responsibility sharing (Berkes 2017; Koop et al. 2017). Due to the high levels of complexity and uncertainty, stewarding is not a search for one optimal solution but requires (i) *monitoring and continuous learning* through on-going and iterative knowledge acquisition and incorporation of learning outcomes into actions and policies (Folke 2016; Berkes 2017; Chapin et al. 2010). This requires fostering learning partnerships and a collective social memory for linking past experiences with the present and future (Koop et al. 2017; Folke et al. 2005).

3.4.2 Unlocking: recognising and dismantling unsustainable path-dependencies

Unlocking refers to the opposite side of innovation: the strategic destabilisation and phase-out of existing unsustainable regimes that create path-dependencies, 'traps' and mal-adaptation, including technological lock-ins, social values and individual behaviours, vested interests, incentive structures and markets (Loorbach 2014; David 2017; Turnheim and Geels 2012).

The (d) *revelation of unsustainable path-dependencies and mal-adaptation* through problem structuring, baseline measurements, transition scenarios and system analyses help identify root causes and drivers of undesirable lock-in (e.g. rules, technologies, actor networks, behaviours) that need to be strategically phased out (Kivimaa and Kern 2016; Bosman et al. 2018). (e) *Undermining regime structures* puts incumbents under pressure by challenging vested interests, incentive structures and reducing the comparative advantage of unsustainable business-as-usual practices to alternatives (Kivimaa and Kern 2016; David 2017). This involves openly challenging and questioning existing narratives and assumptions (Bettini et al. 2015; Bosman et al. 2018), withdrawing (financial, regulatory, political etc.) support and divestment (Geels 2014; Kivimaa and Kern 2016; David 2017) and penalising unsustainable regime technologies and practices (Geels 2014; Kivimaa and Kern 2016; David 2017). Activities to (f) *break open resistance to change* diminish societal and political support for business-as-usual and create opportunities and awareness for alternatives (Bettini et al. 2015; Bosman et al. 2018; Turnheim and Geels 2012). Activities include framing unsustainable technologies and practices as obsolete and amplifying small wins (Termeer et al. 2017; David 2017) and creating awareness and positive visions for alternatives (Turnheim and Geels 2012).

3.4.3 Transforming: enabling, diffusing and embedding radical innovations

The transforming function enables creating, diffusing and embedding novelties (e.g. new ways of organising, producing, consuming and thinking through social, technological and governance innovations). This function is derived from the recognition in both sustainability transitions and resilience approaches that viable and sustainable alternatives are needed to replace existing unsustainable regimes and avoid possibly disastrous consequences on societal well-being and the environment (Chaffin et al. 2016; Rotmans et al. 2001).

Transitions and resilience approaches pay much emphasis to processes that enable (a) *novelty creation*, including creating space, resources and networks to support frontrunners developing and testing diverse types of innovations (Raven et al. 2010; Olsson et al. 2006; Loorbach et al. 2015; Westley et al. 2013). Secondly, activities to (b) *increase the visibility of novelties* help them gain traction and (e.g. public, political, economic) support to encourage wider uptake and challenge existing regimes (Raven et al. 2010; Westley et al. 2013; Brown et al. 2013). Activities include forming advocacy alliances and support networks, connecting to other actors and on-going processes and showcasing innovation (Loorbach et al. 2015; Moore and Westley 2011; Ehnert et al. 2018). For an innovation to result in more enduring change, (c) *novelty embedding* activities routinise and institutionalise new structures, processes, positions or regulations or replicating and scaling of a specific project (Ehnert et al. 2018; Raven et al. 2017). Activities include creating space for learning from tested solutions and practices and developing a bricolage of 'proof-of-concept' elements for contextualisation, replicating and upscaling (Ehnert et al. 2018; Smith and Raven 2012; Bettini et al. 2015).

3.4.4 Orchestrating: coordinating multi-actor governance processes

Orchestrating refers to the coordination of multi-actor governance processes across scales and sectors in alignment with common goals. Governance of transformation is dispersed across actors and networks interacting across scales, sectors and policy priorities (Raven et al. 2012; Chaffin et al. 2016). There is a risk that the governance of transformation falls apart over time without structured coordination that connects the emerging alternatives, ideas, people and solutions (Loorbach 2014; Chaffin et al. 2016; Hodson and Marvin 2010).

The (j) *strategic alignment* of the multiple actors and networks towards long-term goals for sustainability and resilience provides common reference points for concerted action that create synergies and avoid trade-offs across sectors, scales and times (Hodson and Marvin 2010; Loorbach et al. 2015). Such goals need to be co-created to ensure that all interests are heard, increase ownership, deal with conflicts, safeguard against overlooking issues of social justice and mediate good compatibility between knowledge and different contexts (Loorbach et al. 2015; Hölscher et al. 2017). The (k) *mediation of knowledge, resources, contacts, ideas etc. across sectors and scales* creates opportunities for collaboration and supports resource synergies, knowledge and resources dissemination, diffusion of new technologies and practices and conflicts resolutions (Frantzeskaki et al. 2014; Kivimaa 2014). Intermediary, knowledge brokering and boundary spanning activities create convening spaces for face-to-face contact and instigate learning processes by gathering, processing, combining and distributing knowledge (Kivimaa 2014; Gliedt et al. 2018; Olsson et al. 2007; Smink et al. 2015). More formalised mediation processes, taken up for example by local city governments, include overseeing

and connecting actions within a specific context (e.g. city), creating central connection nodes, and brokering information to the policy regime (Frantzeskaki et al. 2014; Gliedt et al. 2018). Incorporating long-term and multi-scale thinking into (political, financial and institutional) incentives and decision-making (l) *creates opportunity contexts* for cooperation and win-win solutions in alignment with the long-term goals (Loorbach 2014). This is necessary because the long-term focus of transformations is often at odds with the ways societies make decisions, which is based on addressing short-term needs and keeping costs low (ibid.; Meadowcroft 2009). Framework conditions also need to leave space for experimentation and policy mixes while setting clear and strict boundaries within which development can take place (Folke 2016; David 2017).

3.5 Discussion and conclusion

The on-going changes of the global climate governance landscape and the persistent inability to avoid high carbon futures and adapt to climate impacts raises questions about why, how, by whom and with what effects climate governance takes place (Bulkeley 2015; Jordan et al. 2015). Drawing on the concepts and insights provided by sustainability transitions and resilience approaches we define transformative climate governance to conceptualise climate governance in the context of sustainability and resilience transformations. Transformative climate governance requires systemic and problem-based approaches that integrate in an inclusive way climate change with sustainability and resilience goals across scales, sectors and policy priorities.

We respond to the need for new frameworks to bridge between actors, activities and responsibilities on global to local levels and the conditions that (need to) emerge for effectively accomplishing climate governance (Huitema et al. 2018; Jordan et al. 2015; Bulkeley 2015). The functions are agency-based: we have used an agency perspective to identify what kind of conditions enable transformative climate governance. The agency-based propositions for transformative climate governance emphasise an action-oriented and empowering approach to understanding and supporting transformative climate governance. Our work also provides a strategic agenda for synthesising the complementarities of sustainability transitions and resilience literatures. Both approaches have by now developed a substantial theory about transformative and adaptive agency and governance that together provide a perspective on how to address unsustainable path-dependencies, risks of thresholds and uncertainty not only with regard to climate change.

Rather than predefining solutions, the functions for transformative climate governance are meant to provide a starting point for understanding the on-going changes in the climate governance landscape at multiple levels and for guiding the development of conditions for transformative climate governance. The functions help exploring knowledge gaps related to how decentralised and polycentric climate governance can be made to work effectively (Jordan et al. 2018; van Asselt et al. 2018) or how innovation diffuse (Howlett 2014). We briefly illustrate how the functions help understanding on-going climate governance, including opportunities and barriers or gaps (see also Hölscher et al. 2018b):

- *Stewarding*: (Unequivocal) climate impacts will detrimentally affect urban and rural populations, infrastructures, consumption and production systems (e.g. agriculture, water) (Steffen et al. 2018; Rosenzweig et al. 2015). Climate-proofing measures to build resilience often focus on short-term and technocratic coping approaches (e.g. building a seawall, awareness raising) and incremental approaches (e.g. incorporation of a future level of risk in planning, upgrade of zoning regulations) rather than more transformative ones (e.g. incorporating resilience principles in infrastructure planning, planned retreat, building social networks) (Torabi et al. 2018).
- *Unlocking*: Effective mitigation and adaptation to climate change require decisive disruptions of the status quo, including user practices and expectations, technologies, business models, market structures, policies and infrastructures (Geels 2018; Meadowcroft 2009). However, the kinds of aggressive efforts necessary to dramatically divest from fossil fuel industries are not yet seen in practice – for example, governments continue to actively support fossil fuel industries through subsidies and support for road and aviation infrastructure (Roberts et al. 2018; Seto et al. 2016).
- *Transforming*: Examples of climate governance experimentation from collaboration between businesses, governments and civil society are already well-document in literature, especially on urban levels (Castàn Broto and Bulkeley 2013; Kivimaa et al. 2017). Questions remain with regard to their wider impacts in policy mixes, upscaling and legitimacy (Turnheim et al. 2018; van Asselt et al. 2018).
- *Orchestrating*: Effective polycentric climate governance requires balancing of monocentric, centralised and polycentric, decentralised force (Jordan et al. 2018). While meta-governance, orchestrating and boundary spanning by for example international agencies or intermediaries help aligning, motivating and supporting climate action across scales and sectors (Abbott 2017; Dąbrowski 2017), currently there is a lack of top-down coordination and mainstreaming of climate change by central (international, national etc.) authorities in addition to a mismatch of regulations and institutional frameworks across levels of governance and across sectors (Seto et al. 2016; Moloney and Horne 2015; van Asselt et al. 2018).

The political dimension of (transformative) climate governance demand serious attention, including what information counts, who makes decisions, what weight is given to different priorities and who bears the costs (Gillard et al. 2016; Bulkeley 2015). We hope that the framework leaves room for exploring related questions. Paying attention to the agency of how conditions for transformative climate governance are created helps understanding who shapes climate governance and priorities, how different actors interact, which factors they consider when selecting strategies and how their activities relate to the emergence of innovations in climate governance (Hodson et al. 2018; Koch et al. 2016). As there are no blueprint solutions for transformative climate governance, guidance must be developed from case study specific evidence (Chaffin et al. 2016).

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Intermezzo A

Capacities for transformative climate governance

Intermezzo A

Capacities for transformative climate governance

Explaining, evaluating and supporting the development of urban climate governance vis-à-vis existing urban governance regimes and whether it results in transformative climate governance requires new frameworks and concepts. Frameworks need to be apt to bridge between the diverse actors and activities driving governance shifts, the institutional and organisational governance conditions that emerge as a result, as well as the contribution of these conditions to navigating urban transformation under climate change. My main premise is that enabling transformative climate governance requires the development, and better understanding, of new governance capacities that create institutional space and facilitate those actions that can purposefully contribute to navigating such sustainability and resilience transformations under climate change in cities. Understood as an emergent property that is constantly mediated through the formal and informal collaboration and learning processes between multiple governance actors and how they interact with their institutional and organisational contexts, the notion of governance capacities facilitates explanation and evaluation of how and whether and whose capacities for transformative climate governance are developing (cf. (Innes and Booher 2003; González and Healey 2005).

This Intermezzo introduces the conceptual framework of capacities for transformative climate governance. The previous chapter has defined and conceptualised transformative climate governance as ideal-type and normative approach that allows actors to problem-based and systemic climate mitigation and adaptation policies (governance of what) that contribute to sustainability and resilience across sectors and scales (governance for what and whom) by creating the conditions for mobilising and responding to different types of transformation dynamics (climate governance processes). I have identified four distinct transformative climate governance functions and agency propositions for delivering those functions. The capacities lens provides a structuring approach to further conceptualise and operationalise an agency-based perspective on how governance conditions are developed for delivering the functions.

The capacities framework is a novel and systematic heuristic to explain and evaluate how, and by whom, the capacities are developed and enacted, what conditions emerge as a result, whether these conditions mark a shift towards transformative climate governance, what are capacity gaps, as well as how capacities can be supported. The main aim of the framework is to facilitate understanding about what transformative climate governance could look like, how it is evolving and how it can be strengthened vis-à-vis existing urban governance regimes. In addition, the capacities framework contributes to synthesising insights from different research approaches strands related to questions of 'transformation governance' for the conceptualisation and operationalisation of capacities for transformative climate governance. I envision diverse applications of the capacities framework: next to descriptive-analytical research, it also has the potential to support transformative research

approaches, which aim to co-create concrete and actionable strategies and solutions in transdisciplinary research settings for strengthening capacities in specific contexts (cf. Wittmayer and Hölscher 2017).

A.1 A capacities' perspective on transforming urban climate governance

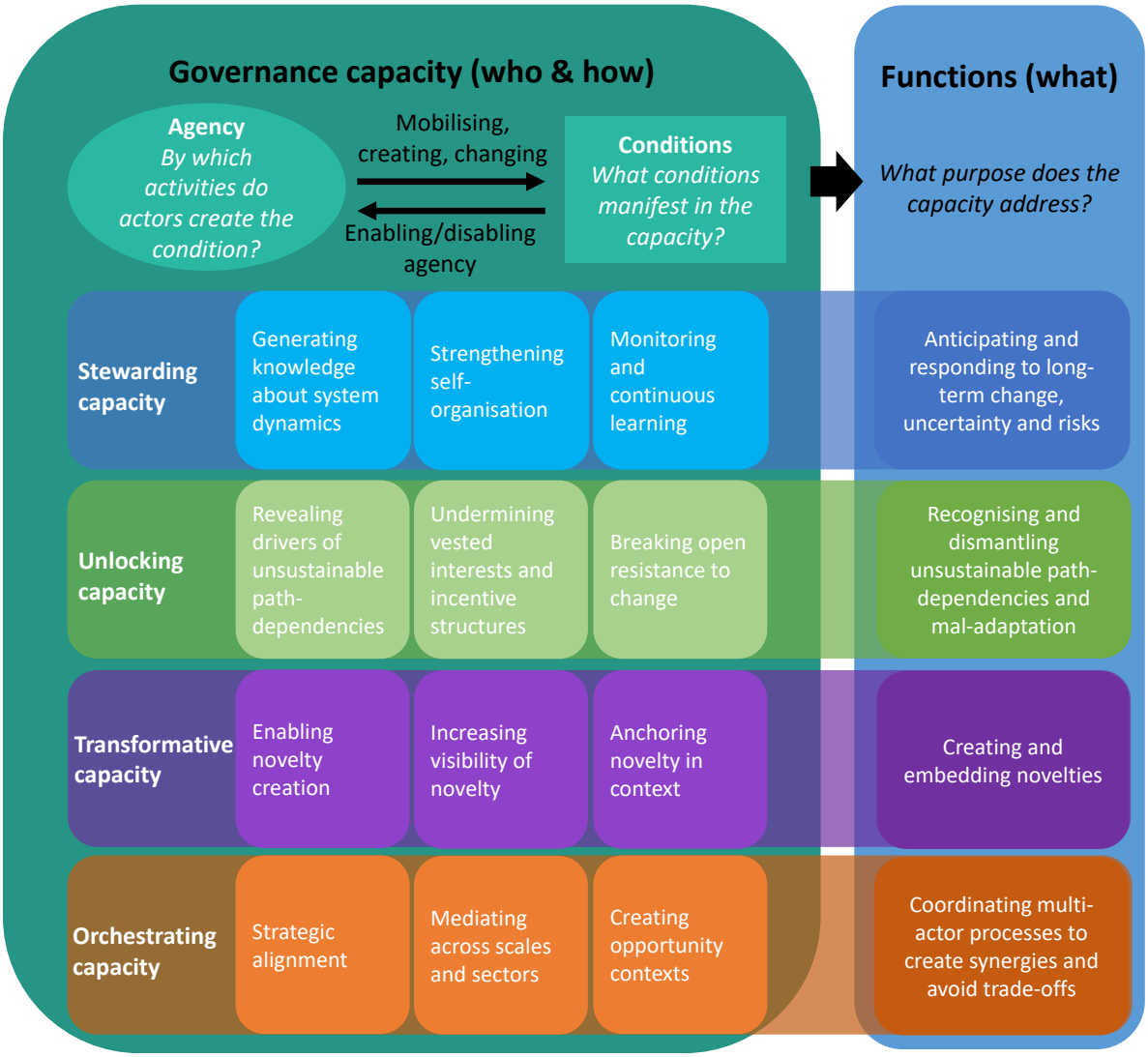
My research objective is to explain the development of urban climate governance and to assess whether it indeed manifests in capacities for transformative climate governance. This involves understanding how and by whom urban climate governance is enacted and evaluating whether new structural conditions emerge as a result of these activities that facilitate navigating urban transformations under climate change. The transformative climate governance functions I identified in the previous chapter by synthesising sustainability transitions and resilience approaches provide a systematic structure for conceptualising agency and for formulating agency-based propositions for transformative climate governance.

The capacity notion helps bridging between these agency-based propositions, the conditions that emerge as a result and the system-level impacts in terms of delivering the transformative climate governance functions (Figure I.A.1, see Section 1.3.1). I define governance capacities as manifest in the collective abilities of actors to mobilise, create and change structural governance conditions (e.g. formal and informal institutions, social networks, financial resources, knowledge), as well as the conditions that result from these activities and enable or disable collective action (cf. Boyd e al. 2014; Bettini 2013; Koop et al. 2017). Governance capacities are mobile: they are continuously developed and adapted through the actions of diverse governance actors. The agency-based perspective on how capacities are being developed makes governance capacity an "action-oriented and empowering concept" (Wolfram et al. 2017: p. 24) to identify opportunities and challenges for transforming urban (climate) governance.

The capacities framework can be applied in various analytical steps to derive diverse insights about transformative climate governance, how it is developing and to which effects (see Table 2.3 in Section 2.4.3, as well as Section 7.1.1). The assessment of capacity output functions allows to evaluate how capacities manifest in system-level change, such as whether novelties are created and embedded (transforming function) or risks are anticipated and responded to (stewarding function). The identification of urban climate governance actors and activities helps to explain who and how the capacities are developing, as well as which new governance conditions become manifest in the capacities.

In summary, the capacities framework allows to recognise the diffuse and dispersed picture of urban climate governance and to identify which capacity exists and where, and by whom this capacity has been generated. It is my hope that the capacities framework helps to not only explain and evaluate transformative (climate) governance in cities, but also to guide the proactive development of capacities. The dynamic and emergent lens of governance capacities concept makes it an action-oriented and empowering concept by highlighting the on-going learning processes and by allowing to

Figure I.A.1: Conceptual framework of capacities for transformative climate governance



derive recommendations about how to strengthen emergent capacities. In this way, governance capacity can act as a boundary concept that extends from the analytical domain of research and opens up a co-creative space between multiple actors to reflect on existing capacities and capacity gaps, and to define ways forward. I will return to opportunities for advancing and applying the capacities framework in Chapter 7.

A.2 Framework: capacities for transformative climate governance

Transformative climate governance starts from the premise that climate change cannot be anymore addressed as an isolated problem in cities: transformative climate governance allows actors to develop climate mitigation and adaptation actions in synergy with other policy priorities and goals so as to contribute to urban transformations towards sustainability and resilience. My definition of

transformative climate governance responds to three questions: Transformative climate governance develops problem-based and systemic climate mitigation and adaptation policies (*governance of what?*) that contribute to sustainability and resilience across sectors and scales (*governance for what and whom?*) by creating the conditions for mobilising and responding to different types of transformation dynamics (*climate governance processes*).

Based on the four functions for transformative climate governance, which relate to distinct transformation dynamics (see Chapter 3), I distinguish between four corresponding capacities to deliver those (Figure I.A.1). Each capacity manifests in different sets of conditions that are created by actors' activities and that enable delivering distinct output functions for transformative climate governance. Together, the capacities enable transformative climate governance: they enable mobilising urban transformation dynamics and develop integrated and systemic climate mitigation and adaptation actions that contribute to sustainability and resilience transformations.

To operationalise the capacities I reviewed sustainability transitions, resilience, (urban) climate governance and meta-governance literatures (see Chapter 2, Section 2.3.1). These literatures offer complementary concepts and insights for conceptualising and operationalising the identified capacities for transformative climate governance (Table I.1). The distinction in governance functions and capacities is already implicitly done by transformation researchers who, for example, identify processes and conditions for innovation and experimentation to create novelties that disrupt existing ways of thinking, doing and organising (Nevens et al. 2013; Castán Broto and Bulkeley 2013; Raven et al. 2017). Another example is the identification of governance processes and conditions that facilitate flexible and adaptive responses to emergent risks, surprises and uncertainties (Torabi et al. 2018; Boyd et al. 2014; Tanner et al. 2009). This resonates the shared assumption that different types of changes occur throughout transformation processes, which require distinct response qualities of governance. However, while there have been constructive debates about whether different approaches enrich each other, so far these debates do not offer an integrated perspective on the different types of transformation dynamics that need to be addressed (Olsson et al. 2014; Pereira et al. 2015; Chaffin et al. 2016).

This section presents how I operationalise the individual capacities for transformative climate governance with regard to the different sub-functions they deliver and the activities identified in the literature by which actors build conditions to deliver the sub-functions. The following three chapters – on the Rotterdam case study (Chapter 4), the NYC case study (Chapter 5) and the comparative case study (Chapter 6) – position the framework in these literatures in different ways. In Chapter 4, on the case study of capacities for transformative climate governance in Rotterdam, the framework is positioned within global climate governance literature and in particular, addressing the question of how to respond to high-end climate change (i.e. climate change beyond 2°C). In Chapter 5, which includes the NYC case study, the framework is positioned within literature on governance for urban sustainability and resilience transformations. Finally, in Chapter 6, which includes the comparative analysis of capacities for transformative climate governance in Rotterdam and NYC, the framework is explicitly positioned within debates on the development of urban climate governance. In this way, the framework is grounded in different types, or at least different nuances, of literatures and in different research questions relating to debates about 'transformations of governance' for 'governance for transformation' (Patterson et al. 2016). This strengthens the theoretical and analytical value of the

framework: the conceptualisation of the framework holds across different literatures and questions about the transformation of governance at multiple scales and in relation to other sectors. Chapter 7 discusses other possibilities for applying the framework.

Table I.A.1: Transformative climate governance capacities and related governance concepts across literatures (adapted from Hölscher et al. 2018a, Chapter 4)

Transformative climate governance capacity	(Urban) climate governance	Sustainability transitions	Resilience	Meta-governance
Stewarding: anticipating and responding to risk and uncertainty	Adaptation and adaptive capacity (Adger et al. 2005; Brown and Westaway 2011; Gupta et al. 2010); transformative adaptation (Wise et al. 2014; Kates et al. 2012; Lonsdale et al. 2015)	-	Adaptive governance and adaptive capacity (Folke et al. 2003; 2005; Dietz et al. 2003; Plummer 2013); resilience (Chapin et al. 2010; Matyas and Pelling 2014; Garmestani and Benson 2013)	-
Unlocking: recognising and dismantling unsustainable path-dependencies	Mitigation and mitigative capacity (Yohe 2001; Burch and Robinson 2007); exnovation (Hermwille 2017)	Regime destabilisation (Geels 2014; Turnheim and Geels 2012; Kivimaa and Kern 2016); phase-out (Loorbach 2014)	-	-
Transformative: creating and embedding novelties	Experimentation (Hoffman 2011; Hildén et al. 2017)	Niche experimentation and leadership (Raven et al. 2010; Brown et al. 2013; Loorbach et al. 2015); scaling and replicating (van den Bosch 2010; Ehnert et al. 2018)	Experimentation and leadership (Westley et al. 2013; Moore and Westley 2011; Olsson et al. 2006; Marshall et al. 2012)	-
Orchestrating: coordinating multi-actor processes	Orchestration (Abbott et al. 2015; Abbott 2017); Multi-level governance and boundary spanning (Bulkeley and Betsill 2013; Dąbrowski 2017); mainstreaming (Aylett 2015; Runhaar et al. 2018; den Exter et al. 2014)	Intermediation and meta-governance (Hodson and Marvin 2010; Hodson et al. 2013; Loorbach 2014; Frantzeskaki et al. 2014)	Polycentric governance (Galaz et al. 2011; Anderies et al. 2016)	Meta-governance (Sørensen 2006; Kooiman and Jentoft 2009; Capano et al. 2015)

A.2.1 Stewarding capacity: anticipating, protecting and recovering from uncertainty and risk

Climate impacts and vulnerabilities cause short-term and long-term risks, uncertainty and surprise in cities (Johnson et al. 2015; Rosenzweig et al. 2015; Carter et al. 2015). Stewarding capacity[9] enables anticipation of and responsiveness to uncertainty and risk while exploiting opportunities beneficial for sustainability. In other words, stewarding contributes to building (existing or new) desirable resilience to flexibly respond to and recover from on-going changes, uncertainty and emerging risks, stresses and surprises to protect critical societal and ecological values and create opportunities beneficial for sustainability and resilience. This strongly relates to resilience approaches' notions of adaptability and adaptive governance that help governing complex systems when knowledge is incomplete and surprise is likely (Folke et al. 2005; Chapin et al. 2010; Chaffin et al. 2014).

The *generation of knowledge* and understanding about both complex, long-term social-ecological system dynamics across scales enables anticipating emergent risks and uncertainties and attuning governance and management systems and development practices to societal and ecological processes and dynamics (Folke 2016; Chapin et al. 2010). Knowledge needs to account for interactions across temporal and spatial scales, organisational and institutional levels, as well as (informational) uncertainty (Folke 2016; Chelleri et al. 2015). Social knowledge generation networks that are nested across scales and combine multiple knowledge systems, including scientific knowledge and tacit knowledge of local communities, underpin the co-production and dissemination of knowledge (Folke et al. 2005; Chaffin et al. 2016; Berkes 2017). Berkes (2017) stresses knowledge co-production as emergent dialogue, whereby the meaning and value of information is co-created among various interests and resulting in increasing levels of trust along with the ability to address complex problems.

Dynamic responses to change and disturbance are the product of *self-organisation* between multiple actors such as local communities, government agencies and non-governmental organisations (NGOs) that facilitate problem-oriented and fit-for-context action and responses (Chaffin et al. 2016; Berkes 2017). As complex problems cut across multiple governance levels, the creation of multi-level, polycentric and decentralised institutions and social networks facilitates context-specific self-organisation and management approaches (Berkes 2017; Diez et al. 2003; Lebel et al. 2006). Open and simple institutions and rules (e.g. rules-of-thumb) and clear responsibilities enable both flexible interpretations in relation to contexts' needs and ensure cohesion and integration between administrative, legislative and regulative frameworks across scales (Koop et al. 2017; Dietz et al. 2003). Inclusive dialogue enhances awareness of risks, responsibility sharing and power balance (Koop et al. 2017; Folke et al. 2005).

[9] I have opted for the term 'stewarding' rather than 'adapting' because it better signals the function – i.e. taking care of supportive social and ecological systems in an adaptive, reflexive and flexible way (cf. Folke 2016; Chapin et al. 2010) – rather than the type of change, which has caused some confusion about adaptive versus transformative capacity and incremental versus radical change (Pelling 2011; Lonsdale et al. 2015). In addition, adaptation is in climate adaptation literature often more narrowly understood in terms of adapting to climate change impacts rather than the explicitly broader understanding sought here.

Table I.A.2: Stewarding capacity

Capacity sub-functions	Governance activities
Generating knowledge about system dynamics	Developing knowledge based on models of cities as dynamic social-ecological-technological systems (Bai et al. 2017; Pickett et al. 2013; McPhearson et al. 2015)
	Identifying long-term impacts and cross-scale teleconnections (Chelleri et al. 2015; Koop et al. 2017)
	Establishing cross-scale, cross-sectoral and public-private networks to integrate different forms of knowledge (e.g. from scientists, practitioners, designers, communities) (McPhearson et al. 2015; Tanner et al. 2009)
	Integrating long-term uncertainty, developing scenarios and identifying and communicating sources of uncertainty (Torabi et al. 2018; Lonsdale et al. 2015; Tanner et al. 2009)
	Ensuring knowledge and information is credible, understandable and accessible and ensuring knowledge cohesion across actors, sectors and scales (Koop et al. 2017; Tanner et al. 2009)
Strengthening self-organisation	Creating multi-level, decentralised and nested institutions and social networks to enable fit-to-context management approaches (McPhearson et al. 2015; Torabi et al. 2018; Koop et al. 2017; Tanner et al. 2009; Boyd et al. 2014; Pahl-Wostl and Knieper 2014)
	Creating open and simple institutions and rules (e.g. rules-of-thumb) to enable flexible interpretations, collaboration and adaptation of rules if needed (Torabi et al. 2018; Koop et al. 2017; Bettini et al. 2015)
	Ensuring inclusive dialogue and informal governance systems to enhance awareness of risks, responsibility sharing and power balance (Koop et al. 2017; Chu et al. 2017; Schewenius et al. 2014; Tanner et al. 2009)
	Incorporating long-term risks and uncertainty into management and planning approaches for redundant, diverse, modular, flexible and safe-fail urban systems (Torabi et al. 2018; Koop et al. 2017; McPhearson et al. 2015; Tanner et al. 2009)
	Clarifying responsibilities and authorities across scales for cohesion and integration between administrative, legislative and regulative frameworks (Koop et al. 2017; Keskitalo et al. 2016)
Monitoring and continuous learning	Iteratively evaluating how the system responds to disturbances and the effects of management in line with underlying management assumptions, objectives and practices (Bettini et al. 2015; Koop et al. 2017; Pahl-Wostl et al. 2013)
	Fostering learning partnerships and a collective social memory of experience for linking past experiences with present and future (Torabi et al. 2018; Koop et al. 2017; Tanner et al. 2009)
	Recognising information gaps and creating open and public discussions on uncertainty (Bettini et al. 2015)

Due to the high levels of complexity and uncertainty, stewarding is not a search for one optimal solution but involves on-going knowledge acquisition through iterative, dynamic learning processes to reflect on and incorporate the consequences of actions and policies (Folke 2016; Berkes 2017; Chapin et al. 2010). *Monitoring and continuous participatory learning* are key ingredients to adapt management objectives and practices to changing situations in line with new information (Koop et al. 2017; Lebel et al. 2006). This requires fostering learning partnerships and a collective social memory for linking past experiences with the present and future (Koop et al. 2017; Folke et al. 2005).

A.2.2 Unlocking capacity: recognising and dismantling unsustainable path-dependencies

Dominant urban land use, design and living patterns that drive current high emission and unsustainable urban development pathways are deeply embedded in existing institutions, technologies, actor networks, behaviours and values (Bai et al. 2017; Ürge-Vorsatz et al. 2018; Seto et al. 2016; Bosman et al. 2018). Unlocking refers to the opposite side of innovation: the strategic destabilisation and phase-out of existing unsustainable regimes that create path-dependencies, 'traps' and mal-adaptation, including technological lock-ins, social values and individual behaviours, vested interests, incentive structures and markets (Loorbach 2014; David 2017; Turnheim and Geels 2012; Westley et al. 2011). Unlocking capacity is manifest in the abilities of actors and the conditions that enable recognising and dismantling of the structural drivers of unsustainable path-dependencies and mal-adaptation.

The *revelation of drivers of unsustainable path-dependencies and mal-adaptation* is critical for unlocking (Bosman et al. 2018; Loorbach et al. 2015). Knowledge generation mechanisms like problem structuring, baseline measurements, transition scenarios and system analyses help to recognise institutions, technologies and behaviours that perpetuate mal-adaptation and need to be strategically phased out (Loorbach et al. 2015; Lebel et al. 2009). Foci areas to identify intervention points are the rules, technologies and actor networks that enforce stability or, when they change, create instability of the regime (Kivimaa and Kern 2016).

Transition scholars theorise how existing regimes can be destabilised by putting incumbents under pressure and *undermining vested interests and existing incentive structures* that reduce the comparative advantage of unsustainable business-as-usual practices to alternatives (Kivimaa and Kern 2016; Edmondson et al. 2018). This involves openly challenging and questioning existing narratives and assumptions (Bettini et al. 2015; Bosman et al. 2014), withdrawing (financial, regulatory, political etc.) support (Geels 2014; Kivimaa and Kern 2016; David 2017) and penalising unsustainable regime technologies and practices (Geels 2014; Kivimaa and Kern 2016; David 2017). To terminate existing unsustainable structures, cultures and practices, it is also necessary to deliberately divest from human and financial capitals, remove physical infrastructures and break-up existing actor networks and key actors that tend to favour the status quo and hold systems in traps (David 2017; Kivimaa and Kern 2016; Chaffin et al. 2016).

The phase-out of existing structures and practices also requires *breaking open resistance to change* to diminish societal and political support for business-as-usual and create opportunities and awareness for alternatives (Bettini et al. 2015; Bosman et al. 2014; Turnheim and Geels 2012). This involves confronting social and cognitive fixations with counterintuitive interventions, framing unsustainable technologies and practices as obsolete and amplifying small wins (Termeer et al. 2017; David 2017). Turnheim and Geels (2012) found in the case of anti-smoking regulation that public education activities, alliances with alternatives and the positioning of smoke concerns within broader cultural visions (e.g. of modern, clean and healthy households) supported growing anti-smoke movements. They conclude that for low-carbon transitions alarming climate scenarios may be less effective in generating public support than positive visions of low-carbon futures.

Table I.A.3: Unlocking capacity

Capacity sub-functions	Governance activities
Revealing drivers of unsustainable path-dependency and mal-adaptation	Implementing baseline measurements and accounting mechanisms based on systemic and cross-scale perspectives (e.g. establishing carbon footprint, transportation patterns) to identify responsibilities for unsustainability and maladaptation (Sperling and Ramaswami 2017; Jhagroe and Frantzeskaki 2015; Loorbach et al. 2015)
	Devising regular accountability mechanisms and monitoring and updating strategies if required (Sperling and Ramaswami 2017)
	Considering transboundary spread of urban systems (e.g. energy, transportation) and key urban materials (Sperling and Ramaswami 2017)
Undermining vested interests and incentive structures	Openly challenging and questioning existing narratives and assumptions (Loorbach et al. 2015; Bettini et al. 2015; Ürge-Vorsatz et al. 2018)
	Withdrawing (financial, regulatory, political etc.) support for and penalising regime technologies, structures and practices (Bettini et al., 2015; Geels, 2014; Kivimaa and Kern 2017)
	Adjusting legal rights and responsibilities to set binding targets, create (dis)incentives and control policies (e.g. carbon and water budgets) (Kivimaa and Kern 2017; Sperling and Ramaswami 2017; Bettini et al.2015; Smith and Raven 2012)
	Divesting in human and financial capital by breaking up existing actor-networks and replacing key actors that underlie regime structures (Kivimaa and Kern 2016)
Breaking open resistance to change	Involving users and stakeholders in developing and modifying rules to foster public support (Sperling and Ramaswami 2017; Kivimaa and Kern 2017)
	Ensuring political support for change (Sperling and Ramaswami 2017; Moloney and Horne 2015; Kivimaa and Kern 2016)
	Providing tailored support mechanisms and right-size incentives for changing behaviours (Sperling and Ramaswami 2017; Moloney and Horne 2015)
	Unblocking stagnations by confronting social and cognitive fixations with counterintuitive interventions and amplifying small wins (Termeer et al. 2017)

A.2.3 Transformative capacity: enabling, diffusing and embedding radical innovations

Escaping current unsustainable and mal-adaptive urban development trajectories requires the development and diffusion of radical alternatives that provide new ways of doing, thinking and organising (Brown et al. 2013; Frantzeskaki et al. 2017; Loorbach et al. 2015). Transformative capacity enables creating, diffusing and embedding novelties (e.g. new ways of organising, producing, consuming and thinking through social, technological and governance innovations).

Transitions and resilience approaches pay much emphasis to processes that *enable novelty creation*, including ensuring space, resources and networks for developing and testing diverse types of innovations (Nevens et al. 2013; Olsson et al. 2006; Loorbach et al. 2015; Westley et al. 2013). This is supported by frontrunners who recognise opportunities and take up leadership for change by championing new narratives and mobilising social and political capital (Westley et al. 2013; Brown et al. 2013; Olsson et al. 2006). Protected and informal space (e.g. in terms of regulatory support and

Table I.A.4: Transformative capacity

Capacity sub-functions	Governance activities
Enabling novelty creation	Developing, testing and experimenting with new paradigms, practices, processes (Loorbach et al. 2015; Frantzeskaki et al. 2012; 2018; Castán Broto and Bulkeley 2013)
	Providing protected and informal co-creation spaces to nurture innovation (Raven et al. 2010; Smith and Raven 2012; Sengers and Raven 2015; Loorbach et al. 2015; Frantzeskaki et al. 2012)
	Supporting and creating informal and heterogeneous (shadow) networks for co-producing innovation (Loorbach et al. 2015; Sengers and Raven 2015; Raven et al. 2010; Brown et al. 2013)
	Flexibly interpreting or temporarily lifting administrative and regulative frameworks (Bettini et al. 2015)
Increasing visibility of novelty	Creating forging alliances and advocacy networks (Brown et al. 2013; Smith and Raven 2012; Ehnert et al. 2018)
	Creating internal support within an organisation through political leadership (den Exter et al. 2014; Wamsler 2015; Runhaar et al. 2018)
	Showcasing innovation as ways for achieving shared future visions and new narratives and linking to global discourses to generate societal and political support (Frantzeskaki et al. 2012; Brown et al. 2013; Smith and Raven 2012; Ehnert et al. 2018; Bettini et al. 2015)
	Showcasing (e.g. resource, social, institutional) synergies from novelty to generate support (Frantzeskaki et al. 2014; Ehnert et al. 2018)
Anchoring novelty in context	Ensuring (financial) viability for long-term implementation and replicating and upscaling (den Exter et al. 2014; Ehnert et al. 2018; Smith and Raven 2012)
	Establishing long-term innovation partnerships for replicating and upscaling (Ehnert et al. 2018; Smith and Raven 2012)
	Learning from tested solutions and practices to develop a bricolage of 'proof-of-concept' element and to enabling contextualisation in other contexts for replicating and upscaling (Ehnert et al. 2018; den Exter et al. 2014; Frantzeskaki et al. 2017)
	Routinising and institutionalising novelty by aligning organisational, institutional and operational structures and processes ('stretch-and-transform' and 'fit-and-conform') (Smith and Raven 2012; Ehnert et al. 2018; Bettini et al. 2015; Frantzeskaki et al. 2017; Wamsler 2015; den Exter et al. 2014; Runhaar et al. 2018)
	Developing open-minded and flexible personnel to take up lessons from innovation and overcome institutional barriers and to train practitioners to apply novelty in daily practice (Brown et al. 2013; Ehnert et al. 2018)

leeway, subsidies, research grants) facilitates protection and safe-to-fail experimentation from the structural pressures of a regime and thus critically facilitates the emergence of radical innovation (Fünfschilling and Truffer 2014; Raven et al. 2010; van Buuren and Loorbach 2009).

To challenge dominant regimes, innovations need to *gain traction and support* (Raven et al. 2010; Westley et al. 2013; Brown et al. 2013). This is achieved by processes that form growing support networks and alliances, connect to other actors and on-going processes and showcase innovation to increase visibility and acceptance of the innovation and encourage wider uptake (Nevens et al. 2013;

Loorbach et al. 2015; Moore and Westley 2011; Ehnert et al. 2018). The importance of public engagement and social acceptance is often overlooked in technocratic government strategies that focus on techno-economic dimensions and ignore deeper changes of behaviours and consumer interest that are needed to spread an innovation like onshore wind (Geels 2017).

For an innovation to result in more enduring change, *novelty embedding* needs to make the implications and lessons from an innovation more generalisable to translate them into existing or new structures, cultures and practices (Nevens et al. 2013; Ehnert et al. 2018; Hölscher et al. 2018b). Embedding can take different forms, including the routinisation and institutionalisation of new structures, processes, positions or regulations or replicating and scaling of a specific project (Ehnert et al. 2018; Bos and Brown 2012; Raven et al. 2018). Critical processes to ensure embedding are the creation of space for learning from tested solutions and practices and developing a bricolage of 'proof-of-concept' elements for contextualisation, replicating and upscaling (Ehnert et al. 2018; Smith and Raven 2012).

A.2.4 Orchestrating capacity: coordinating multi-actor governance processes

The distributed nature of urban climate governance activities across governance networks, scales and sectors induces a need for encouraging, coordinating and assisting action in alignment with shared long-term goals (Pahl-Wostl and Knieper 2014; Hodson and Marvin 2010; Keskitalo et al. 2016). Governance of transformation is dispersed across actors and networks interacting across scales, sectors and policy priorities, and there is a risk that the governance of transformation falls apart over time without structured coordination that connects the emerging alternatives, ideas, people and solutions (Loorbach 2014; Chaffin et al. 2016; Hodson and Marvin 2010). Orchestrating capacity is manifest in the abilities of actors to coordinate multi-actor urban governance processes and foster synergies and minimise trade-offs and conflicts across scales, sectors and time.

The *strategic alignment* of the multiple actors and networks towards long-term goals for sustainability and resilience provides common reference points for concerted action and helps to move from problem-focused to solution-oriented approaches (Hodson and Marvin 2010; Loorbach et al. 2015; Hölscher 2018). Positioning individual issues and priorities such as climate mitigation and adaptation within broader goals also serves to identify synergies and trade-offs across sectors, scales and time (Chelleri et al. 2015; McPhearson et al. 2017). Such a vision needs to be co-created to ensure that all interests are heard, increase ownership, deal with conflicts, safeguard against overlooking issues of social justice and mediate good compatibility between knowledge and different contexts (Loorbach et al. 2015; Wittmayer et al. 2014).

The *mediation* of knowledge, resources, contacts, ideas etc. across sectors and scales creates opportunities for collaboration and supports resource synergies, knowledge and resources dissemination, diffusion of new technologies and practices and conflicts resolutions (Frantzeskaki et al. 2014; Kivimaa 2014). Transitions and resilience scholars in this context highlight the roles of intermediaries, knowledge brokers and boundary spanners that create, mostly informal, convening spaces for face-to-face contact and collaboration networks to instigate learning processes by gathering, processing, combining and distributing knowledge (Kivimaa 2014; Gliedt et al. 2018; Smink et al. 2015). These roles can be taken up by diverse types of actors, including public, private, non-profit organisations and research institutes that provide and distribute information, services, help to

Table I.A.5: Orchestrating capacity

Capacity sub-functions	Governance activities
Strategic Alignment	Defining a shared, long-term and integrative strategic direction and reference points for joint courses of action (Chu et al. 2017; Loorbach et al. 2015; McPhearson et al. 2017; Moloney and Horne 2015)
	Engaging heterogeneous actor groups to create diverse ownership over strategic direction (Loorbach et al. 2015; Frantzeskaki et al. 2014; Moloney and Horne 2015; McPhearson et al. 2017)
	Identify synergies and trade-offs (McPhearson et al. 2017)
	Linking strategic direction to on-going processes (Chan et al. 2015; Loorbach et al. 2015)
Mediating across scales and sectors	Recognising, brokering and integrating resources (financial, knowledge, human etc.) and goals across scales and sectors (Frantzeskaki et al. 2014; Moore and Westley 2011; Dąbrowski 2017)
	Creating formal and informal convening spaces to exchange knowledge and resources, manage conflicts and seek collaboration (e.g. inter-municipal, cross-sectoral) (Hedensted Lund et al. 2012; Hodson and Marvin 2010; Hodson et al. 2013; Frantzeskaki and Kabisch 2016; Kivimaa 2014)
	Setting up formal and informal connection nodes, communication channels and facilitating information platforms to optimise interactions and link formal and informal processes (den Exter et al. 2014; Meier and Rodrigues Bolivar 2016; Keskitalo 2016; Gordon and Johnson 2017)
Creating opportunity contexts	Providing and integrating institutional frameworks for financial incentives, regulations and institutional designs that enable synergies in line with long-term goals (Pahl-Wostl and Knieper 2014; Abbott 2017; Keskitalo 2016; Gordon and Johnson 2017)
	Assisting actors and networks in implementing actions in line with goals (e.g. financing, guidance, technical assistance) (Abbott 2017; Gordon and Johnson 2017; Keskitalo et al. 2016)
	Incorporating long-term and multi-scale thinking, including considerations of social inclusivity, legitimacy and justice, into all decision-making, implementation processes and performance reviews (Chan et al. 2015; Nevens et al. 2013; Evans 2016)

articulate expectations and visions and build social networks (Fischer and Newig 2016; Kivimaa 2014; Gliedt et al. 2018). There is also a need for more formal mediation processes, taken up for example by local city governments that oversee and connect actions within a specific context (e.g. city) and also span across levels of governments by creating central connection nodes, supporting partnerships, clustering niches and brokering information to the policy regime (Frantzeskaki et al. 2014; Hölscher et al. 2018b; Gliedt et al. 2018).

The setting of (political, financial and institutional) incentives and conditions creates an *opportunity context* for cooperation and win-win situations. This involves incorporating long-term and multi-scale thinking into decision-making, implementation processes and performance reviews as well as decisively clarifying costs, benefits and responsibilities at systemic levels for taking up action in alignment with the long-term goals (Loorbach 2014; Hodson and Marvin 2010). This is necessary because the long-term focus of transformations is often at odds with the ways societies make decisions, which is based on addressing short-term needs and keeping costs low (Loorbach 2010; Meadowcroft 2009). Framework conditions also need to leave space for experimentation while setting clear and strict boundaries within which development can take place (Folke 2016). Another element of framework conditions is to enable policy mixes that are congruent by for example facilitating

innovation and phase-out in a way that strategically supports each other in the achievement of goals (David 2017). For example, instruments seeking to promote energy innovations should not oppose the goal of instruments that promote the phase-out of obsolete technologies such as coal in Germany (ibid.). Such goals need to be co-created to ensure that all interests are heard, increase ownership, deal with conflicts, safeguard against overlooking issues of social justice and mediate good compatibility between knowledge and different contexts (Loorbach et al. 2015; Hölscher et al. 2017a).

A.3 Framework applications

Overall, the capacities framework provides a novel heuristic to look at urban climate governance as an open-ended process driven by agency and to do so in relation to the fulfilment of defined governance functions. The capacities framework can be used to analyse and assess the extent to which these capacities are developing and to support governance actors (e.g. city officers, strategists) in developing these more systematically. As will be shown in the following chapters of this book, the empirical applications of the framework yield in-depth insights on the development of urban climate governance. Section 7.1 summarises the key insights generated by the framework.

The empirical applications of the framework to the development of urban climate governance yield in-depth insights on the activities by which actors create new types of governance conditions, and whether these conditions signify new capacities for transformative climate governance. Next to the cases presented in this book, the framework was already applied to different research questions and in different modes. For example, parts of the framework were applied to nine case studies of coupled infrastructure innovations to identify the actors and activities driving the innovation of coupled infrastructures (Hölscher and Wittmayer 2019). From these insights, we were able to formulate action-oriented guidelines and recommendations for federal, regional and local actors. The framework was also used to analyse in retrospect whether and how transition management supports the development of new kind of governance capacities (Hölscher 2018; Hölscher et al. 2017b). This made it possible to identify which process design steps and activities created conditions for systemic and innovative approaches to sustainable urban planning, including system analysis, visioning and the creation of ownership.

Next to the application to different research questions, the capacities framework has the potential to support transformative research approaches, which aim to co-create concrete and actionable strategies and solutions in transdisciplinary research settings (Wittmayer and Hölscher 2017). For example, the framework can support action-oriented research to facilitate the co-creation of governance capacities in specific contexts when it is integrated in practice-based governance frameworks such as transition management (Hölscher 2018). This type of research can address the need for social science knowledge in the face of climate change and for solution-oriented approaches on how society can change course from dangerous climate scenarios (Norgaard 2018). For example, the framework was applied to understand the available capacities in different socio-economic scenarios (Pedde et al. 2019). This study showed that in one scenario a strong economic and political elite capitalises power and resources, but has also the ability to put in place decisive and top-down sustainability a strategies and actions. In another scenario, institutional and organisational capacities

for sustainability and collaboration are weak. This subsequently supported stakeholders in workshops to formulate transformation pathways to achieve long-term visions for a sustainable and resilient future. The framework could also directly guide pathways development by indicating questions about what types of capacities need to be developed and how this could be done (e.g. how can unsustainable practices be phased-out, how can we achieve coordination and collaboration across sectors?) (Frantzeskaki et al. 2019).

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Chapter 4

Steering transformations under climate change: capacities for transformative climate governance and the case of Rotterdam, the Netherlands

Abstract

In light of the persistent failure to reduce emissions decisively, facilitate long-term resilience against climate change and account for the connectedness of climate change with other social, environmental and economic concerns, we present a conceptual framework of capacities for transformative climate governance. Transformative climate governance enables climate mitigation and adaptation while purposefully steering societies towards low-carbon, resilient and sustainable objectives. The framework provides a systematic analytical tool for understanding and supporting the already ongoing changes of the climate governance landscape towards more experimental approaches that include multi-scale, cross-sectoral and public-private collaborations. It distinguishes between different types of capacities needed to address transformation dynamics, including responding to disturbances (stewarding capacity), phasing-out drivers of path dependency (unlocking capacity), creating and embedding novelties (transformative capacity) and coordinating multi-actor processes (orchestrating capacity). Our case study of climate governance in Rotterdam, the Netherlands, demonstrates how the framework helps to map the activities by which multiple actors create new types of conditions for transformative climate governance, assess the effectiveness of the capacities and identify capacity gaps. Transformative and orchestrating capacities in Rotterdam emerged through the creation of space and informal networks for strategic and operational innovation, which also propelled new types of governance arrangements and structures. Both capacities support stewarding and unlocking by integrating and mainstreaming different goals, connecting actors to each other for the development of solutions and mediating interests. Key challenges across capacities remain because of limited mainstreaming of long-term and integrated thinking into institutional and regulatory frameworks. As the ongoing changes in climate governance open up multiple questions about actor roles, effective governance processes, legitimacy and how effective climate governance in the context of transformations can be supported, we invite future research to apply the capacities framework to explore these questions.

Status

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Fit with overall thesis

This paper presents the Rotterdam case study that was conducted for this thesis. In this paper, the capacities framework for transformative climate governance is positioned within global climate governance literature and in particular addressing the question of how to respond to high-end climate change (i.e. climate change beyond 2°C). The Rotterdam case study illustrates the applicability of the framework to explain and evaluate the development of climate governance at the urban scale.

Chapter 4

Steering transformations under climate change: capacities for transformative climate governance and the case of Rotterdam, the Netherlands

4.1 Introduction

In recent years, climate change mitigation and adaptation have become reframed from singular and technical issues and domains such as emissions accounting or short-term risk reductions towards contributing to sustainability and resilience transformations (Hermwille 2016; O'Brien and Selboe 2015). The transformations perspective exemplifies climate change as part of on-going, complex and radical change processes today's societies are experiencing at increasingly accelerated pace. Climate change is symptomatic of highly unsustainable and eroding social fabrics, which are deeply embedded in market patterns, the ways services are provided, institutional conditions and behaviours (Meadowcroft 2009; Shaw et al. 2014). At the same time, many climate impacts are already underway and cannot be reversed, amplifying social, economic and environmental crises and vulnerabilities such as biodiversity loss and social inequalities (IPCC 2014). Especially in case of climate change beyond 2°C, climate impacts could trigger tipping points with largely unknown consequences (Steffen et al. 2015; Russill 2015), and they could cause (sudden) limits to adaptation (Dow et al. 2013).

A crucial question is how to develop effective and equitable climate solutions while unlocking opportunities for realising and maintaining a high quality of life within social-ecological limits (Abel et al. 2016; Pereira et al. 2015). This is especially pertinent considering the noticeably limited capacity of current climate governance systems to decisively shift societal development towards low-carbon, sustainable and resilient futures (Abbott 2014; Howlett 2014; Jordan et al. 2015). Existing governance regimes inside and outside of the climate domain tend to be dominated by incremental decision-making, short-term policy cycles and powerful interests favouring optimisation in the short-term, thus precluding more disruptive changes in the long-term and perpetuating dangerous mal-adaptation (Lonsdale et al. 2015; Loorbach 2014). Amongst others, scholars stress that effective climate governance will encourage synergies, learning, innovation and multi-level cooperation (Termeer et al. 2017; Bulkeley 2015).

Since the mid-2000s, new types of actors, networks and mechanisms enter and shape the increasingly polycentric climate governance landscape (Jordan et al. 2015; Abbott 2017; Ostrom 2014). Actors from different backgrounds, such as business, local governments and civil society, initiate climate actions at multiple scales and form diverse multi-level and transnational collaborations like transnational city networks and self-regulating private networks (Abbott 2014). In these settings, experimentation emerged as a novel governance mode that by its open-ended and learning-based nature generates innovative agreements, policies and practical solutions (Hildén et al. 2017). These governance

processes do not (only) rely on top-down authority but rather on bottom-up, decentralised actions and cross-learning (Cole 2011; van Asselt et al. 2018).

While there is hope that these hybrid and experimental climate governance approaches manifest in new types of governance capacities, their mechanisms and effectiveness are still poorly understood (Jordan et al. 2015; Luederitz et al. 2017). For example, though experimentation is lauded for galvanising innovation and learning, how experimentation connects to on-going policy and planning processes and how the generated novelties can be mainstreamed are less examined (Kivimaa et al. 2017; Turnheim et al. 2018). Likewise, scholars have pointed to governance processes other than experimentation, which demand further attention. This includes phasing-out existing unsustainable and high-emission practices decisively by providing disincentives or unravelling powerful actor networks (Hermwille 2017; Kivimaa and Kern 2017). Especially the distributed nature of the new climate governance landscape raises questions about how to mobilise, structure and coordinate the diverse climate mitigation and adaptation activities towards shared, long-term sustainability and resilience goals (van Asselt et al. 2018; Abbott 2017). While most analyses of polycentric climate action focus on bottom-up, decentralised and voluntary commitments, Abbott (2017) argues that 'orchestration' as an indirect governance mode can strengthen polycentric climate governance by encouraging action, supporting capacities of weaker institutions, setting standards for reporting and facilitating knowledge exchange.

In this paper, we present a conceptual framework of capacities for transformative climate governance. We define transformative climate governance as the processes of interaction and decision-making by which multiple actors seek to address climate mitigation and adaptation while purposefully steering societies towards low-carbon, resilient and sustainable objectives. The framework distinguishes between different types of governance capacities to facilitate a systemic understanding of the diverse governance processes, mechanisms and conditions needed for addressing climate change in the context of on-going transformation dynamics. In particular, the framework serves to deconstruct how the governance capacities are produced by and how they manifest in the relational activities of actors. So far lesser attention has been paid to agency, i.e. the processes and dynamics through which actors mobilise, create and change societal structures and 'accomplish' climate governance (cf. Bulkeley 2015). The agency-centred perspective enables to discern how, and by whom, the new types of governance capacities are produced, what types of conditions signify the new governance architecture, and how effective the capacities are in accomplishing transformative climate governance.

After presenting the capacities framework in section 2, we illustrate in section 3 how the framework helps studying empirically climate governance. We use climate governance in the city of Rotterdam, the Netherlands, as an exploratory case study and identify what types of governance activities manifest in transformative climate governance capacities. In the discussion section, we reflect on the contributions of the framework, limitations and future research directions.

4.2 Capacities framework for transformative climate governance

The central objectives of the capacities framework are to enable identifying, understanding and eventually supporting transformative climate governance – i.e. how governance is "performed, fulfilled and completed in relation to different desires and objectives" (Bulkeley 2015:14). Governance alludes to interactive decision-making processes by which public and private actors define and pursue shared goals to address collective problems within their structural contexts (Betsill and Bulkeley 2006; Kooiman and Jentoft 2009). This resonates the concept of structuration (Giddens 1984): capacities for transformative climate governance are manifest in both the collective abilities of actors to mobilise, create and change societal structures and conditions, such as institutional settings, beliefs and financial resources, as well as in the structural conditions that are created as a result of the activities of actors (cf. Garud et al. 2007).

We identify four capacities for transformative climate governance in relation to different types of transformation dynamics (Table 4.1). This resonates the understanding of climate change as intrinsic part of these dynamics, and that the respective dynamics create different response needs. Transformation dynamics are visible in the path-dependencies and break-down of existing regimes that fail to reduce and respond to emerging challenges and risks, the build-up of new alternatives to replace those regimes, as well as in deep uncertainties, contestation and disruption that are involved in these processes (Loorbach 2014; Patterson et al. 2016; Hölscher et al. 2017a). Governance is then not so much about controlling rather than influencing these dynamics – for example by unsettling unsustainable regimes, enabling innovation and coping with surprise and disruption (Loorbach 2014).

We synthesised different scientific literatures to identify and define the capacities for transformative climate governance, the conditions that manifest in the capacity's existence and the multi-actor activities that create the conditions. We reviewed sustainability transitions, resilience, climate governance and meta-governance literatures because they offer complementary concepts and insights for addressing transformation dynamics (Table 4.1). Climate governance literature highlights different entry points to understanding and supporting mitigation and adaptation, including including transformational adaptation to respond to tipping points and disruptive impacts (Kates et al. 2012; Lonsdale et al. 2015; Wise et al. 2014), experimentation to facilitate innovation (Hildén et al. 2017; Kivimaa et al. 2017) and orchestration to ensure coordination and integration (Chan et al. 2015; Abbott et al. 2015; Abbott 2017). Both sustainability transitions and resilience approaches start from models of how complex adaptive systems evolve and to what extent system change can be anticipated and dealt with in a strategic and systemic way. Sustainability transitions approaches focus on overcoming unsustainable path-dependencies by developing disruptive innovations (Loorbach et al. 2015; Frantzeskaki et al. 2012; Raven et al. 2010) and regime destabilisation (Kivimaa and Kern 2016; Geels 2014). Resilience approaches largely focus on adaptive governance for dealing with emerging disturbances and risks and avoiding undesirable transformations (Chapin et al. 2010; Plummer 2013; Folke et al. 2005). They also research transformative agency for innovation and experimentation (Westley et al. 2013; Olsson et al. 2014). Finally, meta-governance literature specifies processes of coordination to facilitate goal alignment and concerted action of multiple actors and networks in fragmented governance systems (Sørensen 2006; Kooiman and Jentoft 2009; Capano et al. 2015).

Table 4.1: Transformative climate governance capacities and related governance concepts

Transformative climate governance capacity	Transformation dynamics addressed	Climate governance	Sustainability transitions	Resilience	Meta-governance
Stewarding: anticipating and responding to disturbances	Emergent instabilities, uncertainty and surprise	Adaptation and adaptive capacity (Adger et al. 2005; Brown and Westaway 2011; Gupta et al. 2010); transformative adaptation (Wise et al. 2014; Kates et al. 2012; Lonsdale et al. 2015)	-	Adaptive governance and adaptive capacity (Folke et al. 2002; 2005; Dietz et al. 2003; Plummer 2013); resilience (Chapin et al. 2010; Matyas and Pelling 2014; Chandler 2014; Garmestani and Benson 2013)	-
Unlocking: recognising and dismantling unsustainable path-dependencies	Path-dependencies and erosion of unsustainable regimes	Mitigation and mitigative capacity (Yohe 2001; Burch and Robinson 2007); exnovation (Hermwille 2017)	Regime destabilisation (Geels 2014; Turnheim and Geels 2013; Kivimaa and Kern 2016); phase-out (Loorbach 2014)	-	-
Transformative: creating and embedding novelties	Build-up of new and sustainable alternatives	Experimentation (Hoffman 2011; Hildén et al. 2017); mainstreaming (den Exter et al. 2014)	Niche experimentation and leadership (Raven et al. 2010; Bos et al. 2013; Loorbach et al. 2015); scaling and replicating (van den Bosch 2010)	Experimentation and leadership (Westley et al. 2013; Moore and Westley 2011; Olsson et al. 2006; Marshall et al. 2012)	-
Orchestrating: coordinating multi-actor processes	Multi-actor processes across scales, sector and time; synergies and trade-offs; contestation and goal conflicts	Orchestration (Abbott et al. 2015; Abbott 2017; Chan et al. 2015)	Intermediation and meta-governance (Hodson and Marvin 2010; Hodson et al. 2013; Loorbach 2014; Frantzeskaki et al. 2014)	Polycentric governance (Galaz et al. 2011; Anderies et al. 2016)	Meta-governance (Sørensen 2006; Kooiman and Jentoft 2009; Capano et al. 2015)

We reviewed the literatures to first define the different governance functions that need to be fulfilled to address transformation dynamics. We then identified the conditions that manifest in each capacity's existence. Finally, we identified the activities that are listed as creating these conditions and clustered them accordingly (Table 4.2). The full overview of the capacities conceptualisation including supporting sources is given in Tables I.A.2 to I.A.5 in Intermezzo A.

Table 4.2: The transformative climate governance capacities framework: capacities, conditions and activities for transformative climate governance

Governance capacity	Condition	Activities and supporting sources
Stewarding capacity	Generating knowledge about system dynamics	Developing systems models of feedback across scales, sectors and time Integrating different forms/sources of knowledge and understanding Identifying and communicating sources of uncertainty
	Strengthening self-organisation	Creating decentralised and nested institutions and social networks across governance scales that fit to social and ecological contexts and have multiple centres of power Creating open and simple institutions and rules (e.g. rules-of-thumb) that nurture diversity and redundancy to enable flexible patterns of behaviours and adaptation of rules if needed Ensuring inclusive dialogue and participation to enhance awareness of risks, responsibility sharing power balance among interest groups
	Monitoring and continuous learning	Iteratively evaluating how the system responds to disturbances and management Building a collective social memory of experience for linking past experiences with present and future, improving routines Systematically revisiting and questioning underlying assumptions and objectives
Unlocking capacity	Revealing unsustainable path-dependency and mal-adaptation	Identifying sources and responsibilities for undesirable side-effects, (market, political etc.) failures and maladaptation, monitoring trends in stressors and impacts Monitoring trends in stressors, vulnerability analyses, identifying areas with higher/increasing risks and how changes affect different needs and interests
	Undermining vested interests and incentive structures	Withdrawing support for regime technologies, structures and practices Adjusting legal rights and responsibilities to create (dis)incentives and control policies Breaking up existing actor networks, replacement of key actors Divesting in human and financial capital that underlie regime structures
	Breaking open resistance to change	Fostering political willingness and public awareness for change Developing and strengthening (political) counter-movements and support networks
Transformative capacity	Enabling novelty creation	Developing, testing and experimenting with new paradigms, practices, processes Providing protected and informal spaces to nurture innovation Supporting and creating informal and heterogeneous (shadow) networks that develop and test innovation and experiments

Governance capacity	Condition	Activities and supporting sources
	Increasing visibility of novelty	Creating forging alliances and advocacy networks Creating internal support within an organisation through political leadership Providing inspiration through communicating future visions and showcasing innovation
	Anchoring novelty in context	Anticipating and recognising opportunities for change and crises Aligning strategic, organisational, institutional and implementation processes and structures with the novelty, e.g. in overarching policy documents and operational checklists Learning from tested solutions and practices Providing resources (e.g. manpower, skills, finances) to wider practical implementation
Orchestrating capacity	Strategic Alignment	Defining a shared, long-term and integrative strategic direction and reference points for governance (shared goals, vision, narrative) Enlisting and engaging heterogeneous actor groups to create ownership over strategic direction and steer action in line with goals Linking strategic direction to on-going processes
	Mediating across scales and sectors	Recognising, brokering and integrating resources (financial, knowledge, human etc.) and goals Creating formal and informal convening spaces to exchange knowledge and resources and manage conflicts Setting up formal and informal connection nodes, communication channels and facilitating information platforms to optimise interactions and link formal and informal processes
	Creating opportunity contexts	Providing institutional designs for synergies and action in line with goals (e.g. financial incentives, regulations, taxation, recognition, shaming) Assisting actors and networks in implementing actions in line with goals (e.g. financing, guidance, technical assistance) Determining (normative) action mandates and prioritising action and fields Incorporating long-term and multi-scale thinking into decision-making, implementation processes and performance reviews

4.2.1 Stewarding capacity: anticipating and responding to disturbances and uncertainty

On-going transformation dynamics including climate change and other social-ecological changes and stresses create short-term and long-term instabilities, uncertainty and surprise (IPCC 2014; Wise et al. 2014; Dow et al. 2013). Resilience and climate governance scholars stress institutional, social and physical conditions enabling social-ecological systems to recognise, protect and recover from disturbances and surprises in a manner that improves wellbeing and without experiencing radical change (Folke et al. 2005; Dietz et al. 2003; Chaffin et al. 2014). Responses include anything between short-term coping and disaster response and putting in place the conditions for longer-term adaptation and resilience (Termeer et al. 2017) while also considering underlying socio-economic vulnerabilities such as injustice (Lonsdale et al. 2015; Bahadur and Tanner 2014).

Stewarding capacity is defined as the abilities of actors to anticipate, protect and recover from disturbances while exploiting opportunities beneficial for sustainability. It manifests in conditions that enable proactive and flexible responses to continuous and uncertain change. Knowledge generation and integration about social-ecological system dynamics enables anticipating emergent disturbances and uncertainties and identifying available options in light of these (Chapin et al. 2010; Tàbara et al. 2017). Decentralised self-organisation and context-specific rule-making support the abilities of organisations, communities and individuals to independently and flexibly respond to changes and disturbances (Folke et al. 2005; Dietz et al. 2003; Garmestani and Benson 2013). Monitoring and continuous learning are critical conditions for facilitating a collective memory of adaptation options as well as for changing management rules in response to learning of what works and what does not (anymore) (Folke et al. 2005; Gupta et al. 2010; Chapin et al. 2010).

4.2.2 Unlocking capacity: recognising and dismantling unsustainable path-dependencies

The deeply in societal structures, cultures and practices embedded root causes of excessive greenhouse gas emissions and unsustainability need to be phased out (Meadowcroft 2009; Loorbach 2014). Climate governance scholars explore mitigation options including emissions accounting, dis-incentives and decommissioning of high-carbon practices (Burch and Robinson 2007; Hermwille 2017). Sustainability transitions scholars highlight processes for revealing and destabilising unsustainable, highly path-dependent regimes that are deeply embedded in dominant practices, actor networks, institutional structures and infrastructure designs and perpetuate mal-adaptation. The goal is to create institutional space for more sustainable practices (Kivimaa and Kern 2017; Geels 2014; Loorbach 2014).

Unlocking capacity represents the abilities of actors to recognise and dismantle structural drivers of unsustainable path-dependencies and mal-adaptation. The revelation of drivers of unsustainability and path-dependencies creates the condition for revealing institutions, technologies and behaviours that need to be strategically phase-out (Meadowcroft 2009; Burch and Robinson 2007). Undermining vested interests and existing (financial, regulatory) incentive structures enables reducing the comparative advantage of business-as-usual towards emerging alternatives – for example by penalising unsustainable practices (Bettini et al. 2015; Geels 2014; Kivimaa and Kern 2017). Breaking open resistance to change diminishes support for business-as-usual and creates opportunities and awareness for alternatives (Kivimaa and Kern 2017; Hermwille 2017).

4.2.3 Transformative capacity: creating and embedding novelties

Escaping high-emission trajectories and overcoming persistent unsustainability and mal-adaptation requires the development and diffusion of radical alternatives (Tàbara et al. 2017; Kivimaa et al. 2017). Sustainability transitions, resilience and climate governance literatures alike endorse the development and testing of new ideas, narratives, practices, policies and solutions to transform established institutions, infrastructures, behaviours, economies etc. (Loorbach et al. 2015; Westley et al. 2013). Important activities relate to the learning processes involved in the testing of innovations and their subsequent mainstreaming into policy and decision-making processes (Kivimaa et al. 2017; den Exter et al. 2014; Lonsdale et al. 2015).

Transformative capacity is defined as the abilities of actors to create novelties and embed them in structures, practices and discourses. Creating the condition for novelty creation ensures space, resources and networks for developing and testing innovations (Raven et al. 2010; Loorbach et al. 2015; Frantzeskaki et al. 2012; Olsson et al. 2006). To challenge dominant regimes and motivate wider acceptance, uptake and replication, the innovation needs to gain visibility (Nevens et al. 2013; Frantzeskaki et al. 2012; Moore and Westley 2011) and it needs to be anchored in existing or new structures, cultures and practices to make the implications and lessons from an innovation generalizable (Bos and Brown 2012; den Exter et al. 2014; Nevens et al. 2013; Kivimaa et al. 2017).

4.2.4 Orchestrating capacity: coordinating multi-actor processes

The distributed nature of climate governance activities at different scales and in different sectors requires encouraging, coordinating and assisting action in alignment with shared long-term goals to enable 'small wins' in multiple areas while creating momentum for larger-scale changes (cf. Patterson et al. 2016; Abbott 2017). In climate governance literature, 'orchestration' is used to describe the indirect intermediation activities of, for example, international organisations such as the UNFCCC in aligning, enlisting and supporting state and sub-national actors and their climate actions (Chan et al. 2015; Abbott et al. 2015). Transitions and resilience scholars highlight the importance of intermediary spaces and strategic partnerships for integrating and mediating different social interests and resources within polycentric governance structures (Frantzeskaki et al. 2014; Hodson and Marvin 2010; Anderies et al. 2016). Meta-governance literature helps identifying activities that facilitate coordination in fragmented governance systems focusing on alignment, mediation and rule-setting (Jessop 1998; Capano et al. 2015; Sørensen 2006).

Orchestrating capacity refers to the abilities to coordinate multi-actor processes and foster synergies and minimise trade-offs and conflicts across scales, sectors and time. Strategic alignment is a key condition for orchestrating because it supports the formulation of shared and long-term goals towards which actions are oriented (Hodson and Marvin 2010; Sørensen 2006; Abbott 2017; Loorbach et al. 2015). Mediating across scales and sectors in open networks represents conditions for knowledge and resource sharing and conflict resolutions to optimise interaction processes (Abbott 2017; Beisheim and Simon 2015; Jessop 2011; den Exter et al. 2014). The creation of opportunity contexts ensures overarching framework conditions that incentivise and assist actions towards shared and long-term goals (Jessop 2011; Abbott 2017; Chan et al. 2015).

4.3 Illustrating case study: understanding transformative climate governance capacities in Rotterdam

To show the utility of the capacities framework we trace how the activities by which actors in the city of Rotterdam, the Netherlands, address climate change in city policy and planning practices created new types of conditions that manifest in capacities for transformative climate governance.

While climate governance in cities only represents one scale for addressing climate change, cities have become recognised as an increasingly important one both to prepare for the profound impacts of

climate change urban populations and to mobilise the potential of cities for contributing to global resilience and sustainability (Castán Broto 2017; Wolfram and Frantzeskaki 2016). Additionally, urban climate governance is marked by complex multi-level and transnational relationships, including regional planning processes and transnational city networks (Castán Broto 2017). We selected Rotterdam as a case study because Rotterdam is highly vulnerable to climate impacts such as rising water levels, intense rainfalls and heat waves (Molenaar et al. 2013) and it has built a reputation as a pioneer in addressing climate change, sustainability and resilience in policy programmes and practical solutions. This enables to explore and illustrate our theoretical propositions in the capacities framework by studying an actual empirical attempt of transformative climate governance (Yin 2003).

4.3.1 Case study methodology

The case study serves to illustrate the utility of the framework to assess the levels of transformative climate governance capacities and to identify the activities that create the capacity conditions, challenges and gaps. The analytical focus is on the climate-related policy and planning activities that are driven by the city government and how these create the conditions for transformative climate governance in Rotterdam.

We applied the framework in the following steps. Firstly, we analysed how the transformation dynamics are addressed as a result of climate governance in Rotterdam, i.e. how the capacity functions are exerted in climate policy and planning practice. For example, we identified what kinds of risks are recognised or overlooked, what path-dependencies are addressed, and what types of innovations are developed. This enables to assess the effectiveness of the capacities. Secondly, we identified the activities by which actors in Rotterdam created the conditions for addressing the transformation dynamics and that manifest in different capacity levels. This step involved theory-driven coding of the collected data to relate the identified activities to the capacity conditions of the framework (Saldana 2009). In a final step, we identified capacity gaps that relate to shortcomings of climate governance outcomes in Rotterdam and insufficiently developed capacities' levels and conditions. Appendix C shows how the empirical material was systematically analysed by applying the governance capacities framework.

The case study provides a snapshot of transformative climate governance capacities in Rotterdam city. We did not intend to show how the capacities emerged over time and to determine an absolute value for the capacities' effectiveness and levels. We rather sought to illustrate the activities that by today manifest in the capacities and to show how the capacity levels and gaps influence how climate governance is practiced in an empirical setting. The study starts from 2007, when climate mitigation and adaptation first appeared on the city's policy agenda, to take the activities that have contributed to the emergence of the capacities into account without placing them on a timeline.

Different data were collected for the study: (i) between March and June 2015, 28 semi-structured interviews were conducted in person with climate governance practitioners in Rotterdam. An effort was made to ensure a mix of respondents; the interviewees included policy officers from the city government (n=11) and regional (n=1) and national (n=1) governmental bodies, representatives from knowledge institutes (n=4), local businesses and architects (n=6), local NGOs (n=2), community groups (n=1) and politicians (n=2). (ii) Desk research was performed including a press analysis and a literature

review of policy documents (strategies, visions, plans on climate change from year 2005 to 2016) and scientific articles about climate and sustainability governance in Rotterdam and the Netherlands. (iii) Two of the authors were involved in different vision and strategy development processes in Rotterdam between 2012 and 2016. These processes included the re-development of the city harbour (Stadshaven) (Frantzeskaki et al. 2014) and the formulation of the resilience strategy (City of Rotterdam 2016; Lodder et al. 2016).

4.3.2 Towards transformative climate governance in Rotterdam?

Climate change mitigation and adaptation were first introduced on the city government's agenda in 2007 with the goal to reduce CO_2-emissions in Rotterdam by 50% in 2025 compared to 1990, the participation in the C40 Climate Leadership Group and the launch of the Rotterdam Climate Initiative (RCI) (RCI 2007). Concomitantly, water policy entrepreneurs formulated the goal to become climate-proof by 2025 while creating opportunities to enhance the city's social and economic attractiveness (RCI 2009; de Greef 2005; de Graaf and van der Brugge 2010). This resulted in the launch of the Rotterdam Climate Proof programme in 2008 as part of the RCI.

Until today, the climate change focus was successively expanded towards sustainability, liveability and resilience (Gemeente Rotterdam 2012; 2015; 2016) – climate adaptation and mitigation are integrated with goals for a clean, green, healthy, safe and economically robust city. This strategic approach was institutionalised in the city government's cross-cutting Sustainability and Climate Adaptation Offices that coordinate climate, resilience and sustainability-related actions and seek collaborations with other city departments, other levels of government (e.g. regional water boards), businesses, community organisations and knowledge institutes to develop and share knowledge and implement projects. The city participates in transnational city networks such as the Rockefeller Foundation's 100 Resilient Cities (100RC) programme, which supported the development of a resilience strategy and facilitates knowledge exchange between cities.

The city gained international recognition particularly by its high-profile proof-of-concept experiments for climate adaptation that deliver co-benefits for greening, recreation, community-building and economic development. Examples include the Benthemplein water square, which combines rainwater management with area development, the multifunctional underground water storage facility at Museumplein car park and the floating pavilion. The Dakakkers is the first multifunctional rooftop garden in Rotterdam, combining flood protection with commercial and recreational use. Currently a 100% climate-proof neighourbood in the Zomerhofkwartier is being developed.

In the following, we identify the activities that contributed to this approach to climate governance in Rotterdam and how the resulting capacities influence how transformation dynamics are addressed.

4.3.2.1 Stewarding capacity in Rotterdam

Stewarding capacity influences which and how disturbances are anticipated and what responses are enabled. In Rotterdam, stewarding is mainly addressed in relation to water safety, a long-standing policy priority in the city and the Netherlands. The introduction of other resilience goals connected water-related risks with improving neighbourhoods, liveability and emergency services. Stewarding

capacity has resulted in a relatively high level of flood protection, but key challenges include the enabling of individual adaptation measures and the mainstreaming of adaptation into policy and planning decisions.

Stewarding capacity is manifest in vast knowledge about future climate-related risks and vulnerabilities. The knowledge is largely water-related, though there is an increasing consideration of socio-economic vulnerabilities like inequality and cyber security. National, regional and international knowledge programmes and partnerships support knowledge generation. For example, Knowledge for Climate, a Dutch research collaboration, and the public-private National Delta Programme contributed to research on climate risks and adaptation strategies (e.g. van den Berg et al. 2013; van Veelen 2013). Knowledge was generated in form of scenarios (Ligtvoet et al. 2015), flood maps (RCI 2012) and participatory visioning processes (Frantzeskaki et al. 2014). Knowledge generation is also mandated; for example, the province of South-Holland asks municipalities to make risk assessments for inhabitants of outer-dike areas.

Water and flood safety are shared responsibilities across national, regional and local governmental bodies including the regional water boards, Rijkswaterstaat (the Dutch Ministry of Infrastructure and Water Management), the Province of South Holland and the city government. This results in both large-scale and small-scale measures: To protect Rotterdam and the surrounding region from flooding, the national and regional governments established a large-scale flood and sea-level rise defense system, including the Maeslantkering storm surge barrier, permanent sand dunes and dikes. The city government implements zoning plans and small-scale flood protection measures throughout the entire urban area, including blue-green corridors, integrating buildings with dikes and multifunctional water storage facilities. An integrated planning approach supports context-specific interventions to address climate risks and contribute to equity, urban green and economic development. Public-private partnerships such as the RCP or neighbourhood-based planning processes promote collaboration between public and private partners for project development.

Stewarding capacity in Rotterdam faces several shortcomings. Firstly, policies and interventions focus mostly on water safety and on technical measures to optimise the current system. This fails to incentivise long-term and co-beneficial adaptive solutions: no direct financing is available and it is difficult to capitalise the (uncertain) benefits. Secondly, climate-proofing is not mainstreamed and existing regulations remain inconsistent and unspecific. For example, existing guidelines on what tiles are used in residential areas hinder the installation of permeable tiles during road maintenance. Responsibilities for maintaining flood safety are unclear. This especially affects outer-dike areas, where residents are responsible for limiting their risks of water damage. Regional and local authorities assess the security situation, provide information and support. However, inhabitants are not aware about risks, and they have limited tools or incentives for flood-proofing their homes.

4.3.2.2 Unlocking capacity in Rotterdam

Unlocking capacity determines what and how drivers of unsustainability and path-dependencies are recognised and reduced. Unlocking climate governance efforts in Rotterdam focus on energy-related drivers of emissions in connection with drivers of air and noise pollution and waste. Despite progress on sustainable energy and transport, unlocking capacity is curtailed by powerful political and economic

interests that prevent a fundamental questioning of what drives unsustainability in Rotterdam. For example, two new coal plants were established to power the energy-demanding activities in the port, driving the city's CO_2-emissions up by 42% compared to 1990.

Research on drivers of unsustainability and emissions in Rotterdam helps identifying target areas for action. Supported by the C40 networks, the RCI carried out research on key emission contributors and identified the port, mobility and buildings as key intervention points. Annual reports monitor the effect of interventions. Other research develops transition pathways or roadmaps to explore different options for how to achieve a sustainable port industry or sustainable mobility (Samadi et al. 2016).

A support network of key (political and civil society) actors is critical to create the condition for increasing opportunities for change. For example, the RCI brings together key actors from the city government, the port and industry to mobilise their ideas and commitment for energy conservation, sustainable energy and CO_2-capture initiatives. The local energy cooperative Blijstrom supports the government's efforts to inform and assist building owners to retrofit. This type of awareness raising supports a wider outreach to more heterogeneous populations. It also enabled to identify homeowner associations as a critical actor group because of their leverage in changing energy use in buildings.

Political support is critical for changing incentive structures and creating investment opportunities. The support from the council for the sustainability strategy provides budget for investments in windmills, energy efficient municipal buildings and electric vehicles. A recent success was the ban of old vehicles from the city centre. However, the ban also exemplifies the challenge to radically destabilise business-as-usual: While requiring relatively high investments (e.g. for installing monitoring systems), these have little effect (in terms of actual vehicles banned and pollution reduced).

The increasing emissions levels in the port underscore the challenge in Rotterdam to fundamentally question existing economic interests and networks. The energy transition pathways for the port premise the unabated continuation of industrial activities to not jeopardise the economic position of the port and job opportunities. Relatedly, the existing incentive structures still favour short-term interests and investments and sustainability is not part of the working process but remains only a consideration in explicit sustainability-labelled projects. As a result, while there are efforts to develop new business cases– for example involving privileges and funding constructions for electric freight transport and retrofitting – these remain thin. Renewable energy projects also face complex regulations and permit requirements (e.g. buildings need to comply with aesthetic guidelines) and require technical expertise.

4.3.2.3 Transformative capacity in Rotterdam

Transformative capacity influences what type of new innovations are developed and how they are embedded into structures, cultures and practices. Rotterdam has gained its frontrunner reputation from the climate change, sustainability and resilience strategies and the experimenting with innovative pilot projects. In developing and implementing the new strategies and operational approaches, governance processes themselves were innovated to enable more open-ended, hybrid

and collaborative decision-making. However, the innovative strategies, solutions and networks still act within niches and remain disconnected from other planning and decision-making processes.

Transformative capacity is manifest in the creation of ample informal and protective spaces, in which relatively small groups of public and private actors from different governance levels come together to share knowledge and develop innovations. These spaces facilitated collaboration, out-of-the-box thinking and navigating existing regulatory constraints. In the mid-2000s, policy entrepreneurs used international momentum to introduce mitigation goals and to reframe the city's water management approach from 'keeping water out' towards 'water as opportunity for liveability' (de Greef 2005). This created informal spaces to formulate new strategies and develop projects. Innovative solutions like the Benthemplein water square and the floating pavilion could be developed by positioning them as proof-of-concepts to provide inspiration for a climate-proof city and to market the city as a frontrunner.

The new strategic goals were mainstreamed into operational processes and innovative solutions were upscaled and replicated. For example, the Rotterdam Adaptation Strategy (RCI 2012) demonstrates prototypes of adaptive solutions. The goals were connected to on-going strategies and processes, including the redevelopment of the old city ports (Frantzeskaki et al. 2014; Frantzeskaki and Tillie 2014). Lessons-learned from implementing proof-of-concept projects support their replication and upscaling. The maintenance of the Benthemplein water square proved tedious due to its technical complexity. Other water squares were implemented with reduced complexity but building on the success principles of the Benthemplein square. The involved architecture firm plans to upscale the Benthemplein square to a climate-proof city quarter – the Zomerhofkwartier. The planning process builds on the water retention function already covered and on experiences, collaborations and financing options created during the water square process.

The integration of diverse goals and the facilitation of protected, open-ended innovation processes prompted new governance structures and networks that promote and coordinate priority-setting, mainstreaming and experimentation activities. Local, regional and international partnerships were established, including the RDM Campus, 100RC and Clean Tech Delta, which support the development of innovations by providing space for continuous experimentation.

While there is abundant space for experimentation, the innovative strategies, solutions and networks remain disconnected from on-going planning and decision-making processes. There is no consistent translation of strategic objectives into action programmes. This results in limited mainstreaming of, for example, climate adaptation into institutional and legal frameworks. Learning from practical experiments to harvest lessons and feed them into strategies and agendas remains largely informal due to time constraints. The innovations often remain stand-alone initiatives, which are showcased internationally, rather than locally, to create business opportunities for local companies.

4.3.2.4 Orchestrating capacity in Rotterdam

Orchestrating capacity enables coordinated climate governance interventions in line with overarching visions for sustainability and resilience. The innovation processes in Rotterdam resulted in long-term sustainability and resilience goals that guide climate governance activities. New formal and informal governance structures and networks emerged to mediate priorities, knowledge and resources across

sectors and scales. However, limited outreach beyond a relatively small actor group, disconnection from on-going governance processes and unavailability of viable long-term financing signify orchestrating capacity gaps.

Orchestrating capacity is visible in the long-term strategic direction for climate mitigation, adaptation, sustainability and resilience, which resonates in official policy documents, changing narratives and the ways solutions are designed and implemented. The strategies were formulated in collaborative processes including citizen surveys and cross-departmental and public-private debate to stimulate ownership. The integration of different goals helps to develop multi-functional solutions, identify trade-offs and it spurs new coalitions. For example, the programme 'River as Tidal Park' to strengthen the Meuse river as central, green space connects economic activity, greening, biodiversity and recreation and is implemented by the port authority, the city government and environmental organisations.

To coordinate the implementation of the strategic agenda, diverse formal and informal networks and communication channels were created to integrate and mediate priorities across scales and sectors. The Rotterdam Climate and Sustainability Offices are tasked with motivating, overseeing and coordinating planning processes across sectors. Their cross-departmental set-up makes them central nodes for knowledge exchange and pooling. The offices' policy officers initiate and organise joint visioning processes, identify opportunities for experimentation and piggy-backing climate mitigation and adaptation initiatives, search and allocate funding sources and participate in cross-scale collaborations and international city networks. The position of the Chief Resilience Officer provides a key contact point for pooling all resilience efforts in the city. Each Climate Office's member was placed in different city departments to ensure the office's agenda is taken up in each department's initiatives.

Public-private partnerships support the activities of the Climate and Sustainability Offices on tactical and operational levels. The RCI is responsible for streamlining, encouraging and supporting initiatives for energy conservation, sustainable energy and CO_2-capture. Projects are implemented together with different networks consisting of local government agencies, companies, knowledge institute and citizens. The Global Centre of Excellence on Climate Adaptation and the Climate Adaptation Academy were launched in Rotterdam. These contribute to international city alignment and knowledge exchange by providing training programmes on climate adaptation and resilience.

While orchestrating capacity in Rotterdam informally emerged from the need for oversight and coordination of climate governance activities, orchestration is limited to a relatively small actor group. Climate governance is still considered as 'doing something extra' for higher costs. There is a disconnect between the more diffuse and informal resilience and sustainability networks and more formalised decision-making and planning processes. A key challenge in light of the prevailing focus on (short-term) economic development is to ensure financing of the implementation of the strategic agendas by setting conditions for collaborative, long-term investments and determining responsibilities for carrying costs.

4.4 Discussion: lessons learned and ways forward for understanding and supporting transformative climate governance

We presented a novel framework that distinguishes between four capacities for transformative climate governance. Drawing on our illustrative case study of climate governance in Rotterdam, we discuss the utility of the framework for understanding and supporting capacities for transformative climate governance. We also reflect on future applications and limitations of the framework for analysing and facilitating the on-going change towards transformative climate governance.

4.4.1 Understanding and supporting capacities for transformative climate governance: activities, conditions and capacity gaps

Our case study demonstrates how the capacities framework helps to map the activities by which multiple actors create new types of conditions for accomplishing transformative climate governance, to assess the effectiveness of the established capacities and to identify capacity gaps. A growing number of scholars voice the urgency for a 'transformation of governance' to respond more radically and systemically to on-going transformation dynamics and to address the mismatches of existing governance regimes that these dynamics reveal (Patterson et al. 2016; Loorbach 2014; Termeer et al. 2017). However, while existing work in climate governance and transformation governance literatures has informed policy and practice actions, the insights and knowledge on actors, responsibilities and roles in partnering for bringing these actions to realisation remain mostly theoretical (Gillard et al. 2016; Koop et al. 2017; Castán Broto 2017). Research on experimentation and politics in climate governance (Kivimaa et al. 2017; Hoffman and Loeber 2015) and operational governance approaches like transition management (Loorbach et al. 2015) contribute practical but fragmented insights on agency-level understandings of governance for transformation.

The action-oriented perspective of the capacities framework creates a bridge between 'what is the solution' and 'ability to realise the solution'. It provides a systemic, multi-level and learning-based understanding of what types of governance capacities enable transformative climate governance and by which activities they are established, changed and enriched over time. It thus enables an assessment and explanation of the available conditions for the governance capacities, how the capacities influence the way climate governance is practiced, and it enables the identification of opportunities, challenges and capacity gaps. Appendix C summarises the governance activities that have contributed to creating different types of conditions manifest in new capacities for transformative climate governance in Rotterdam.

For example, we learn from our case study that multi-scale governance networks and integrative planning approaches support fit-to-context solutions, but they require a clear definition and communication of responsibilities, collaborative decision-making processes and flexible regulation to account for diverse regional and local needs. Connecting to key stakeholder groups increases societal support and awareness for renouncing 'the old', yet unlocking capacity can be constrained in fundamentally questioning existing unsustainable practices because of vested political and economic interests. Transformative and orchestrating capacities in Rotterdam almost simultaneously emerged

through the creation of space and informal networks for strategic and operational innovation, which also propelled new types of governance arrangements and structures. The utilisation of momentum for change, such as changing international narratives, and cross-sectoral and public-private collaboration were critical for creating innovation space.

While the capacities require different institutional contexts, skill sets and instruments, our case study shows that the capacities mutually reinforce each other and that gaps in one capacity can impede another. Other scholars found that adaptive capacity can overshadow transformative capacity by prompting people to protect existing structures and functions even though this will cause higher costs and vulnerabilities in the long-term (Wilson et al. 2013; Pahl-Wostl et al. 2013). In Rotterdam, transformative and orchestrating capacities support stewarding and unlocking capacity by integrating and mainstreaming different goals (e.g. social resilience), connecting actors to each other for the development of solutions and mediating interests. Key challenges across capacities remain because of limited mainstreaming of innovative long-term and integrated thinking into institutional and regulatory frameworks and a prevailing focus on economic development in planning and decision-making practice. While there is a lot of strength in the informal approach through which emerging cross-departmental and public-private networks in Rotterdam organise orchestration and experimentation, the impact on wider policy and planning processes is limited. Limited mainstreaming results in trade-offs – even between resilience and sustainability goals: charging stations for electric cars were set-up in a flood-prone area, increasing water-related vulnerabilities and threatening to cause power outages during floods.

Strengthening the capacities in Rotterdam requires rethinking how orchestrating and anchoring processes can be structurally supported and provided with a legitimate mandate to create long-term and integrated framework conditions that counter short-term economic interests and clarify responsibilities. Linking strategies, projects and actors in line with complex goals such as resilience, which are not easily understood, requires engaging credibly with a range of stakeholders and bringing in technical and process expertise (Brown 2017).

4.4.2 Applications and limitations of the framework

We suggest the framework as a tool to derive more generalizable results on how and what new forms of climate governance are emerging on global to local scales and how effective these are for addressing climate change and steering transformation dynamics.

The application of the framework to different contexts and scales can yield generalizable results on activities, opportunities and challenges for building capacities for transformative climate governance. For example, the framework can support the comparison of cities to reveal the most effective pathways for increasing governance capacities to accomplish transformative climate governance in relation to different contextual needs, institutional conditions and resources (Koop et al. 2017). The framework can also support action-oriented research to facilitate the co-creation of governance capacities in specific contexts through practice-based governance frameworks such as transition management (Hölscher 2018).

Future research needs to assess rigorously the effectiveness of the governance capacities in accomplishing transformative climate governance (Jordan et al. 2015). The framework leaves room for formulating indicators to assess certain capacity levels (Pedde et al. 2019) or for linking the capacities to evaluation schemes, which for example enable the assessment of the impact and directionality of climate experiments (Luederitz et al. 2017). Evaluating the capacities' effectiveness also requires reflection on legitimacy and normativity issues to determine whether vested interests and power imbalances influence decision-making (Avelino et al. 2017).

Central to debates on transformation of governance is a hybridisation of actors (Patterson et al. 2016; Avelino et al. 2016). In our case study the local government remains the critical actor leading efforts on climate, resilience and sustainability. Within the Climate and Sustainability Offices actors take on new roles as orchestrators of climate governance efforts in Rotterdam. They closely collaborate with private businesses and civil society organisations. The capacities framework can be connected with an actor analysis to pay attention to what types of actors engage in which activities, to clarify the role of partnerships and to reflect on whether transformative climate governance implies a re-organisation of governmental tasks vis-à-vis private actors (Hölscher et al. 2017b). This question extends across governance scales: For example, regulatory authority in Rotterdam for climate mitigation is constrained due to a lower prioritisation nationally (Lenhart 2015).

4.5 Conclusions

In light of the persistent failure to reduce emissions decisively, facilitate long-term resilience against climate change and account for the connectedness of climate change with other social, environmental and economic concerns, the climate governance landscape is changing towards more polycentric, hybrid and experimental approaches that include multi-scale, cross-sectoral and public-private collaborations.

We presented a capacities framework to provide a systematic analytical tool for understanding and supporting the on-going changes towards transformative climate governance. The framework provides an agency-focused understanding of the types of governance capacities that are required for addressing climate change in the context of on-going transformation dynamics and for steering such dynamics towards sustainability and resilience. Our illustrative case study of climate governance in Rotterdam shows the utility of the framework for assessing the available conditions for the governance capacities, discussing how they influence the way climate governance is practiced, and identifying actors and activities, opportunities, challenges and capacity gaps.

The on-going changes in climate governance open up multiple questions about actor roles, effective governance processes, legitimacy and how effective climate governance in the context of transformations can be supported. We invite future research to apply (elements of) the framework to explore these questions.

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Chapter 5

Capacities for urban transformations governance and the case of New York City

Abstract

The narrative of urban sustainability transformations epitomises the hope that urban governance can create the conditions to plan and govern cities in a way that they contribute to local and global sustainability and resilience. So far, urban governance is not delivering: novel governance approaches are emerging in cities worldwide, yet are unable to transform conventional policymaking and planning to allow for innovative, co-beneficial and long-term solutions and actions to emerge and institutionalise. We present a capacities framework for urban transformations governance, starting from the need to fulfil distinct output functions ('what needs to happen') for mobilising and influencing urban transformation dynamics. The framework helps to diagnose and inform urban governance for responding to disturbances (stewarding capacity), phasing-out drivers of path-dependency (unlocking capacity), creating and embedding novelties (transformative capacity) and coordinating multi-actor processes (orchestrating capacity). Our case study of climate governance in New York City exemplifies the framework's applicability and explanatory power to identify conditions and activities facilitating transformation (governance), and to reveal gaps and barriers of these vis-à-vis the existing governance regime. Our framework thereby functions as a tool to explore what new forms of urban transformation governance are emerging, how effective these are, and how to strengthen capacities.

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Fit with overall thesis

This paper presents the New York City case study that was conducted for this thesis. The capacities framework is in this paper positioned within literature on governance for urban sustainability and resilience transformations. The case study shows the applicability of the framework to explain and evaluate urban climate governance as an example of shifts in urban governance towards 'governance for transformation'.

Chapter 5

Capacities for urban transformations governance and the case of New York City

5.1 Introduction

A new narrative of sustainable and resilient urban transformations has been gaining ground in scientific and policy discourses, for example being enshrined in the New Urban Agenda (UN-Habitat 2016) and the Sustainable Development Goals (SDGs, UN 2016). Cities increasingly have to grapple with a variety of interrelated challenges, including pollution, poverty and inequality, ageing infrastructure and climate change (Haase et al. 2018; UN-Habitat 2016; Seto et al. 2017). The new narrative epitomises the hope that cities concentrate the conditions and resources for delivering the fundamental changes in urban energy, transportation, water use, land use, consumption patterns and lifestyles that are needed to ensure wellbeing in cities and beyond (Romero-Lankao et al. 2018; Koch et al. 2016; Elmqvist et al. 2018; Winnington et al. 2016). For example, it regards cities as ideally placed for delivering effective climate change action while also decreasing air pollution, strengthening local communities and polishing recreation spaces (Castán Broto 2017; Chu et al. 2017; McPhearson et al. 2016a; b).

The zealous narrative of urban opportunities for navigating urban transformations towards desirable directions contrasts with how these opportunities are mobilised in practice. Local governments worldwide have already demonstrated how more open-ended, experimental and collaborative approaches enable to harness opportunities for developing innovative and integrated policies, goals and solutions (Frantzeskaki et al. 2017; Raven et al. 2017; Huang-Lachmann et al. 2016; Castán Broto 2017). A plethora of actors from local communities, regional and national governments, businesses and research institutes contribute to knowledge generation, experimentation with social, economic and technological innovations and self-organisation of service provisions (Burch et al. 2016; Frantzeskaki et al. 2016b; Hughes et al. 2017). However, even when these efforts manifest in new solutions, narratives, practices and institutions, so far they are countered by the negative impacts of urbanisation, unsustainable production and consumption, pollution and inequality and thus unable to create stepping stones for transforming urban systems (Ürge-Vorsatz et al. 2018; Rink et al. 2018). For example, continued investments in maladaptive infrastructures such as building area development in flood-prone areas are at odds with the implementation of climate-resilient building codes and flood zones (Torabi et al. 2018; Rosenzweig et al. 2015).

In our view, this disconnect between narrated opportunities and on-the-ground practice signifies a mismatch of existing urban governance regimes and characteristics of urban transformations. Urban transformations are complex, long-term, uncertain and contested processes of radical change in urban systems, which result from the interaction and feedback of diverse driving forces across sectors, scales

and time (Wolfram et al. 2017; Rink et al. 2018). Therefore, urban transformations cannot be managed or brought about by traditional urban policymaking and planning approaches that merely aim at sustaining and optimising existing urban regimes (Loorbach et al. 2015; Rink et al. 2018; Frantzeskaki et al. 2018). The majority of urban governance systems is still characterised by administrative and jurisdictional divisions across sectors and scales and short-sighted political cycles, resulting in policies, plans and solutions that prioritise 'pressing' and rather isolated urban needs over long-term sustainability and resilience goals (Wamsler 2015; Friend et al. 2014; Torabi et al. 2018). This type of decision-making and planning exacerbates existing path-dependencies and mal-adaptation, for example when infrastructure developments do not account for long-term and multiple benefits and societal needs (Torabi et al. 2018; Ürge-Vorsatz et al. 2018). While the emerging learning-based and collaborative approaches open-up new avenues for organising urban governance for transformations, their mechanisms and effectiveness are still under-examined and they have not yet become an alternative to existing urban governance regimes (Romero-Lankao et al. 2018; Elmqvist et al. 2019).

In this paper, we take a step back to first conceptualise what type of urban governance contributes to sustainability and resilience transformations. We premise that significant changes of urban governance have to accompany, or, even precede a radical re-direction of urban development pathways towards sustainability and resilience (Rink et al. 2018; McCormick et al. 2013; Romero-Lankao et al. 2018). Steering and achieving desirable urban transformations requires new collaborations across domains, long-term planning horizons beyond electoral cycles, and learning-based approaches that allow for innovation and synergies to emerge and flourish (Loorbach et al. 2015; Koch et al. 2016; Burch et al. 2018). Our aim is to employ this understanding of urban transformation governance to facilitate a better explain whether the emerging, learning-based and collaborative urban governance approaches contribute to transformative change, and how they can be strengthened vis-à-vis existing urban governance regimes to mainstream and scale sustainable innovations.

We present and illustrate a conceptual framework of governance capacities that enables exploration and explanation of the development of urban transformation governance vis-à-vis existing urban governance regimes. We first present the capacities framework for steering sustainability and resilience transformations in cities, starting from a comprehensive understanding of urban transformation governance that mobilises the driving forces of urban transformations to influence the direction and speed of emerging urban transformations (section 2). The agency-centred perspective of the framework allows to explain how, and by whom, new conditions for urban transformation governance are developing, to evaluate whether these conditions manifest in capacities for urban transformation governance, and to derive recommendations for how to strengthen the capacities. We illustrate in section 3 how the framework helps studying empirical attempts at urban transformation governance. Our case study of climate governance in New York City (NYC) exemplifies the framework's explanatory power in explaining by which activities diverse actors have created conditions for long-term, ambitious and integrated climate, sustainability and resilience agendas, cross-cutting collaboration and experimentation with innovative solutions. In the discussion section 4, we reflect on the contributions of the framework, limitations and future research. In section 5 we conclude with an outlook on how to strengthen urban transformation governance.

5.2 Capacities for urban transformation governance

The call for radical change towards sustainable and resilient urban systems has prompted diverse work on urban transformation governance (Wolfram and Frantzeskaki 2016; Elmqvist et al. 2018). The common departure point is the shared assumptions that urban systems are in permanent non-equilibrium state and that change in urban systems is complex, uncertain and contested (Wolfram et al. 2017; Loorbach et al. 2015; Rink et al. 2018; Romeo-Lankao et al. 2018). Highlighting the inherent tension between the self-organisation properties of complex urban systems and the idea of planning towards a desirable societal goal, transformative approaches to urban governance advocate a 'transformation of urban governance' that shifts away from steady-state approaches which control urban systems through singular policies and solutions. Rather, urban transformation governance creates conditions for mobilising and navigating the driving forces and dynamics of urban transformations in alignment with long-term sustainability and resilience goals (Loorbach et al. 2015; Pickett et al. 2013; Meerow et al. 2016). Sustainability and resilience thus serve as complementary goals for orienting urban transformations in terms of normative parameters (sustainability) and ability to respond to dynamics, disturbances and uncertainty (resilience) (Elmqvist et al. 2019).

We developed a capacities framework to enable explaining, evaluating and supporting urban transformation governance (see also Hölscher et al. 2018). The framework provides an agency-oriented perspective to bridge how activities of actors create conditions for governing urban transformations. Our capacities notion recognises that urban governance manifests in the interactive decision-making processes by which public and private actors collaborate and the outputs they produce to address collective problems at this scale (Jabareen 2013; Kooiman and Jentoft 2009; Hodson et al. 2018). While institutional and organisational conditions (e.g. institutional settings, rules and regulations, networks), knowledge resources and discourses are important components of governance capacity, building-up capacities for urban transformation governance ultimately depends on the abilities of actors to mobilise, create and remove governance conditions (Koop et al. 2017; Bettini 2013). Governance capacities are thus manifest in the emergent processes and patterns resulting from the activities by which actors mobilise and put in use structural governance conditions and in the conditions themselves that together determine how urban transformation governance is accomplished (Hölscher et al. 2018; cf. Koop et al. 2017).

Our framework conceptualises urban transformation governance as an ideal-type and normative approach that enables to mobilise and influence the driving forces and dynamics characterising urban transformations towards achieving sustainability and resilience in the long-term. We posit that different types of conditions and processes (e.g. experimentation, partnerships) are needed to mobilise and play into the diverse driving forces and dynamics characterising urban transformations. Different research strands concerned with urban transformation governance offer complementary concepts and insights for conceptualising and operationalising capacities for urban transformation governance in relation to different driving forces and dynamics of urban transformations. Urban sustainability transitions scholarship focuses on overcoming persistent institutional, technological and socio-cultural path-dependencies in urban (sub-)systems like mobility, food or energy by experimenting with and diffusing innovations and challenging vested interests, existing institutions and behaviours (Frantzeskaki et al. 2018; Raven et al. 2017; Castán Broto 2017; Caprotti and Cowley 2017). Urban resilience and adaptive governance literatures highlight the need for flexible and decentralised

institutions that enable learning, self-organisation and fit-to-context management approaches (Torabi et al. 2018; Chu et al. 2017; Wamsler 2015). We also turned to meta-governance literature, which helps to further conceptualise and operationalise the capacity for coordination of multiple and fragmented but purpose-oriented governance networks to facilitate goal alignment and concerted actions across sectors and scales (Jessop 1997; 2011; Sørensen 2006; Doberstein 2013; Engberg and Norvig Larson 2010).

From the integration of sustainability transitions, resilience and meta-governance approaches, we inductively identified four capacities for urban transformation governance that enable fulfilling distinct output functions by addressing different types of transformation dynamics (Table 5.1). Based on these functions we can derive the governance conditions, processes and actions that make up effective urban transformation governance (cf. Benz et al. 2007): We reviewed the literatures in terms of the activities they identify in relation to delivering the distinct functions and inductively clustered these into different types of sub-functions that enable delivering the capacity functions. While the functions are output-oriented, i.e. they help to address different types of transformation dynamics to build and maintain sustainability and resilience, the activities create the conditions for delivering the governance functions. Tables I.A.2 to I.A.5 in Intermezzo A present a detailed overview of the agency-based operationalisation of capacities (in terms of how to deliver the sub-functions) and supporting sources.

5.2.1 Stewarding capacity: anticipating and responding to uncertainty and risk

Urban transformation processes are driven by system-level changes including climate change, economic deterioration and urbanisation that create short-term and long-term instabilities, uncertainty and surprise (Johnson et al. 2015; Carter et al. 2014; Rosenzweig et al. 2015). Resilience and adaptive capacity are key concepts to identify critical institutional, social and physical conditions enabling urban systems to anticipate, react to and recover from risks and surprises (Bettini et al. 2015; Chu et al. 2017; Chelleri et al. 2015; Pickett et al. 2014). Urban resilience demands attentiveness to the structural drivers of vulnerability and mal-adaptation (Pelling and Manuel-Navarrete 2011; Tanner et al. 2009) as well as teleconnections and far-stretched impacts (Chelleri et al. 2015; Pickett et al. 2014).

We define stewarding capacity as the abilities of actors to anticipate, protect and recover from risks while exploiting opportunities beneficial for sustainability. It is manifest in conditions that enable learning and flexible responses to (uncertain) change and disturbance. Generation and integration of knowledge about complex and long-term social-ecological system dynamics across scales enable the anticipation of emergent risks and uncertainties (Koop et al. 2017; McPhearson et al. 2015; Chelleri et al. 2015). Decentralised, fit-for-context and flexible institutions and networks that incorporate long-term risks facilitate dynamic responses to changes and disturbances (Torabi et al. 2018; Boyd et al. 2014; Tanner et al. 2009). Monitoring and participatory learning are key ingredients to reconsider and adapt management objectives and practices to changing situations in line with new information (Tanner et al. 2009; Koop et al. 2017).

Table 5.1: Functions, capacities and sub-functions for urban transformation governance and related governance concepts (adapted from Hölscher et al. 2018, Chapter 4)

Function and capacity	Sub-functions	Transformation dynamics addressed	Sustainability transitions	Resilience	Meta-governance
Stewarding *Ability to anticipate, protect and recover from uncertainty and risk while exploiting opportunities beneficial for sustainability*	• Generating knowledge about system dynamics • Strengthening self-organisation • Monitoring and continuous learning	Emergent instabilities, uncertainty and surprise affecting urban systems and creating vulnerabilities	-	Adaptive governance and adaptive capacity (Pahl-Wostl et al. 2007; Plummer 2013; Berkes 2017); resilience (Jabareen 2013; Meerow et al. 2016; Matyas and Pelling 2014)	-
Unlocking *Ability to recognise and dismantle structural drivers of unsustainable path-dependencies and mal-adaptation*	• Revealing drivers of unsustainable path-dependency and mal-adaptation • Undermining vested interests and incentive structures • Breaking open resistance to change	Institutional, technological and behavioural path-dependencies and lock-ins, which perpetuate high-emission trajectories and mal-adaptation	Regime destabilisation (Geels 2014; Turnheim and Geels 2013; Kivimaa and Kern 2016; David 2017; Bosman et al. 2018); phase-out (Loorbach 2014)	-	-
Transforming *Ability to create and diffuse novelties that contribute to sustainability and resilience and to embed these novelties in structures, practices and discourses*	• Enabling novelty creation • Increasing visibility of novelty • Anchoring novelty in context	Build-up of new and sustainable alternatives	Niche experimentation and leadership (Raven et al. 2010; Brown et al. 2013); embedding, scaling and replicating (Ehnert et al. 2018); transition arenas to create guiding visions and agendas (Loorbach et al. 2015)	Experimentation and leadership (Westley et al. 2013; Moore and Westley 2011; Biggs et al. 2010)	-
Orchestrating *Ability to coordinate multi-actor governance*	• Strategic Alignment • Mediating across scales and sectors	Contested and diffuse interactions across scales, sector and time	Intermediation, boundary spanning and brokering (Hodson and	Polycentric governance (Pahl-Wostl and Knieper 2014; Galaz et al. 2011;	Meta-governance (Sørensen 2006; Kooiman and Jentoft 2009; Capano et al.

Function and capacity	Sub-functions	Transformation dynamics addressed	Sustainability transitions	Resilience	Meta-governance
processes and foster synergies and minimise trade-offs and conflicts across scales, sectors and time	• Creating opportunity contexts	causing synergies and trade-offs	Marvin 2010; Frantzeskaki et al. 2014; Kivimaa 2014)	Anderies et al. 2016)	2015; Doberstein 2013)

5.2.2 Unlocking capacity: recognising and dismantling unsustainable path-dependencies

Dominant urban land-use, design and living patterns propel excessive air pollution, land and water consumption and CO_2-emissions (Lelevield et al. 2015; Seto et al. 2014) as well as high levels of inequality among urban inhabitants (Koch et al. 2016; Pickett et al. 2013). Infrastructural, institutional and behavioural lock-ins create path-dependencies and mal-adaptation (Ürge-Vorsatz et al. 2018; Brown et al. 2013; Malekpour et al. 2015). Sustainability transitions approaches analyse how the co-evolution of dominant technologies, social interests, expectations and institutional structures in urban systems drives path-dependency and mal-adaptation (Moloney and Horne 2015; Shaw et al. 2014; Moss 2014; Adil and Ko 2016). These regime structures, cultures and practices need to be unveiled and dismantled to overcome the resulting path-dependencies and lock-ins, for example by providing dis-incentives and raising awareness (Geels 2014; Kern and Kivimaa 2016; Bosman et al. 2018).

Unlocking capacity is manifest in the abilities of actors to recognise and dismantle structural drivers of unsustainable path-dependencies and mal-adaptation. Knowledge generation mechanisms like baseline measurements and system analyses create the condition for recognising institutions, technologies and behaviours that perpetuate mal-adaptation and need to be strategically phased out (Sperling and Ramaswami 2017; Loorbach et al. 2015; Jhagroe and Frantzeskaki 2015). Excavating vested interests and existing (financial, regulatory) incentive structures serves to reduce the comparative advantage of business-as-usual (Sperling and Ramaswami 2017; Bettini et al. 2015; van der Heijden et al. 2014). Breaking open resistance to change diminishes support for business-as-usual and creates opportunities and awareness for alternatives (Kivimaa and Kern 2017; Sperling and Ramaswami 2017; Moloney and Horne 2015).

5.2.3 Transformative capacity: creating and embedding novelties

Escaping current unsustainable and mal-adaptive urban development trajectories requires the development and diffusion of radical alternatives that provide new ways of doing, thinking and organising (Loorbach et al. 2015). Urban experimentation has become an important mode of urban governance as a way to test innovations (Caprotti and Cowley 2017; Castán Broto 2017; Bulkeley et al. 2016; Raven et al. 2017). Increasing attention is paid to processes of learning from, replicating and upscaling of experiments (Luederitz et al. 2016; Ehnert et al. 2018; Raven et al. 2017) as well as to the

institutionalisation of (new) sustainability and climate change agendas into urban planning (den Exter et al. 2014; Wamsler 2015).

We define transformative capacity as the abilities of actors to create novelties (for doing, thinking, organising) that contribute to sustainability and resilience and to embed them in structures, practices and discourses. Creating the condition for novelty creation ensures space, resources and networks for developing and testing innovations (Raven et al. 2010; 2017; Loorbach et al. 2015; Nevens et al. 2013). To challenge dominant regimes and motivate acceptance and update, the innovation needs to gain visibility, traction and support (Nevens et al. 2013; Frantzeskaki et al. 2017; Brown et al. 2013). Anchoring the novelty in context ensures its replication and scaling by making the implications and lessons from an innovation more generalisable and fitting them into existing or new structures, cultures and practices (Frantzeskaki et al. 2017; Ehnert et al. 2018; den Exter et al. 2014; Wamsler 2015).

5.2.4 Orchestrating capacity: coordinating multi-actor processes

Urban sustainability and resilience transformations touch upon a diverse bundle of socially negotiated, mobile and partially competing, goals, affect different actors in different ways and their dynamics extend across sectors and geographical scales (Koch et al. 2016; Chelleri et al. 2015). Key questions are how co-beneficial strategies and solutions can be encouraged, coordinated and assisted aligning to shared long-term goals (Hodson and Marvin 2010; Moloney and Horne 2015; Gordon and Johnson 2017; Ürge-Vorsatz et al. 2018). Research found that local governments are re-inventing their roles from planners and regulators to facilitators of strategic, vision-oriented networks and partnerships that integrate and mediate different social interests and resources (Frantzeskaki et al. 2014; 2017; Hedensted Lund et al. 2012). In this context, intermediation and meta-governance have gained increasing attention as ways to streamline the dispersed activities at multiple scales, to facilitate synergies and enable 'small wins' in multiple areas while creating momentum for larger-scale changes (Fuhr et al. 2018; Frantzeskaki et al. 2014; Hodson and Marvin 2010).

Orchestrating capacity refers to the abilities of actors to coordinate multi-actor governance processes and foster synergies and minimise trade-offs and conflicts across scales, sectors and time. Strategic alignment orients the activities of diverse actors towards shared, integrated and long-term goals (Hodson and Marvin 2010; Moloney and Horne 2015; Chu et al. 2017; McPhearson et al. 2017). Conditions to mediate and share knowledge, conflicts and resources across sectors and scales are manifest in formal and informal structures, spaces and communication channels (Hedensted Lund et al. 2012; Kivimaa 2014). Opportunity contexts to incentivise and assist actions towards long-term goals are established by framework conditions that clarify costs, benefits and responsibilities (Koop et al. 2017; Hölscher 2018). This requires support from national and regional actors that set legislative standards and provide financial support (Castán Broto 2017; Johnson et al. 2015).

5.3 Illustrating case study: capacities for urban transformation governance in New York City

We illustrate the capacities framework by tracing the climate governance activities by which actors in NYC have created new types of governance conditions that manifest in new capacities for urban transformation governance. This section presents our case study methodology and the analysis of whether and how climate governance activities created the conditions for accomplishing stewarding, unlocking, transforming and orchestrating functions in NYC.

We approach climate governance in NYC as suitable example to show how urban transformation governance activities and conditions evolve and change existing governance regimes. Climate change is a key persistent problem that due to its systemic and long-term nature cannot be addressed through short-term responses and in isolation from other urban (governance) processes (Runhaar et al. 2018; Wamsler 2015). In cities worldwide, the topic of climate change on the policy agenda has driven changes in existing urban governance regimes to enable experimentation, collaboration, learning and long-term planning (Aylett 2015; den Exter et al. 2015; Castán Broto 2017). NYC is a city that proactively experiments with addressing climate change while achieving long-term sustainability and resilience goals. This is visible in the ambitious and cross-cutting climate change, sustainability and resilience agendas published by the city government and the portfolio of innovative solutions for climate mitigation and adaptation (Solecki et al. 2016; Forgione et al. 2016; McPhearson et al. 2014; McPhearson and Wijsman 2017; Depietri and McPhearson 2018). The experimentation with these new types of systemic, long-term goals has opened up opportunities for setting up new governance mechanisms and networks for managing long-term climate risks while encouraging equity and prosperity. The case study of climate governance in NYC thus enables to study how actors experiment with and develop new types of capacities for urban transformation governance.

5.3.1 Case study methodology

The case study provides a snapshot of transformative climate governance capacities in NYC today, while accounting for the activities that contributed to the emergence of the capacities starting from 2007, when the city's first climate mitigation and sustainability plan was released.

5.3.1.1 Climate governance in NYC

NYC is a delta and port city and an important global economic centre accommodating over 8.55 Million people (US Census Bureau 2015). Expected climate impacts in NYC include rising sea levels, increasing severity of heavy downpours and storms, flooding, heat waves, droughts and extreme wind events (NPCC 2015). The city has already experienced climate extremes, most notably hurricane Sandy's landfall in October 2012. Sandy caused an estimated $19 billion in damage and 43 deaths, flooded sewer systems, roads and subway stations, disrupted vital transport networks and power and water supply (NYC 2013). It underscored the vulnerability of low-income, coastal communities, which have been severely affected while struggling with rising rents, increasing depth and delays in repairs (Cowan and Hogan 2014). NYC faces social stratification, population growth, air and noise pollution, economic downturn and escalating housing prices (McPhearson et al. 2014; Solecki 2012).

The city government's approach to climate governance started with integrated climate mitigation and sustainability goals in 2007. This focus was successively expanded towards climate adaptation and broader resilience pursuits. Mayor Bloomberg (2002-2014) commissioned the cross-cutting sustainability and climate mitigation plan PlaNYC, which was released in 2007 and tied goals such as emissions reductions, improving air quality, managing population growth, modernising infrastructure to the city's long-term quality and global competitiveness (NYC 2007). In response to extreme weather events, the 2011 update of PlaNYC included goals and initiatives on heat stress reduction, storm water management and infrastructure protection (NYC 2011). After hurricane Sandy, the public-private Special Initiative for Rebuilding and Resiliency (SIRR) was convened to develop a programme for reducing the city's vulnerability to coastal flooding and storm surge and for rebuilding communities affected by Sandy (NYC 2013). When Mayor de Blasio took office in 2014, he introduced affordable housing and social equity as top priorities in the next PlaNYC update, called OneNYC (NYC 2015a).

The cross-cutting Mayor's Offices of Sustainability (MOS) and Recovery and Resiliency (ORR) spearhead the city government's efforts on climate change, resilience and sustainability. They are charged with knowledge and strategy development, fostering partnerships and enlisting in and overseeing projects' implementation. Multiple city departments contribute to the city's overarching strategies and goals and put in place departmental sustainability and resilience offices and strategies. The city government works closely together with business networks (e.g. the NYC Waterfront Alliance, Urban Green Council), sets up, oversees and collaborates in cross-sectoral and cross-scale knowledge platforms and partnerships, and participates in international city networks (e.g. C40, 100 Resilient Cities (100RC)). NGOs and community organisations are mostly informally involved, engaging in knowledge development, community organising, advocacy and project implementation.

5.3.1.2 Data collection and analysis

Different data were collected for the study. We performed desk research to review policy documents (strategies, visions and programmes from 2007 to 2017, including e.g. NYC 2007, 2010, 2015), media articles and scientific papers about climate and sustainability governance in NYC. Between October 2015 and January 2016, we conducted 38 semi-structured interviews in person with climate governance actors in NYC. The interviewees included policy officers from the city government (n=12), regional (n=4) and national (n=2) governmental bodies, as well as representatives from knowledge institutes and partnerships (n=7), local businesses, architects and stakeholder platforms (n=6), NGOs and community-based organisations (n=7). We covered different sectors: water, transport, energy, health, buildings, parks and recreation, environmental protection, emergency management and housing.

The collected data was analysed in reference to the conceptual capacities framework. We applied the capacities framework by following a step-wise analytical coding process to make connections between the activities, conditions and capacity functions – i.e. to connect actors ('who'), activities and conditions ('how') and output functions ('what') (Table 5.2; Strauss and Corbin 1998; Saldana 2009). The steps were iterative because insights gained from further analysis could add or differentiate insights gained from earlier steps. Appendix C illustrates how the empirical material was systematically analysed by applying the governance capacities framework.

Table 5.2: Analysis steps to apply the capacities framework

Step	Questions addressed	Results
(1) Assessment of capacity output functions	What strategies, programmes, actions, regulations etc. exist to accomplish stewarding, unlocking, transforming and orchestrating?	***Evaluation of urban transformation governance:*** to what extent are the output functions accomplished in terms of what system-level changes?
(2) Identification of urban climate governance activities and actors	What activities are being undertaken in both cities to develop and implement strategies, networks, programmes, actions, knowledge etc. for stewarding, unlocking, transforming and orchestrating? Which actors engage in these activities?	***Explanation of urban transformation governance activities:*** what activities and actors develop new conditions manifest in capacities?
(3) Identification of governance conditions	What conditions (e.g. knowledge, networks, partnerships, resources) were created to accomplish stewarding, unlocking, transforming and orchestrating?	***Explanation of urban transformation governance conditions:*** what institutional, knowledge, network and social conditions support fulfilment of capacity functions and manifest in capacities?
(4) Identification of capacity gaps and challenges	What are challenges, shortcomings, conflicts, gaps etc. for stewarding, unlocking, transforming and orchestrating?	***Identification and explanation of capacity gaps:*** what are shortcomings in fulfilling output functions and how do they come about (e.g. challenges in developing conditions)?

5.3.2 Transformative climate governance capacities in New York City

In the following we show how the capacities framework helps to understand whether and how new conditions for delivering different functions of urban transformation governance are developing. In NYC, a long-term, systemic, collaborative and experimental approach to climate governance is emerging that crosses multiple policy sectors and domains (e.g. transport, energy, health, justice), involves multiple actors and facilitates innovative solutions. This has helped to move beyond single climate innovation programmes or solutions and to address climate mitigation and adaptation in the context of broader urban transformation processes. We call this a starting approach for transformative climate governance, which itself acts transformative, because it challenges existing governance regimes in NYC that tend to make decisions in sectoral siloes (Hölscher et al. 2019).

Our analysis of the development of transformative climate governance in NYC illustrates how the capacities framework helps explaining and evaluating emerging activities and conditions for urban transformation governance. We outline how each of the capacity functions – stewarding, unlocking, transforming and orchestrating – are addressed and delivered in NYC and identify the key conditions that deliver the respective function, the activities by which these have been created and capacity gaps and challenges. The analysis of the different types of governance capacities shows that diverse institutional, knowledge, network and social conditions were created to systemically address mitigation and adaptation in policy and planning (Table 5.3). A detailed overview of results, including how activities were related to sub-functions and conditions, is given in Appendix C.

Table 5.3: Transformative climate governance capacities (conditions and activities) in NYC

Institutional conditions	Knowledge conditions	Network conditions	Social conditions
Stewarding capacity			
Conditions:			
Fit-to-context, flexible and knowledge-based institutions for dealing with different needs	**Co-production and integration of knowledge about systemic and long-term risks and uncertainty**	**Polycentric and multi-actor networks across scales and sectors to implement projects in line with context needs**	**Social capital and empowerment for local self-organisation**
Activities:			
Integrating long-term, systemic risks and uncertainties Adopting problem-based, fit-to-context and no-regret approaches Providing flexible regulation and incentives to facilitate fit-to-context risk protection Assigning and communicating responsibilities	Long-term forecasting of systemic risks and uncertainties Problem-based and context-specific knowledge Continuously updating plans and resilience and sustainability indicators Mandating knowledge generation to ensure access to data Science-policy-community interface	Creating issue-specific, multi-level and multi-stakeholder programmes and partnerships Involving communities in joint and context-specific visioning, planning and implementation processes	Raising awareness about risks and response options Strengthening social networks to enable self-organised response and social resilience
Unlocking capacity			
Conditions:			
Dismantling of institutional path-dependency and competitive advantage of business-as-usual	**Linking past, present and future to identify path-dependencies and mal-adaptation**	**Support networks with an explicit mission for change**	**Social and political awareness and support for departing from business-as-usual**
Activities:			
Setting standards and providing incentives for sustainable investments Integrating sustainability into public tendering Implementing regulation to control unsustainable practices	Road mapping and scenario analyses to explore phase-out options Conducting regular emissions inventories Mandating knowledge generation to ensure access to data	Setting up public-private partnerships for issue-specific action Setting up support networks with key stakeholders (groups) Identifying key stakeholders and groups to know whom to reach out to	Raising awareness and providing assistance for sustainable investments and behaviour change Lobbying for political support
Transformative capacity			
Conditions:			
Space for experimentation as governance approach to learn about new solutions	**Learning institutions for harvesting knowledge from experimentation**	**Multi-actor and inclusive innovation and advocacy networks**	**(Trans-)local support for the innovation story**

Institutional conditions	Knowledge conditions	Network conditions	Social conditions
Activities:			
Temporary lifting or avoiding existing regulations Creating open mind-set for taking up innovations in tactical agendas and daily practices Allocating budget to developing and maintaining innovation, upscaling and replicating Leadership for creating and using opportunities for change	Identifying proof-of-concept lessons from innovations to facilitate replicating and embedding Identifying opportunities from innovation for upscaling Identifying bricolage of solution elements to mainstream innovations into urban planning processes and decisions	Forming informal and formal 'coalitions of the willing' for strategic and operational innovation Involving communities in design and implementation of experiments Creating advocacy coalitions to carry the innovation story Setting up cross-sectoral networks and partnerships tasked with (embedding of) innovation Participating in regional, national and international networking, best practice and knowledge exchange	Mobilising political leadership to put new and ambitious goals on the agenda Piggy-backing and quickly expressing potential of a new solution Creating and advocating an inspiring innovation story Showcasing innovations as market potential for the city
Orchestrating capacity			
Conditions:			
Long-term nexus approach when drafting, implementing and financing (sectoral) policies and solutions	**Co-creation of social-technological-ecological systems knowledge**	**Formal and informal connection channels, network brokering and intermediary spaces**	**Co-ownership over shared and long-term visions**
Activities:			
Developing long-term climate mitigation and adaptation, sustainability and resilience goals Redefining responsibilities for carrying costs Creating competitions to leverage innovative, long-term and co-beneficial solutions	Employing a systems perspective to aggregate knowledge about drivers, risks, opportunities and challenges Identifying opportunities, synergies and trade-offs between different goals Pooling and integrating knowledge and resources across scales and sectors	Establishing central and cross-cutting connection nodes for pooling knowledge, actions and resources Designating theme-leads and contact persons Identifying private and community-based initiatives Creating neutral co-creation spaces and knowledge partnerships to build trust for knowledge sharing	Involving multiple actors from different city departments and private organisations in strategy formulation Public outreaching and participation

5.3.2.1 Stewarding capacity in NYC

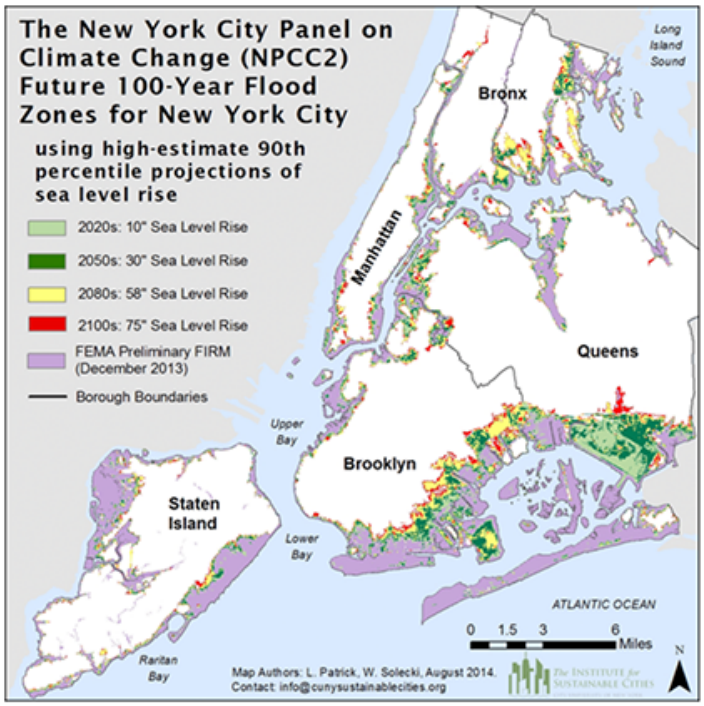
The main stewarding objectives of climate governance policies, plans and actions in NYC are the protection and recovery of the population and infrastructure from climate impacts like flooding, storms and heat waves while contributing to liveability, economic development and social equity. The practical approach combines long-term infrastructure protection with community resilience and short-term emergency relief. The NYC government revised hurricane evacuation zones, placing a greater focus on the varying angles of approach for different storms, and employs regulatory instruments, including building codes and zoning, to ensure that building and area developments take future climate impacts into account, and establishes community-planning processes. Conditions for developing and implementing stewarding interventions have been developed through the creation of a vast amount of knowledge on systemic risks and uncertainties relating to flooding, storms, ecosystem services and health, the set-up of integrated, long-term and multi-level planning approaches and the support of diverse social networks.

Stewarding capacity is manifest in the vast amount of knowledge about climate risks and socio-economic vulnerabilities for different issue areas (e.g. emergency planning, coastal resilience, buildings). This includes projections on long-term sea-level rise and flood safety risks, heat and health stresses and infrastructure risks (Figure 5.1). The Hazard Mitigation Plan considers how climate change may change the physical, social and economic vulnerabilities from natural and non-natural hazards including coastal storms, disease outbreak, drought, flooding and cyber threats (NYC 2014a). Diverse partnerships between actors from academia, local, regional and national governments and local communities support the generation of knowledge. The NYC Panel on Climate Change (NPCC) regularly reports on climate impacts and adaptation needs in NYC (NPCC 2015). NYC city departments contribute to creating knowledge on emergency planning, coastal resilience and ecosystem services. The Department of Parks and Recreation (DPR) collaborates with knowledge institutes such as the Urban Field Station and Natural Areas Conservancy and local communities to monitor the social-ecological values of nature in the city (Forgione et al. 2016).

The NYC government adapted the systemic, long-term and context-specific perspective on risks, vulnerabilities and uncertainty in planning and management approaches to facilitate adaptive management and self-organisation. ORR coordinates and oversees the implementation of the multi-layered strategy for strengthening resilient communities and infrastructures including legislative, community support and investment actions. Different departments take the lead in implementing initiatives touching their responsibility in a decentralised way. The Department of Environmental Protection (DEP) leads green infrastructure developments as a cost-effective tool to manage stormwater while contributing social-ecological value. Infrastructure systems (e.g. transport, energy) are adapted through multi-level governance networks that develop fit-to-context approaches at multiple scales (e.g. buildings, neighbourhoods, coast). For example, effective flood-zoning policies and building codes require cooperation among the Federal Emergency Management Agency (FEMA), DOB and the Planning Department.

Community-specific strategies and community engagement gain increasing momentum to develop place-based interventions, access local knowledge and foster social resilience. The Economic Development Corporation (EDC) facilitates neighbourhood-based visioning processes to integrate

Figure 5.1: NPCC projections on potential areas that could be impacted by the 100-year flood in the 2020s, 2050s, 2080s and 2100 (source: NPCC 2015: p. 12)



climate adaptation with community concerns. DRP engages communities in maintaining the city's green, for example through the GreenThumb programme (Campbell et al. 2016; NYC Parks 2016).

An unclear distribution of responsibilities across multiple jurisdictions and a lack of mainstreaming adaptive and long-term risk strategies constrain stewarding capacity. The former became visible in the aftermath of hurricane Sandy, when local, state and federal agencies struggled with providing relief. In neighbourhoods with strong community organisations, such as in Redhook, these could fill this void (Cowan and Hogan 2014). The lack of mainstreaming and multi-scale integration results in contradictory rules and investments especially in flood-prone waterfronts where developments continue to be allowed. Effective flood-zoning policies and building codes require cooperation among the Federal Emergency Management Agency (FEMA), the Department of Buildings and the Planning Department.

5.3.2.2 Unlocking capacity in NYC

Unlocking climate governance efforts in NYC focus on reducing emissions from buildings, which are responsible for over 70% of the city's total emissions (NYC 2015b), and from transport while improving health, wellbeing and economic prosperity (NYC 2014b; NYC2015a). Unlocking outputs include changes in regulation and physical structures and awareness raising to facilitate renewable energy production, energy efficiency in buildings and sustainable and safe transport. Conditions for unlocking manifest in the identification of and awareness raising on drivers of emissions in connection with drivers of air and noise pollution, waste and inequality, support networks with an explicit mission for change and social and political awareness and support for departing from business-as-usual.

Various knowledge input mechanisms, including emissions inventories and information disclosure mandates, help to reveal structural drivers of emissions (e.g. energy use in buildings) and relationships with other risks (e.g. health). This was critical to identify target areas for action and synergies between different issue areas and to generate political and societal support. The new building plan outlines a roadmap for making NYC's buildings low-carbon and reducing emissions by 80% by 2050 (NYC 2015b). Reporting mechanisms and partnerships facilitate reporting and data analysis. The Greener Greater Buildings Plan (GGBP) (NYC 2009) mandates owners of buildings over 50.000 ft² to annually disclose their energy and water consumption and identify target areas for policies and cost-effective upgrades.

The creation of social and political support is a critical condition for legislative changes and incentives for behavioural changes and investments in sustainable and low-carbon physical structures. Critical for the buy-in to the GGBP was the involvement of key actor groups (e.g. large homeowner associations) in the NYC Green Codes Task Force that gave recommendations for building code changes. A key challenge is still to facilitate energy retrofitting in buildings under 50.000 ft², which are more heterogeneous in their ownership and energy structure. Other types of awareness raising activities by MOS to achieve a wider outreach include the Retrofit Accelerator, which offers free advisory services on energy efficiency improvements. Additionally, training is provided to build the skills for using new energy technologies.

Securing political support is critical for changing incentive structures. The high-level political support for climate mitigation and sustainability legitimised the integration of sustainability standards into public procurement. Political lobbying and the fact that MOS directly reports to the Mayor supported the building code changes. Communicating the benefits and the availability of cost-effective alternatives help to make strong cases for changing regulation. The NYC Health Department's data on the health benefits of reducing air pollution substantiated the DEP's push to regulate the phase-out of high sulphur heating oil, which also reduced emissions.

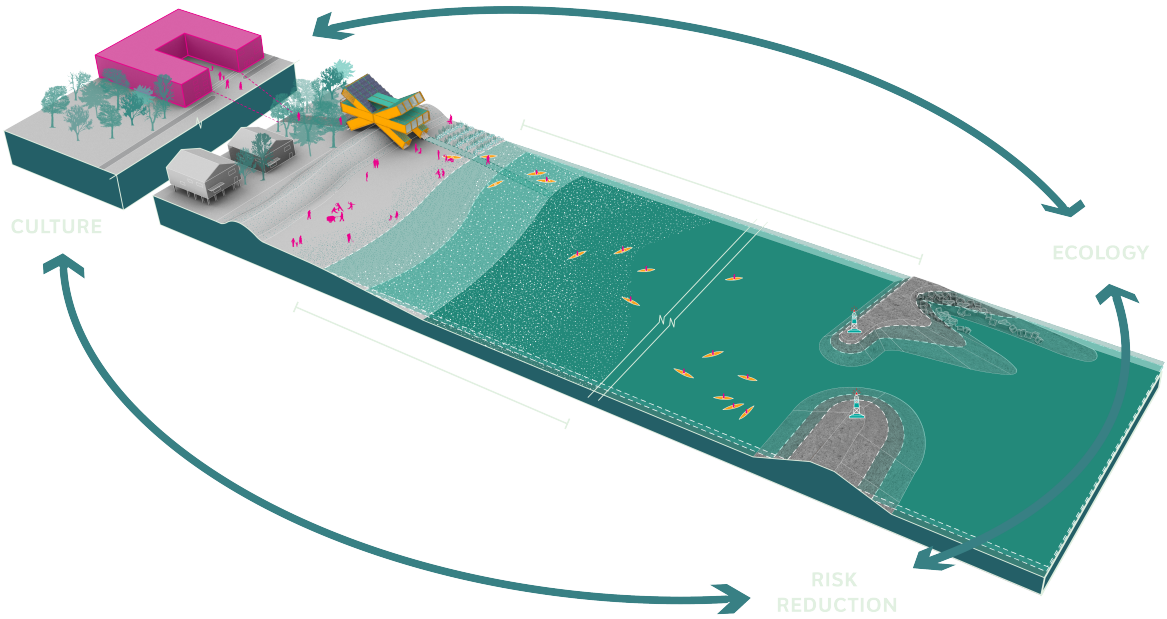
A central challenge for unlocking capacity in NYC is the implementation of decisive measures that challenge existing economic structures and vested interests. Existing regulations hamper more decisive action to change energy use and transport patterns. This is exacerbated by political disputes between city and state agencies that have overlapping jurisdictions. For example, the Department of Transportation's (DOT) plan to impose congestion charges for entering the core of Manhattan was blocked by the New York State government for political reasons.

5.3.2.3 Transformative capacity in NYC

Transformative capacity in NYC is evident in the continuous innovation of how climate change is addressed on strategic, operational, institutional and organisational levels. Strategic goals and agendas were redefined to position climate mitigation and adaptation as opportunity for sustainable and resilience and innovative, multifunctional solutions were implemented. The integrated goals were institutionalised through new governance structures for more open-ended and hybrid decision-making and planning. Conditions for creating and embedding these novelties are include the creation of spaces for (learning from) experimentation and heterogeneous networks and partnerships.

The initiative and high-level political support from the Mayors and individual departments' Commissioners created space for formulating new strategies and testing new solution-approaches like green infrastructure. Hurricane Sandy demonstrated urgency for resilience and resulted in the establishment of SIRR as a heterogeneous network to develop a resilience plan (NYC 2013). This created informal space for diverse actors to come together and share ideas and resources in open and collaborative innovation learning processes. The Rebuild-by-Design (RbD) competition that was initiated by the Federal Department of Housing and Urban Development (HUD) after Hurricane Sandy pioneered a novel process design to co-develop innovative, fit-to-context and integrative resilience solutions. The competition asked for innovative projects to support long-term rebuilding, community resilience and sustainability in the Sandy-affected region. It demanded far-reaching expert and community engagement. Three of the winning designs are in NYC: The BIG U foresees the instalment of a 10-mile system of berms and other protections around Lower Manhattan (Big 2016), the Living Breakwaters project envisions living reefs along Staten Island's south shore to accommodate flooding (Figure 5.2), and the Hunts Point Lifelines project in the Bronx integrates flood protection, recreation, health, local livelihood development and emergency management (RbD 2016).

Figure 5.2: The Living Breakwater Project envisions living reefs along Staten Island's south shore to accommodate flooding, protect ecology and strengthen local communities. This is a concept image that was developed for the Rebuild by Design competition (source: SCAPE Team for the Rebuild by Design Competition 2015).



The integrated goals were anchored in institutional and organisational practices. Action programmes on specific topics were developed to lay out new solution options in alignment with long-term strategic approaches (e.g. NYC 2010; 2015b; NYC Planning 2011). In an effort to embed the integrated thinking into organisational processes MOS and ORR and dedicated sustainability and resilience offices within city departments were established. To ensure optimal implementation of new energy reporting technologies and standards, the Department of Citywide Administrative Services (DCAS) trains

building operators on energy reporting. DEP continuously explores further options for implementing and upscaling the implementation of green infrastructure, also by engaging in international knowledge exchange processes.

The strategic goals and innovative solution approaches do not yet permeate city-wide planning and policy activities. Mainstream implementation is constrained by existing institutions that still dominate funding decisions and the legitimacy of service provisions. In moving towards the implementation phase, the RbD-projects were confronted with complex regulatory barriers and conflicting interests of local, regional and federal public agencies and private stakeholders. This could partially be eased by strategically selecting sites with less regulatory constraints (e.g. avoiding imminent domains) and fewer jurisdictions and by intensive multi-stakeholder communication.

5.3.2.4 Orchestrating capacity in NYC

Orchestrating capacity is evident in the city-wide long-term and integrated climate, sustainability and resilience goals and the formal and informal conditions and processes that were established to mediate priorities, knowledge and resources of multiple actors across sectors and scales in line with these overarching goals. These conditions support the alignment, oversight and collaboration of diverse actors and networks in line with shared, strategic and long-term goals and the development of co-beneficial climate solutions that make use of multiple synergies.

A key condition for orchestrating capacity is the strategic and integrated climate, sustainability and resilience policy agenda, which facilitates strategic alignment across city-wide and departmental policy documents and ways solutions. This goal integration is achieved by co-creative agenda setting processes at multiple governance levels. MOS and ORR coordinate issue-specific cross-departmental, public-private task forces (e.g. climate adaptation, built environment) to align priorities, foster trust and spark new relationships for synergistic project implementation. Through these heterogeneous collaborations, synergies and trade-offs could be identified. For example, green infrastructures could be put forth as a cost-effective way to manage stormwater while contributing to social-ecological value (McPhearson et al. 2014). The collaboration of DPR and DOB in the Urban Heat Island group resulted in the requirement to plant street trees as part of building development. An identified trade-off is between restricting air conditioning to reduce emissions and the vulnerability of low-income populations having neither access to air conditioning nor green space to protect them from heat waves.

Diverse formal and informal networks, nodes and communication channels were established to integrate and mediate priorities and pool resources for implementation. MOS and ORR are central nodes with multiple tasks: facilitate strategy development, oversee and streamline implementation processes, channel information and knowledge, connect to other on-going processes, assign responsibilities, search funding and lobby for support. They participate in cross-scale partnerships to align goals and mediate knowledge and resources across local, regional and federal levels. The Chief Resilience Officer is a key position and contact point for pooling all resilience efforts in the city by working across departments and with local communities. Similar positions have been created within individual departments to bring the agenda into the departments. An informal cross-departmental group of sustainability and resilience 'peers' informally exchanges experiences.

Diverse actors and partnerships support mediation efforts by acting as intermediary to facilitate knowledge exchange and trust building. The Harbor Estuary Program is a federally authorised programme that brings together federal, state and local agencies and citizen groups to define common goals and priorities for the management of the harbour estuary. Private partnerships such as the Waterfront Alliance integrate and represent the interests of business actors to the city government. Non-governmental organisations and knowledge institutes take up roles as facilitators of knowledge sharing, trust building and community engagement. The Science and Resilience Institute @ Jamaica Bay (SRI@JB) mediates scientific and community knowledge between universities, local communities and public agencies by creating an informal space that is not politicised to share ideas and concerns, doing transdisciplinary research and introducing research results into the discussion.

Delivering the orchestrating function is time demanding. Due to time, staff and resource limitations, the ability to align and reach out to the public and to mainstream the strategic perspective are hindered. Community-based organisations such as the NYC Environmental Justice Alliance generate knowledge on climate risks and lobby for more support of vulnerable communities, but feel insufficiently engaged by the city government. Additionally, while processes like RbD experimented with new funding options, the strategic orientation is not translated into consistent long-term and multi-beneficial financing mechanisms. Establishing such mechanisms requires support from federal and state governments. For example, FEMA's funds for post-disaster relief are still tied to rebuilding what was there before rather than ensuring protection from future risks.

5.4 Discussion

We developed a framework of four capacities for urban transformation governance in response to the growing calls for a 'transformation of urban governance' for effectively steering urban transformations towards sustainability and resilience (McCormick et al. 2013; Frantzeskaki et al. 2016a; 2016b; Rink et al. 2018; Romero-Lankao et al. 2018). Our capacities framework can be used to analyse and assess the extent to which these capacities are developing and to support governance actors (e.g. city officers, strategists) in developing these more systematically vis-à-vis existing urban governance regimes. We posit that by strengthening the capacities for urban transformation governance it is possible to close the current disconnect between narrated urban opportunities and lagging on-the-ground practice.

5.4.1 Towards a systematic and agency-based understanding of urban transformation governance

The transformative perspective on urban governance underscores the need for governance approaches that allow flexible, innovative and systemic strategies and solutions to respond to and mobilise complex, contested and uncertain urban transformation dynamics. Research on urban transformation governance has so far failed to deliver detailed and systemic explanations and evaluations of the roles of actors, interactions, mechanisms and processes in bringing urban transformative governance to realisation (Rink et al. 2018; Koop et al. 2018; Bettini et al. 2015). This limits the understanding about how, and by whom, urban transformation governance is developed and delivered, and how it can be strengthened vis-à-vis existing governance regimes.

Our capacities framework provides a comprehensive and agency-centred perspective that bridges different research approaches to explain, evaluate and support the development of urban transformation governance vis-à-vis existing governance regimes. The distinction in output functions for mobilising and influencing the driving forces and dynamics characterising urban transformations is implicitly done by urban transformation researchers. For example, processes and conditions for innovation and experimentation are identified to create novelties that disrupt existing ways of thinking, doing and organising (Nevens et al. 2013; Castán Broto and Bulkeley 2013; Raven et al. 2017). Other examples are governance processes and conditions that facilitate flexible and adaptive responses to emergent risks, surprises and uncertainties (Torabi et al. 2018; Boyd et al. 2014; Tanner et al. 2009). The distinction in different output functions and corresponding capacities allows to integrate the insights of different approaches in terms of 'what needs to happen' for urban transformations to unfold, as well as 'how to make it happen'.

Our case study illustrates the explanatory power of the framework to explain and qualitatively assess whether and how new types of capacities for transformation governance are developing in NYC, and to identify capacity gaps that restrain the full potential of this type of governance. As shown in Table 5.3 and Appendix C, capacities for transformation governance in NYC are visible in diverse institutional, knowledge, network and social conditions that have been created to address mitigation and adaptation in a more innovative, systemic and collaborative policy and planning. For example, the long-term and integrated perspective on climate mitigation, adaptation, sustainability and resilience provides a shared narrative and mobilises actors to pool their efforts and seek synergies (e.g. between emissions reductions in buildings, health and justice) when drafting, implementing and financing (sectoral) policies and solutions, such as green infrastructure innovations that touch on multiple responsibilities and jurisdictions. The establishment of formal and informal connection channels and spaces support alignment, knowledge exchange and collaboration across city departments and between the city government and private actors. Similarly, we found that the creation of (e.g., regulatory, institutional) space for experimentation contributes to strategic, operational and institutional innovations in how climate change is addressed in NYC.

While new conditions are developing – and the insights into what and how conditions are developing inform also other cities in how to move forward – these need to be strengthened vis-à-vis the existing governance regime in NYC. Despite some experimentation with innovative and multi-functional solutions, these often remain isolated and stand-alone initiatives, which indicates gaps in transformative capacity to embed the innovative strategies and solution approaches within mainstream governance processes. Overall, the majority of existing incentive structures and regulations in NYC still favour short-term economic interests and investments, which pre-empts systematic and synergistic protection from long-term risks and decisive unlocking and phase-out of the root causes of emissions and unsustainability. There is thus a clear need for strengthening the created conditions, for example by making more decisive legal and regulatory changes that facilitate experimentation, collaboration and prioritisation of long-term co-benefits over short-term and largely isolated and powerful economic interests. This also demands from the local government in NYC to take up more formalised roles and collaborate with governments at regional and federal levels to streamline and align regulations and rules.

5.4.2 Advancing and applying the capacities framework

Table 5.2 summarises the different types of questions the framework enables to address for studying and learning from ongoing efforts to develop urban transformation governance. While we understand the framework itself as open for further advancement and application, we highlight several avenues for future research.

We suggest the capacities framework as a tool to derive more generalisable results on how and what new forms of urban transformation governance are emerging and how effective these are for steering sustainability and resilience transformations. We understand capacity as an enabler of change, not the change itself. Derived from this, we recognise that multiple parallel processes and context dependencies (e.g. social dynamics, political elections, cultures, values) determine how a function is fulfilled (Koop et al. 2017; Castán Broto 2017). The lens of capacity therefore aids a deeper, integrated and empirically-based understanding of the most important enabling and limiting conditions that determine governance capacity as well as how conditions are created and changed (Koop et al. 2017). The application of the framework to different contexts and scales can yield generalisable results on activities, opportunities and challenges for building capacities for urban transformation governance and thus reveal pathways for increasing governance capacities in relation to different contextual needs, institutional conditions and resources.

As a high-level structuring approach of functions and capacities for transformation governance, the framework can also be applied to conceptually advance and explore specific questions related to the individual capacities. Existing shortcomings of urban transformation governance and the challenges of mainstreaming, which are also visible in experimenting cities like NYC, indicate a need for improving understanding about how the diffuse urban governance landscape can be coordinated. Relatedly, this will improve our understanding on how climate, sustainability and resilience goals and agendas can be more mainstreamed (Hölscher et al. 2019; Aylett 2015; den Exter et al. 2014). For example, while there are many insights on activities enabling innovation and experimentation, whether the generated novelties contribute to a common vision and how they can be mainstreamed, replicated and scaled has received little attention (Caprotti and Cowley 2017; Ehnert et al. 2018; Raven et al. 2017). Likewise, the question of how to overcome technological, institutional and behavioural lock-in by unveiling vested interests, disrupting institutional procedures and disincentivising unsustainable practices and lifestyles demands more scrutiny (Ürge-Vorsatz et al. 2018; Brown et al. 2013; Bai et al. 2018). Such research would help to strengthen the conceptualisation of the capacities, because it feeds back to literature that is just starting to emerge.

Thirdly, the framework provides a prism to approach questions about 'who' is involved in transformation governance. Like in NYC also in other cities worldwide rather than there being one sole authoritative position, actor or institution, heterogeneous groups of individual actors, organisations and actor networks across sectors and jurisdictions, both in and outside of government, have important roles in urban governance with implications on how climate change, sustainability and resilience are addressed (Castán Broto 2017; Hodson et al. 2018). While our case study shows that the framework helps to identify the types of actors taking up responsibilities and action, we see room for linking the framework with a more consistent theory and approach about who is taking up actions, why and by using which strategies – as well as about what are existing urban governance regime networks

that need to be dismantled. For example, despite the integration of social equity values into resilience planning, large investments are still made in economically important areas like Lower Manhattan while more socio-economically vulnerable neighbourhoods remain with infrastructures vulnerable to flooding. We acknowledge that these questions about the political struggles of urban transformation (governance) cannot be understood by merely looking at the activities, arrangements and structural conditions, but also requires critical scrutiny of the (construction of) narratives that provide a rationale for intervention (Castán Broto 2017).

Finally, we suggest the capacities framework as a practical and action-oriented tool to support reflection on and co-creation of governance capacities. The dynamic perspective on how governance capacity is developing makes capacity an empowering concept (Wolfram et al. 2017). It draws attention to the on-going learning processes and based on an understanding of the capacities' conditions and activities makes it possible to derive recommendations about how to address capacity gaps. For example, the framework can support action-oriented research to facilitate the co-creation of governance capacities in specific contexts when it is integrated in practice-based governance frameworks such as transition management (Hölscher 2018; Pedde et al. 2019). In this sense, the capacities framework provides a basic frame for questioning existing governance structures and practices and for developing conditions that enable urban transformation governance in line with Table 5.2.

5.5 Conclusions

The disconnect between the zealous narrative of urban opportunities and how these are harnessed in practice demands closer attention to what types of conditions facilitate urban transformation governance and how they are developed, and by whom, vis-à-vis existing urban governance regimes. Our capacities framework responds to this need for better understanding and supporting urban transformation governance. We suggest the framework as a tool to derive more generalisable results on what new forms of urban transformation governance are emerging, how effective these are for contributing to urban sustainability and resilience transformations and for deriving pathways for effectively strengthening the capacities.

The capacities framework allows to study and learn from ongoing efforts to develop urban transformation governance. We could identify critical conditions and activities facilitating more transformative approaches to addressing sustainability and resilience in NYC, which can inform urban governance practice (in other cities). These mark an important shift from traditional urban governance approaches that tend to make decisions in siloes and based on short-term (economic) interests. In addition, we can reveal barriers and gaps relating to how urban transformation governance is developing vis-à-vis existing governance regimes – most notably relating to the persistence of mainstream structures and siloes across departments, scales and time.

As such, the framework provides a frame for deeper research about how to strengthen the 'transformation of governance' for 'governance for transformation'. Given the complexity of the

challenge, as also illustrated in NYC, this is critical for actually delivering on the hopes invested in cities as key loci for achieving sustainability and resilience locally and globally.

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Chapter 6

Tales of transforming cities: Transformative climate governance capacities in New York City, U.S. and Rotterdam, Netherlands

Abstract

Climate change actions in cities worldwide are driving deep changes in urban governance. We ask whether new capacities for transformative climate governance are emerging in two cities that have experimented with urban climate governance: Rotterdam, the Netherlands, and New York City (NYC), United States. Transformative climate governance creates the conditions for developing integrated and innovative climate mitigation and adaptation policies and interventions that respond to and shape urban transformation dynamics and contribute to sustainability and resilience. The comparison of capacities for transformative climate governance in Rotterdam and NYC offers insights into the emerging features of urban climate governance vis-à-vis existing urban governance regimes: how urban climate governance is driven and delivered, what new governance conditions emerge, and whether these conditions enable transformative climate governance. In both cities, an integrated, experimental and inclusive approach to climate governance is emerging, which crosses multiple policy sectors and domains (e.g. transport, energy, health, justice), involves a variety of actors and facilitates innovative solutions. Envisioning, long-term goal and knowledge integration, experimentation and tapping into coalitions for change help to provide the basis (including guiding principles, urgency, actor networks, innovative solutions) for transformative climate governance. However, these transformative approaches tend to be still subordinate to business-as-usual interests and policy and planning approaches, which favour isolated, incremental and short-term responses. The challenge for strengthening transformative climate governance will be to develop rigorous institutional and organisational conditions that decisively stipulate a prioritisation of climate change across scales and sectors, provide action mandates and enable wider coordination, collaboration and learning.

Status

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Fit with overall thesis

This paper presents the results from the comparative analysis of capacities for transformative climate governance in Rotterdam and New York City. It links back to the main theoretical and empirical research questions of this thesis and identifies patterns, similarities and differences in activities and the conditions they create to enable transformative climate governance. This allows explaining the changes driven by urban climate governance, identifying capacity gaps and discussing how to further strengthen capacities for transformative climate governance.

Chapter 6

Tales of transforming cities: Transformative climate governance capacities in New York City, U.S. and Rotterdam, Netherlands

6.1 Introduction

In the last decade, climate action in cities has become formally recognised as a vital part of the global response to climate change and pressing sustainability challenges (Amundsen et al. 2018; van den Heijden 2018). What is common across the burgeoning activities to govern climate change in cities worldwide is that they are driving deep changes in urban governance towards more integrated, experimental and inclusive approaches (Castán Broto 2017; Romero-Lankao et al. 2018a; Bulkeley and Betsill 2013). In an effort to integrate climate change into urban decision-making and planning processes, local governments have framed climate mitigation and adaptation as opportunities for enhancing liveability and wellbeing in cities (Shaw et al. 2014; Aylett 2015; den Exter et al. 2014). Urban climate experimentation has been a central means for trialling and de-risking innovative and agile sustainable solutions (Castán Broto and Bulkeley 2013; Evans et al. 2016). The premise is that experimentation facilitates collaborative learning processes between multiple actors, dealing with significant uncertainties and complexities of climate change and radical innovation (Bulkeley et al. 2016; Karvonen 2018). While local governments have taken a leading role in urban climate governance, a plethora of actors from local communities, regional and national governments, businesses and research institutes contribute to delivering climate action by generating and integrating knowledge, experimenting with social, economic and technological innovations and self-organising service provisions (Bulkeley 2010; Burch et al. 2016; Moloney and Horne 2015; Hughes et al. 2017).

In this paper, we ask whether climate governance efforts in cities have created new capacities for transformative climate governance. We employ transformative climate governance to position urban climate governance as part of the quest for urban transformations towards sustainability and resilience. This means that climate mitigation and adaptation are not any more isolated objectives, but integrated within the need for radical and structural changes in urban systems to create and maintain environmental integrity, social equity, human well-being and economic feasibility in the long-term (cf. Pickett et al. 2013; McCormick et al. 2013). Transformative climate governance implies a fundamental change of urban governance systems to take more seriously the complex, uncertain and contested dynamics of urban transformations under climate change that unfold across scales and sectors (Loorbach et al. 2015; Romero-Lankao et al. 2018a; Alberti et al. 2018). Due to the complex interactions between climate change and urban systems, sectoral and add-on approaches to addressing climate change that primarily serve to mitigate the negative externalities of other policy areas are unable to

create stepping stones for overcoming the structural root causes of excessive greenhouse gas emissions and vulnerability to climate-related impacts (Shaw et al. 2014; Burch et al. 2018).

To date, even in cities that are leading with ambitious climate agendas climate policy and planning initiatives often remain add-on priorities to short-term and optimisation-focused mainstream policy and planning practices (Anguelovski and Carmin 2011; Aylett 2015). As a result, action for climate change frequently draws the short straw when competing with 'pressing' urban needs and it relies on easy investments in low-hanging fruits that do not fundamentally question existing behaviours and interests (Ürge-Vorsatz et al. 2018; Gouldson et al. 2015). Climate mitigation and adaptation are often developed in incremental, reactive and technocratic ways, which perpetuate mal-adaptation (Moloney and Horne 2015; Torabi et al. 2018). For example, many climate adaptation measures are technological interventions to reduce hazard exposure and vulnerability of buildings and infrastructures without accounting for the social, cultural, economic, political and institutional characteristics of cities (Nordgren et al. 2016). Such measures fail to address issues related to the long-term uncertainties as well as unequal burdens of climate impacts (Torabi et al. 2018; Reckien et al. 2017).

We compare climate governance activities in Rotterdam, the Netherlands, and New York City (NYC), United States, and assess whether these have resulted in new capacities for transformative climate governance. Rotterdam and NYC are examples of cities providing global leadership and setting a standard for climate change adaptation and mitigation with ambitious and cross-cutting climate, sustainability and resilience agendas and a portfolio of innovative solutions for climate mitigation and adaptation (Solecki et al. 2016; Forgione et al. 2016; McPhearson et al. 2014; McPhearson and Wijsman 2017; Ernst et al. 2016; Frantzeskaki and Tillie 2014; Depietri and McPhearson 2018). The comparison of governance capacities in both cities offers insights into the emerging features of urban climate governance vis-à-vis existing urban governance regimes, including how and by whom urban climate governance is driven and constrained, what governance conditions emerge as a result, and whether these conditions indeed enable transformative climate governance.

6.2 Conceptual framework: capacities for transformative climate governance

This section first defines transformative climate governance in cities and then presents our conceptual framework of capacities for transformative climate governance. The term 'governance' recognises that diverse types of actors (e.g. from civil society, economy, government, research) participate in the intentional coordination of social actions through hybrid forms of partnerships and networks (Kooiman 1993; Jessop 1997). The lens of governance capacities helps understanding how, and by whom, urban climate governance is enacted, what conditions emerge as a result, whether these conditions mark a shift towards transformative climate governance, and what are capacity gaps.

The conceptual framework draws on work related to urban climate governance that has converged within the loosely connected field of urban transformation research (Wolfram et al. 2017). Urban transformation research has been driven by the recognition that radical societal change is needed to achieve sustainable and resilient urban systems (ibid.). It includes urban sustainability transitions

approaches that address questions related to the critical enablers and barriers to innovations in climate solutions and governance (Burch et al. 2014; Brown et al. 2013) as well as what type of governance facilitates low-carbon transitions and climate adaptation (Nevens et al. 2013; Hodson and Marvin 2010; Loorbach et al. 2015; Frantzeskaki et al. 2018). Urban climate adaptation and resilience literatures highlight the need for flexible and decentralised governance institutions and social networks that enable learning, self-organisation and fit-to-context management approaches in the face of long-term and uncertain risks (Boyd et al. 2014; Torabi et al. 2018).

6.2.1 Transformative climate governance in cities

Transformative climate governance starts from the premise that climate change cannot be anymore addressed as an isolated problem in cities. Rather, a view of climate change as a symptom, and amplifier, of unsustainable path-dependencies and mal-adaptation in urban planning makes clear that climate mitigation and adaptation should be part of the quest for transformations to sustainability and resilience (Romero-Lankao et al. 2018a; Burch et al. 2018). This is what we term *transformative* climate governance: transformative climate governance develops problem-based and systemic climate mitigation and adaptation policies and interventions that contribute to and maintain environmental integrity, social equity and well-being and economic feasibility (sustainability) under complex, contested and uncertain transformation dynamics (resilience) (cf. Hölscher et al. 2018a; Pickett et al. 2013; Meerow et al. 2016).

On the one hand, embedding governance activities to address climate change within the endeavour to steer urban sustainability and resilience transformations opens up opportunities for systemic climate solutions that also enhance the quality of life, ensure social equity and help avoid locking a city into counterproductive infrastructures and policies (Romero-Lankao et al. 2018a; McPhearson et al. 2016a; 2016b; Burch et al. 2018). This draws attention to the social and economic root causes driving high-emission trajectories and vulnerabilities to climate change in cities, including individual values and behaviours, built urban structures, political conflicts and economic opportunities (Ürge-Vorsatz et al. 2018; Rosenzweig et al. 2015; Burch et al. 2018).

On the other hand, addressing climate change in the context of urban transformations reveals the systemic, complex, uncertain, contested and long-term characteristics of climate change (Romero-Lankao et al. 2018b; McCormick et al. 2013). Transformation dynamics are visible in institutional, technological and behavioural path-dependencies and lock-ins, which perpetuate high-emission trajectories and mal-adaptation (Ürge-Vorsatz et al. 2018; Seto et al. 2016). They also become visible in the uncertainty of future climate impacts and how they affect urban systems (Carter et al. 2015; Rosenzweig et al. 2015). This requires long-term governance approaches that give special attention to learning, participation, knowledge co-production, long-term thinking, experimentation and flexibility (Wolfram and Frantzeskaki 2016; Wittmayer et al. 2018).

In summary, our definition of transformative climate governance in cities responds to three questions: Transformative climate governance develops problem-based and systemic climate mitigation and adaptation policies (*governance of what?*) that contribute to sustainability and resilience across sectors and scales (*governance for what and whom?*) by creating the conditions for mobilising and responding to different types of transformation dynamics (*climate governance processes*) (Table 6.1).

Table 6.1: Tenets for transformative climate governance in cities

Characteristics of climate change as urban transformation challenge	Tenets for transformative climate governance in cities
Systemic: cross-scale, cross-sectoral and long-term drivers and impacts • Climate change is propelled by and affects multiple urban systems (e.g. economy, agriculture, water, health, transport) and systems' dimensions (e.g. urban land use, infrastructures, lifestyles (Rosenzweig et al. 2015; Seto et al. 2017; Ürge-Vorsatz et al. 2018). • Drivers and impacts are cross-sectoral and cross-scale; e.g. they interact with diverse processes (e.g. wetland loss, ageing infrastructure, coastal development vulnerabilities) (Alberti et al. 2018). • Long periods of time pass between the emission of GHGs and the impacts of a changing climate (Meadowcroft 2009).	**Problem-based system perspective: climate governance of what?** Develop fit-to-context and fit-to-purpose climate strategies and actions that address the social, economic, institutional, technological, political and economic root causes driving high emissions, mal-adaptation and vulnerabilities to climate change impacts in the long-term and across scales and sectors (Ürge-Vorsatz et al. 2018; Wittmayer et al. 2018; Runhaar et al. 2018; Romero-Lankao et al. 2018b).
Co-evolution: build-up and break-down patterns involving path-dependency, uncertainty and thresholds • Mutually reinforcing physical, economic and social constraints (e.g. long infrastructure lifetimes, institutions, behaviours, large capital costs) constrain the rate and magnitude of emissions reductions and climate adaptation in cities (Seto et al. 2016; Rosenzweig et al. 2015). • A lot of uncertainties girdle climate impacts, e.g. concerning the sensitivity of the climate system (how much warming will result from a certain increase of GHG concentrations), regional climate impacts and consequences for ecosystems (Meadowcroft 2009; Carter et al. 2015). • These climate-related uncertainties are exacerbated by the likelihood of surprises and unexpected shocks – as illustrated by Hurricanes Sandy and Katrina – which can lead to radical discontinuities (Alberti et al. 2018).	**Mobilising transformation dynamics in tune with opportunity contexts: climate governance processes** Mobilise and respond to different types of transformation dynamics by facilitating disruptive innovation, destabilising unsustainable regimes (Bosman et al. 2018; Ürge-Vorsatz et al. 2018; Loorbach et al. 2015) and safeguarding from disturbances, risks and uncertainty (Rosenzweig et al. 2015; Torabi et al. 2018). This requires staying tuned to opportunity contexts to make use of crisis as opportunities for overcoming system inertia while ensuring effective coping and incremental responses that contribute to radical change in the long-term.
Sustainability and resilience: normativity, trade-offs and contestation While responsibilities for climate change are unequally distributed, climate change will impact vary across different geographical locations and different groups (Castán Broto 2017; Reckien et al. 2017; Romero-Lankao et al. 2018b).	**Co-creating integrated climate, sustainability and resilience goals: climate governance for what and for whom?** Ensure co-creative and inclusive decision-making processes to position climate mitigation and adaptation within sustainability and resilience goals, foster social justice and provide a broad variety of approaches and solutions building on discussions about the allocation of responsibilities and duties among diverse public and private actors (Tanner et al. 2009; Wittmayer et al. 2018). Sustainability is a socially negotiated, normative set of goals for achieving environmental integrity, social equity, human well-being and economic feasibility now and in the future (Pickett et al. 2013). Resilience indicates the

Characteristics of climate change as urban transformation challenge	Tenets for transformative climate governance in cities
	properties and interactions determining whether urban systems can adapt and transform in response to disturbances and uncertainty in the short- and mid-term and shape change in the long-term (ibid.; Meerow et al. 2016).

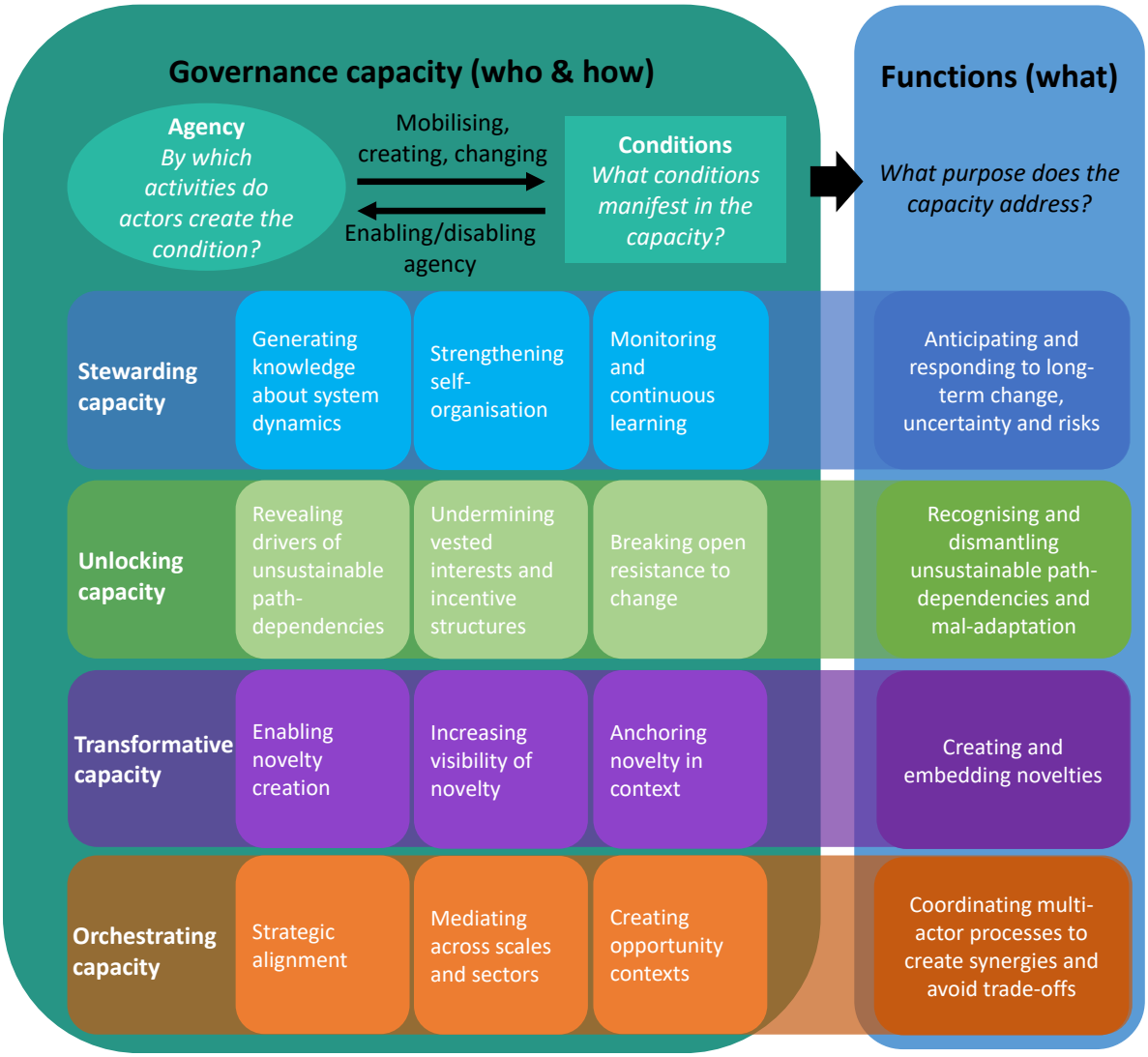
6.2.2 Capacities for transformative climate governance

Transformative climate governance is transformative of urban governance systems themselves, by postulating new types of conditions for integrated, innovative, flexible and inclusive approaches to addressing climate change, sustainability and resilience. We developed a framework of capacities for transformative climate governance that helps explaining and evaluating what types of governance conditions are created by urban climate governance activities, and whether these conditions contribute to transformative climate governance (cf. Hölscher et al. 2018a).

The perspective on governance capacity helps bridging between the diverse actors and activities engaged in urban climate governance and the conditions that (need to) emerge as a result by connecting actors ('who'), context and strategies ('how'), and outcomes ('what') (Figure 6.1). It views governance as a structuration process: According to structuration theory actors are both enabled and constrained in their actions by the structural frameworks in which they operate (Giddens 1979). However, actors are also able to adapt to and change their structural contexts (ibid.; Garud et al. 2007). Accordingly, while multiple actors perform acts of governing by making purposive decisions, deliberate actions and strategic choices, their actions and interactions are shaped by institutionalised working arrangements (e.g. organisational settings, rules, regulations) and broader socio-economic and political contexts (e.g. political commitment, available resources) (Hodson et al. 2018; Koop et al. 2017). Governance capacities are thus manifest in the activities through which actors deliberate between contested solutions (rather than promoting individual actor interests) and navigate their structural contexts, which also change as a result of actors' interventions (Koop et al. 2017; Bettini et al. 2015). Governance capacities are mobile: they are continuously developed and adapted through the actions of diverse governance actors.

As shown in Figure 6.1, the framework distinguishes between four critical capacities. Each capacity manifests in different types conditions that are created by actors' activities and that enable delivering distinct output functions for transformative climate governance. Together, the capacities enable transformative climate governance: they enable mobilising urban transformation dynamics and develop integrated and systemic climate mitigation and adaptation actions that contribute to sustainability and resilience. Tables I.A.2 to I.A.5 in Intermezzo A provide a comprehensive overview of the operationalisation of the capacities with the supporting sources (Hölscher et al. 2018a).

Figure 6.1: Conceptual framework: capacities for transformative climate governance



Stewarding capacity

Climate impacts and vulnerabilities cause short-term and long-term risks, uncertainty and surprise in cities (Johnson et al. 2015; Rosenzweig et al. 2015; Carter et al. 2015). Stewarding capacity enables anticipation of and responsiveness to uncertainty and risk while exploiting opportunities beneficial for sustainability. Stewarding capacity is manifest in conditions that enable learning and flexible responses to (uncertain) change and disturbance. The generation of knowledge about complex, long-term social-ecological system dynamics across scales enables the anticipation of emergent risks and uncertainties (Koop et al. 2017; McPhearson et al. 2015; Chelleri et al. 2015). Decentralised, fit-for-context and flexible institutions and networks that incorporate long-term risks facilitate dynamic responses to changes and disturbances (Torabi et al. 2018; Tanner et al. 2009; Boyd et al. 2014). Monitoring and participatory learning are key ingredients to adapt management objectives and practices to changing situations in line with new information (Tanner et al. 2009; Koop et al. 2017).

Unlocking capacity

Dominant urban land use, design and living patterns that drive current high emission and unsustainable urban development pathways are deeply embedded in existing institutions, technologies, actor networks, behaviours and values (Bai et al. 2017; Ürge-Vorsatz et al. 2018; Seto et al. 2016; Bosman et al. 2018). Unlocking capacity is manifest in the abilities of actors and the conditions that enable recognising and dismantling of the structural drivers of unsustainable path-dependencies and mal-adaptation. Knowledge generation mechanisms like baseline measurements and system analyses help to recognise institutions, technologies and behaviours that perpetuate mal-adaptation and need to be strategically phased out (Sperling and Ramaswami 2017; Loorbach et al. 2015; Jhagroe and Frantzeskaki 2015). Undermining vested interests, existing (financial, regulatory) incentive structures and actor networks serves to reduce the comparative advantage of business-as-usual and developing economically attractive business cases (Sperling and Ramaswami 2017; Gouldson et al. 2015; Kivimaa and Kern 2016; Seto et al. 2016). Breaking open resistance to change diminishes support for business-as-usual and creates opportunities and awareness for alternatives (Bettini et al. 2015; Sperling and Ramaswami 2017; Moloney and Horne 2015; Meadowcroft 2009).

Transformative capacity

Escaping current unsustainable and mal-adaptive urban development trajectories requires the development and diffusion of radical alternatives that provide new ways of doing, thinking and organising (Brown et al. 2013; Frantzeskaki et al. 2017; Loorbach et al. 2015). Transformative capacity enables creating novelties that contribute to sustainability and resilience and the embedding of these novelties in structures, practices and discourses. The condition for novelty creation ensures space, resources and networks for developing and testing innovations (Raven et al. 2010; Loorbach et al. 2015; Nevens et al. 2013; McPhearson et al 2017). To challenge dominant regimes and motivate acceptance and update, innovation needs to gain traction and support, which is facilitated by the condition to increase the visibility of novelty (Nevens et al. 2013; Frantzeskaki et al. 2017; Brown et al. 2013). Anchoring the novelty in context ensures its replication, scaling and mainstreaming by routinizing and institutionalising the innovation in organisational, institutional and operational structures and processes (Ehnert et al. 2018; den Exter et al. 2014; Wamsler 2015).

Orchestrating capacity

The distributed nature of urban climate governance activities across governance networks, scales and sectors induces a need for encouraging, coordinating and assisting action in alignment with shared long-term goals (Pahl-Wostl and Knieper 2014; Hodson and Marvin 2010; Keskitalo et al. 2016). Orchestrating capacity is manifest in the abilities of actors to coordinate multi-actor urban governance processes and foster synergies and minimise trade-offs and conflicts across scales, sectors and time. Strategic alignment supports the formulation of shared, integrated and long-term goals towards which climate actions are oriented (Hodson and Marvin 2010; Moloney and Horne 2015; Chu et al. 2017; McPhearson et al. 2017). Mediating across scales and sectors through formal and informal structures, spaces and communication channels enables knowledge and resource sharing and conflict resolutions (Hodson and Marvin 2010; Kivimaa 2014). The creation of opportunity contexts establishes framework

conditions for clarifying costs, benefits and responsibilities and incentivising and assisting actions towards long-term goals (Pahl-Wostl and Knieper 2014; Fidelman et al. 2013).

6.3 Materials and method

We conducted a qualitative comparative case study to compare climate governance activities in Rotterdam and NYC and whether these have resulted in new types of capacities for transformative climate governance. The comparison of governance activities and resulting capacity conditions in Rotterdam and NYC enables interpreting similarities, differences and patterns manifest in capacities for transformative climate governance in different urban contexts (Eisenhardt and Graebner 2007). Details on data collection and analysis will follow an introduction to the case study contexts.

6.3.1 Learning from Rotterdam and New York City

Rotterdam and NYC are examples of cities where local governments have pioneered integrated and ambitious strategies and innovative solutions for addressing climate change, sustainability and resilience. Both cities are members of Connecting Delta Cities and 100 Resilient Cities, and other international city networks used to exchange knowledge and promote inter-city learning. Our case selection builds on the assumption that in both cities new types of governance capacities have already been built. The cities therefore offer ample opportunities to learn about activities and conditions for transformative climate governance, as well as how they can be strengthened.

Rotterdam and NYC are both delta cities, mark important economic centres in their region and face a diversity of climate change impacts and broader socio-economic challenges. Rotterdam is located in the South-West of the Netherlands, has a population of over 650.000 inhabitants and hosts the largest ports in Europe. NYC is located at the east coast of the US and accommodates an estimated population of over 8.55 Million people (US Census Bureau 2015). Expected climate impacts in Rotterdam and NYC include sea level rise, rising river and groundwater levels, increasing severity of heavy downpours and storms, coastal and storm surges and heat waves (Molenaar et al. 2013; NPCC 2015). Both cities have already experienced climate extremes that highlighted numerous risks for the cities' populations and infrastructure. In NYC, Hurricane Sandy's landfall in October 2012 has been a hallmark that exemplified the city's climate resilience challenges (NYC 2013; Depietri and McPhearson 2018; McPhearson et al. 2014).

In Rotterdam, climate change was introduced in the city government's agenda in 2007 with the Mayor's goal to reduce CO_2-emissions by 50% in 2025 compared to 1990 and the launch of the Rotterdam Climate Initiative (RCI). Concomitantly, water policy entrepreneurs formulated the goal to become climate-proof by 2025. This involved reframing the perception of water as a threat towards recognising climate adaptation as opportunity for improving the city's social and economic attractiveness (RCI 2009; de Greef 2005; van der Brugge and de Graaf 2010). Until today, the climate change focus was successively expanded towards sustainability, liveability and, most recently, resilience (Gemeente Rotterdam 2012; 2015; 2016). However, the official CO_2-reduction target was removed for political reasons. This strategic approach was institutionalised in the city government's cross-cutting

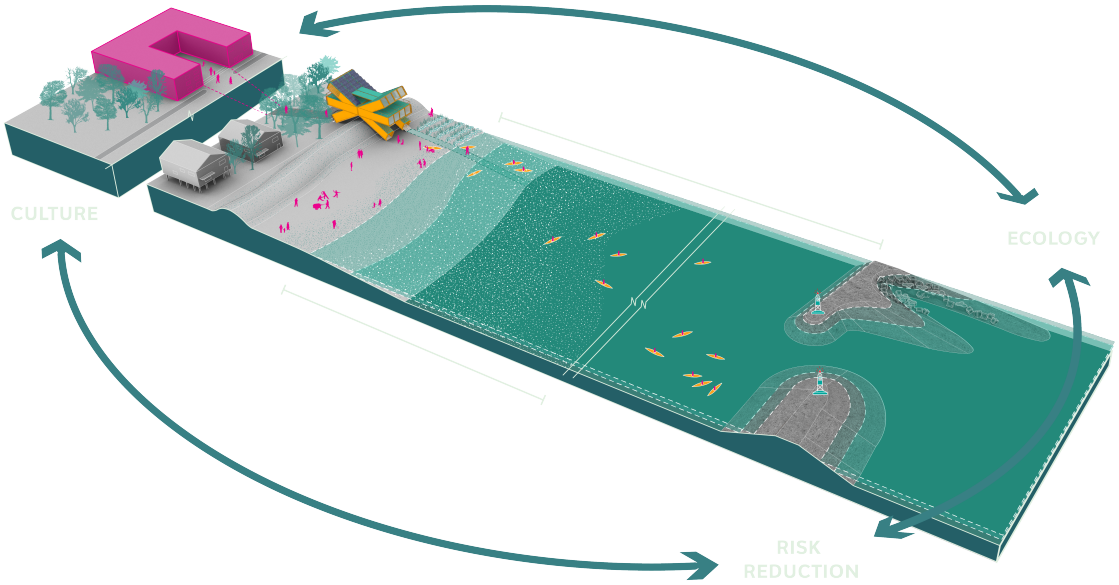
Sustainability and Climate Adaptation Offices that coordinate climate, resilience and sustainability-related actions and collaborate with other city departments, levels of government (e.g. national government, water boards (regional government bodies charged with managing water barriers, waterways, water quality) and private actors. The city gained international recognition particularly through its high-profile proof-of-concept experiments that deliver co-benefits for climate adaptation, greening, recreation, community-building and economic development. Examples include the Benthemplein water square, which combines rainwater management with area development, the multifunctional underground water storage facility at Museumplein car park and the Floating Pavilion in the City Ports area (Figure 6.2).

Figure 6.2: Floating Pavilion and trees for climate adaptation in Rotterdam (source: Gemeente Rotterdam 2018)

In NYC, Mayor Bloomberg (2002-2014) ignited the city-wide agenda on sustainability and climate mitigation by commissioning a cross-cutting sustainability and climate mitigation plan. Released in 2007, PlaNYC tied goals such as emissions reductions, improving air quality, managing population growth, modernising infrastructure and the city's long-term liveability and global competitiveness (NYC 2007). Following Hurricane Sandy in late 2012, the Special Initiative for Rebuilding and Resiliency (SIRR) was convened to develop a programme for reducing the city's vulnerability to coastal flooding and storm surge and for rebuilding communities (NYC 2013). When Mayor de Blasio took office in 2014, he issued 'One New York: The Plan for a Strong and Just City' (OneNYC) (NYC 2015a), introducing affordable housing and social equity as top priorities for resilience and sustainability. The cross-departmental Mayor's Offices of Sustainability (MOS) and Recovery and Resiliency (ORR) were established to spearhead the city government's efforts on climate change, resilience and sustainability. MOS, ORR and city departments closely work together with business networks, community organisations and they participate in cross-sectoral and cross-scale knowledge platforms and partnerships. These efforts resulted in diverse measures, including green infrastructure projects,

regulations (e.g. on energy efficiency in buildings) and community resilience building. For example, the NYC Cool Neighbourhoods programme was launched in 2017 to protect citizens from extreme heat by combining green infrastructure, health training and supporting low-income households (NYC 2017). The Federal Department of Housing and Urban Development (HUD) initiated the Rebuild-by-Design (RbD) competition to develop and implement innovative projects for rebuilding, community resilience and sustainability in the Sandy-affected region. This is resulted in three innovative projects located in NYC: The BIG U integrates green infrastructure and liveability for flood protection in Lower Manhattan, the Living Breakwaters project envisions living reefs along Staten Island's south shore to accommodate flooding (Figure 6.3), and the Hunts Point Lifelines project in the Bronx integrates flood protection, recreation, health, local livelihood development and emergency management (RbD 2016; Grannis et al. 2016).

Figure 6.3: The Living Breakwater Project envisions living reefs along Staten Island's south shore to accommodate flooding, protect ecology and strengthen local communities. This is a concept image that was developed for the Rebuild by Design competition (source: SCAPE Team for the Rebuild by Design Competition 2015).



6.3.2 Data collection and analysis

We performed desktop research to review policy documents (strategies, visions and programmes from 2007 to 2017, including Gemeente Rotterdam 2015; 2016; RCI 2012 for Rotterdam and NYC 2007; 2010; 2015 for NYC), media articles and scientific papers about climate, resilience and sustainability governance in Rotterdam and NYC. Secondly, we conducted semi-structured interviews with a mix of informants from local, regional (in Rotterdam referring to water boards, in NYC from the New York State government), national governance scales as well as from government, market and civil society that are involved in climate governance in the context of the respective city (Table 6.2). We attended workshops and meetings related to strategy formulation and knowledge exchange. In Rotterdam, two of the authors were involved in different vision and strategy development processes in Rotterdam city

between 2012 and 2016, including the re-development of the City Ports area (Frantzeskaki et al. 2014) and the formulation of the resilience strategy (Gemeente Rotterdam 2016; Lodder et al. 2016). One author has been a member of the NYC ORR's Urban Heat Island Task Force, advises on research and implementation for multiple city agencies, and co-leads the integrated NYC Stormwater Resiliency research together with ORR and NYC Department of Environmental Protection (DEP) to deliver recommendations for significant city investments to enable short- and long-term flood resiliency.

Table 6.2: Interviews conducted for the case studies

Case study	Interviews in total	Interviewees according to sector	Period interviews were conducted
Rotterdam	28	Local city government (11) Regional government (1) National government (1) Knowledge institutes (4) Local businesses and architects (6) NGOs and community-based organisations (3) Politicians (2)	03 – 06/2015
NYC	38	Local city government (12) Regional government (4) National government (2) Knowledge institutes (7) Local businesses, architects and business platforms (6) NGOs and community-based organisations (7)	10/2015 – 01/2016

For each case study, the collected data was analysed in reference to the capacities framework (see also Hölscher et al. 2018a). Firstly, we analysed how the capacity output functions stewarding, unlocking, transforming and orchestrating are addressed in climate-related policy and planning practice in Rotterdam and NYC. Secondly, for each capacity we analysed the activities by which multiple actors develop and implement climate-related action and whether the activities manifest in new types of governance conditions. This step involved theory-driven coding of the collected data to relate the activities to the capacity conditions of the framework (Saldana 2009; see Appendix C). Thirdly, we identified challenges that reflect capacity gaps for fulfilling the functions.

This paper presents the findings from our comparative analysis of the governance capacities in Rotterdam and NYC to identify similarities, differences and patterns in what types of conditions were created, how and by whom they were created and how the functions were fulfilled (Eisenhardt and Graebner 2007).

6.4 Results: capacities for transformative climate governance in Rotterdam and NYC

The activities and processes to govern climate change in Rotterdam and NYC manifest in new conditions for stewarding, unlocking, transformative and orchestrating capacity. These help to address climate mitigation and adaptation in integrated, inclusive and experimental ways to facilitate responding to uncertainty and risk, phasing out drivers of unsustainable path-dependency and mal-adaptation, create social, technological and institutional innovations and coordinate multi-actor processes across scales and sectors. Appendix C includes a full overview of conditions and activities with examples and illustrations from both cities.

6.4.1 Stewarding capacity in Rotterdam and NYC

Stewarding capacity influences which and how disturbances are anticipated and what responses are enabled. In both cities, conditions for stewarding have been created by developing a vast amount of knowledge on systemic risks and uncertainties relating to flooding, storms and health, establishing integrated, long-term and multi-level planning approaches and supporting diverse social networks. While Rotterdam and the Netherlands have a long-standing policy tradition on ensuring water safety, which is reflected in the high levels of infrastructure protection in Rotterdam, NYC combines long-term infrastructure protection with community resilience and providing short-term emergency relief.

In both cities, a thorough knowledge base was created about short-term and long-term climate impacts and related social-ecological risks and vulnerabilities. Knowledge includes projections of long-term sea-level rise and flood safety risks, heat and health stresses and infrastructure risks (RCI 2012; NPCC 2015). Informants have highlighted the critical role of knowledge programmes in bringing together actors from local, regional and national governments, academia, businesses and local communities to generate issue-specific knowledge at different scales (e.g. regional, communities). In the Netherlands, the Dutch government initiated multi-actor research programmes like Knowledge for Climate to generate knowledge on climate impacts in high-impact regions in the Netherlands, including Rotterdam (van den Berg et al. 2013; van Veelen 2013). Mayor Bloomberg set up the NYC Panel on Climate Change (NPCC) to report on climate risks and adaptation needs (NPCC 2015). NYC city departments including Emergency Management (EMD), Parks and Recreation (DPR) and the Health Department contribute to creating knowledge on emergency planning, coastal resilience and ecosystem services (NYC 2015b; Forgione et al. 2016). In both cities, informants also highlighted the creation of knowledge mandates about risks. For example, the province of South-Holland asks municipalities to make risk assessments for inhabitants of outer-dike areas.

The systemic, long-term and context-specific perspective on risks, vulnerabilities and uncertainty was integrated in planning and management approaches. The NYC government revised hurricane evacuation zones, placing a greater focus on the varying angles of approach for different storms, and employs regulatory instruments, including building codes and zoning, to ensure that building and area developments take future climate impacts into account. Planning and management approaches are place-based to take different needs into account for interventions (e.g. regional, neighbourhoods). In Rotterdam, large-scale (e.g. Maasvlakte stormsurge barrier) and small-scale flood protection

measures (e.g. blue-green corridors) complement each other. Informants value green infrastructure as a cost-effective way to manage stormwater while contributing to social-ecological value (Frantzeskaki and Tillie 2014; McPhearson et al. 2014).

While the local governments, in particular the Climate Office in Rotterdam and ORR in NYC, are the main actors responsible for ensuring and overseeing climate-proofing safeguarding measures, they establish and collaborate with diverse networks and partnerships to enable cross-boundary and cross-sectoral implementation. In both cities water and flood safety are shared responsibilities across national, regional and local governmental bodies, which requires coordination and collaboration. In NYC, effective flood-zoning policies and building codes require cooperation among the Federal Emergency Management Agency (FEMA), DOB and the Planning Department. Community engagement and participatory planning processes are increasingly employed to access local knowledge, gain support and foster resilient neighbourhoods. The Rotterdam Resilience Strategy has identified community initiatives that could be connected to the city's resilience efforts (Lodder et al. 2016). In NYC, DPR engages communities in maintaining the city's green, for example through the GreenThumb programme (Campbell et al. 2016; NYC Parks 2016).

In both cities, stewarding capacity is constrained by an unclear distribution of responsibilities and a lack of mainstreaming of integrated and long-term risk management approaches. The former results conflicts of interests and limited financing opportunities. In Rotterdam, regional water boards collect taxes for water safety, but they are by national law not allowed to invest in flood defence in unembanked areas, such as the low-income South District. The lack of mainstreaming results in contradictory rules and investments that often disincentivise long-term and co-beneficial safeguarding measures. The US National Flood Insurance Program restrains some building adaptation options (e.g. elevation) by demanding to (re-)build 'in kind'.

6.4.2 Unlocking capacity in Rotterdam and NYC

Unlocking capacity determines what and how drivers of unsustainability and path-dependencies are recognised and reduced. Unlocking capacity in Rotterdam and NYC is manifest in the identification of and awareness raising on drivers of emissions in connection with drivers of air and noise pollution, waste and inequality, and the creation of new incentives and regulations to control unsustainable practices and support alternatives.

In both cities, informants found that the revelation of drivers of emissions and relationships with other vulnerabilities and unsustainabilities was critical to identify target areas for action and synergies between different issue areas and to generate political and societal support. Roadmaps and transition pathways help to explore different options on how to reduce emissions, for example from the port in Rotterdam (Samadi et al. 2016) or buildings in NYC (NYC 2015b). In NYC, the city government mandates reporting mechanisms to collect data. For example, the Greener Greater Buildings Plan (GGBP) (NYC 2009) mandates owners of buildings over 50.000 ft² to annually disclose their energy and water consumption and identify target areas for policies and cost-effective upgrades. There is also a high level of institutional capacity for departments like the NYC Department of Health and Mental Health' (Health Department) to collect data.

Incentives, regulations and procurement standards promote investments in renewable energy production, energy efficiency in buildings and sustainable transport. The NYC government adopted legislative changes like the GGBP to change building regulations. The Rotterdam government supports the development of new business cases, for example involving privileges and funding constructions for electric freight transport and retrofitting. To achieve changes in incentive structures and regulations, actors from the climate and sustainability offices lobby for political and societal support and proactively communicate the co-benefits of individual measures. The Health Department's data on the health benefits of reducing air pollution substantiated DEP's push to regulate the phase-out of high sulphur heating oil, which also reduced emissions. Likewise, it was highlighted that the involvement of key actor groups (e.g. large homeowner associations) in the NYC Green Codes Task Force to make recommendations for the building and construction code changes was critical for the buy-in to the GGBP.

The main challenge for unlocking capacity in Rotterdam and NYC relates to a lack of mainstreaming and prioritising of sustainability and climate concerns. Existing interests, incentive structures and regulations favour short-term economic interests and investments. For example, any action towards sustainable energy in the port of Rotterdam premise the unabated continuation of industrial activities. This impedes measures that decisively challenge existing economic structures, interests and behaviour – business cases for sustainable energy investments remain thin and unappealing because of complex regulations, permit requirements and the need for technical expertise. The block of congestion charges for entering the core of Manhattan by the New York State government indicates the need for collaboration between city and state agencies with overlapping jurisdictions.

Another key challenge in both cities is to reach out to more heterogeneous populations, for example to buildings that have different types of ownerships and energy structures. In Rotterdam, the local energy cooperative Blijstrom supports the Sustainability Office by providing assistance to citizens that want to retrofit their private homes. In NYC, MOS established the Retrofit Accelerator to offer free advisory services on energy efficiency improvements.

6.4.3 Transformative capacity in Rotterdam and NYC

Transformative capacity influences what type of new innovations are developed and how they are embedded into structures, cultures and practices. Transformative capacity in Rotterdam and NYC is evident in the multiple strategic, operational, institutional and organisational innovations in how climate mitigation and adaptation are addressed. Strategic goals and agendas were redefined to position climate mitigation and adaptation as opportunity for sustainable and resilience and innovative, multifunctional solutions were implemented. The integrated goals were embedded in new cross-sectoral governance structures to coordinate multi-actor implementation.

The initiative and high-level political support from the Mayors and, in NYC, also from individual departments' Commissioners were critical for putting strategic and operational innovations for climate change, sustainability and resilience on the political and public agenda. Policy entrepreneurs were able to use opportunities for change – like the International Architecture Biennale in Rotterdam and Hurricane Sandy in NYC – to develop climate adaptation and resilience plans.

The creation of informal spaces, in which small and heterogeneous actor groups come together to share ideas and resources in open and collaborative innovation learning processes, has been critical to enable out-of-the-box thinking and ensure flexibility in navigating existing regulations. In Rotterdam, the Floating Pavilion Partnership brought together actors from knowledge institutes, the local government, private companies and local communities to create knowledge on floating developments and implement the Floating Pavilion pilot project. The RbD-competition, which was initiated by HUD after Hurricane Sandy and resulted in three resilience projects in NYC, demanded far-reaching expert and community engagement to ensure local support and relevance. The involvement of diverse actors enables resource synergies, but also requires interest mediation and time. The implementation of a first water square in Rotterdam failed because there was no community support; the Benthemplein square is successfully used as a community square because local groups co-designed it.

The strategic and operational innovations were embedded into new governance structures and operational processes to enable wider uptake, replication and scaling. The cross-departmental Climate Adaptation and Sustainability Offices in Rotterdam and MOS and ORR in NYC were established to embed the integrated thinking on strategic goals into organisational processes within the respective city governments. Institutionalised partnerships like the RDM Campus in Rotterdam continue the development of innovations like floating constructions. The strategic goals were operationalised into or connected to action programmes on specific topics, such as the NYC Cool Neighbourhoods programme (NYC 2017) and the redevelopment of the old city ports area in Rotterdam (Frantzeskaki et al. 2014). Vice versa, the experimentation with innovative solutions resulted in proof-of-concept lessons. Other water squares were implemented in Rotterdam taking on board lessons to reduce technical complexity. The architecture firm De Urbanisten that implemented the Benthemplein water square builds on the water retention function covered by the square to develop a climate-proof city quarter, the Zomerhofkwartier, in the area.

Despite these successes in innovating climate governance approaches, strategies and solutions in Rotterdam and NYC, these do not yet permeate city-wide planning and decision-making. In Rotterdam, innovative projects often remain stand-alone initiatives, which are showcased internationally, rather than locally, to create business opportunities for local companies (Hölscher et al. 2018b). Learning from experiments remains largely ad-hoc due to time constrains. While first-time innovations can benefit from lifted regulations and financial support, upscaling and replication are more constrained by existing regulations and short-term cost-benefit-calculations. In moving towards the implementation phase of the RbD-projects in NYC, the project teams were confronted with complex regulatory barriers and competing interests of multiple public agencies and private stakeholders.

6.4.4 Orchestrating capacity in Rotterdam and NYC

Orchestrating capacity creates synergies between climate governance and other policy sectors across scales in line with overarching visions for sustainability and resilience. Orchestrating capacity in Rotterdam and NYC is evident in the city-wide long-term and integrated climate, sustainability and resilience goals and the formal and informal conditions and processes that were established to streamline and coordinate the activities of multiple actors and networks so they contribute towards these goals across sectors and scales.

The city-wide strategic agendas on climate change, sustainability and resilience in Rotterdam (e.g. Gemeente Rotterdam 2015; 2016) and NYC (e.g. NYC 2007; 2015) provide overarching orientations for integrating climate priorities in sectoral policies and for designing co-beneficial climate solutions. The discussions on how to integrate different priorities also reveals trade-offs, like in NYC between restricting air conditioning to reduce emissions and the vulnerability of low-income populations, who have neither access to air conditioning nor green space, against heat waves.

The co-creative agenda setting processes create opportunities for cross-sectoral and cross-scale collaboration in project development and implementation. In NYC, the strategy development processes resulted in the establishment of formal and permanent cross-departmental, public-private task forces on specific themes like built environment and climate adaptation to align priorities, develop agendas and implement solutions. The collaboration of DPR and DOB in the Urban Heat Island group resulted in the requirement to plant street trees as part of building development.

New governance structures were created within both city governments to coordinate the implementation of the strategic agendas and ensure that climate priorities are considered. The city's sustainability and resilience offices are central nodes for overseeing, initiating and drafting the strategies and their implementation. They channel information and knowledge, establish connections with on-going processes, motivate action, search for funding and lobby for support. They also participate in cross-scale partnerships and networks to align goals and mediate knowledge and resources across local, regional and national levels. In both cities, the 100RC programme funds the formal position of a Chief Resilience Officer that is tasked with establishing a comprehensive resilience vision for minimising the impact of unforeseen events, work across departments and with the local communities. In NYC, different departments take the lead in coordinating cross-sectoral and cross-scale action on specific topics: For example, EMD coordinates NYC's disaster and emergency planning and response operations. In Rotterdam, each Climate Office's member is placed in different city departments to ensure the office's agenda is taken up in each department's initiatives.

Private organisations and knowledge partnerships support alignment and mediation processes in Rotterdam and NYC by facilitating open spaces for knowledge sharing, reflection and idea collection. In NYC, the Harbor Estuary Program is a federally authorised programme that brings together federal, state and local agencies and citizen groups to define common goals and priorities for action around the management of the New York-New Jersey harbour and estuary. Many partnerships involve knowledge institutes; they act as the moderating actor facilitating knowledge sharing, trust building and community engagement. The SRI@JB in NYC mediates scientific and community knowledge between universities, local communities and public agencies by creating an informal space to share ideas and concerns, doing transdisciplinary research and introducing research results into the discussion.

Strategic visioning and alignment, partnership-building and mediation of knowledge and resources are time and resource-intensive. Despite the increasing diversity of networks, spaces and channels to coordinate and integrate systemic climate action in Rotterdam and NYC, these do not extend beyond a still relatively small group of key actors. As a result, in most governance practice climate mitigation and adaptation are still considered as 'doing something extra'. The absence of formal conditions for collaborative financing in line with the long-term and systemic goals makes the goals vulnerable to shifting priorities and hinders piggy-backing.

6.5 Discussion: lessons for transformative climate governance in cities

We sought to understand whether and how new capacities for transformative climate governance are developed as cities like Rotterdam and NYC experiment with urban climate governance. In Rotterdam and NYC, an integrated, experimental and inclusive approach to climate governance is emerging, which crosses multiple policy sectors and domains (e.g. transport, energy, health, justice), involves a variety of actors and facilitates innovative solutions. This has helped to move beyond single climate innovation programmes or solutions for responding to climate risks and uncertainty and phasing-out high-emission and unsustainable path-dependencies.

Our premise was that transformative climate governance needs to create conditions for developing integrated and systemic climate mitigation and adaptation policies and interventions that respond to and shape urban transformation dynamics and contribute to sustainability and resilience in the long-term. The analysis of the different types of governance capacities show that diverse institutional, knowledge, network and social conditions were created in both cities to systemically address mitigation and adaptation in policy and planning (Table 6.3). The orchestrating capacity that was developed in both cities underpins the transformative approaches to stewarding from uncertainty and risk, unlocking unsustainable path-dependencies and transforming for innovative solutions and approaches. The reframing of climate mitigation and adaptation as opportunity for sustainability and resilience has given way to putting in place institutional conditions for a systemic and long-term orientation for climate risk management and planning and experimentation with multi-functional solutions within broader goals for wellbeing and liveability in the cities. For example, the integrated perspective on climate, sustainability and resilience was embedded in context-sensitive, problem-based and community-based approaches to manage risks and vulnerabilities. The integrated perspective on climate change, sustainability and resilience also facilitates the generation of systemic knowledge on risks and drivers of unsustainability and path-dependency. For example, in NYC the connection of climate mitigation and air pollution has supported the phase-out of sulphur heating oil. Each capacity manifests in diverse network conditions that enable collaboration across scales and sectors in polycentric partnerships. The orchestration of these networks through connection nodes and intermediary spaces like the climate and sustainability offices for knowledge sharing and trust building ensures alignment and knowledge sharing between these partnerships and monitors action in line with the strategic vision.

However, Rotterdam and NYC are currently confronted with moving beyond the initial momentum for integrated and experimental approaches to climate governance. The capacity gaps in Rotterdam and NYC signify a lack of mainstreaming and prioritising climate-related concerns in city-wide policy and planning processes. The majority of existing incentive structures and regulations still favour short-term economic interests and investments, pre-empting co-beneficial protection from long-term risks and decisive phase-out of the root causes of emissions and sustainability. This perpetuates counteracting investments (e.g. building developments in flood-prone areas) and undermines the contribution of innovative solutions into the policy mix as they remain disconnected from mainstream policy and planning. Additionally, mitigation and adaptation actions are still often technocratic and do not account for long-term uncertainty and behavioural change. This resonates challenges in other

Table 6.3: Transformative climate governance capacities (conditions and activities) in Rotterdam and NYC

Capacity conditions		Activities
Stewarding capacity		
Generating knowledge about system dynamics	Knowledge condition: *Long-term, systemic and context-specific knowledge about risks and uncertainties*	Long-term forecasting of systemic risks and uncertainties across scales Generating problem-based and context-specific knowledge in vulnerability hot spots Identifying and prioritising high-risk areas for directing investments
	Network condition: *Knowledge partnerships*	Creating issue-specific and multi-stakeholder research programmes and partnerships for knowledge generation across scales and sectors Formalising research partnerships and networks
	Institutional condition: *Knowledge mandates*	Mandating knowledge generation to ensure access to data
Strengthening self-organisation for stewarding	Institutional condition: *Flexible, problem-based and fit-to-context planning and management approaches*	Integrating long-term, systemic risks and uncertainties into planning and management approaches Adopting problem-based, fit-to-context and no-regret planning and management approaches Providing flexible regulation and incentives to facilitate fit-to-context risk protection Clearly assigning and communicating responsibilities of actors
	Network condition: *Multi-scale and cross-sectoral networks and partnerships for risk planning and management*	Establishing issue-specific, multi-level and cross-sectoral collaborations to develop and implement projects in line with context needs Involving communities in joint and context-specific visioning, planning and implementation processes
	Social condition: *Social capital and actor empowerment*	Raising awareness about risks and response options Strengthening social networks to enable self-organised response and social resilience
Monitoring and continuous learning	Knowledge condition: *Institutional and social memory*	Drawing on past experience and learning about new solutions Continuously updating plans and resilience and sustainability indicators
Unlocking capacity		
Revealing unsustainable path-dependency and mal-adaptation	Knowledge condition: *Identifying and exploring systemic drivers*	Identifying systemic social and economic drivers of unsustainability and path-dependency Road mapping and scenario analyses to explore phase-out options Conducting regular emissions inventories
	Network condition: *Knowledge partnerships*	Establishing public-private knowledge partnerships to identify drivers and explore phase-out options
	Institutional condition: *Knowledge mandates*	Mandating knowledge generation to ensure access to data
Undermining vested interests and	Institutional condition: *Support for sustainable business cases and investments*	Setting standards for sustainable investments Providing incentives for sustainable investments

Capacity conditions		Activities
incentive structures		Integrating sustainability into public tendering
	Institutional condition: *Control of unsustainable practices*	Implementing regulation to control unsustainable practices
Breaking open resistance to change	Social condition: *Societal and political awareness and support*	Raising awareness and providing assistance for sustainable investments and behaviour change Lobbying for political support
	Network condition: *Key support networks and partnerships*	Setting up public-private partnerships for issue-specific action Setting up support networks with key stakeholders (groups)
Transformative capacity		
Enabling novelty creation	Social condition: *Leadership for creating and using opportunities for change*	Mobilising political leadership to put new and ambitious goals on the agenda Making use of momentum and opportunities for change Piggy-backing and quickly expressing potential of a new solution
	Network condition: *Multi-actor innovation networks*	Forming informal 'coalitions of the willing' for strategic and operational innovation Involving communities in design and implementation of experiments
	Institutional condition: *(Regulatory, financial) space for innovation*	Temporary lifting or avoiding existing regulations
Increasing visibility of novelty	Social condition: *(Trans-)local support for the innovation story*	Creating and advocating an inspiring innovation story Showcasing innovations as market potential for the city
	Network condition: *Advocacy coalitions*	Creating advocacy coalitions to carry the innovation story Participating in and hosting local, regional, national and international networking, best practice and knowledge exchange events for visibility
Anchoring novelty in context	Knowledge condition: *Learning for replication and upscaling*	Identifying proof-of-concept lessons from innovations to facilitate replicating and embedding Identifying opportunities from innovation for upscaling Identifying bricolage of solution elements to mainstream innovations into urban planning processes and decisions
	Network condition: *Self-sustaining innovation networks*	Formalising operational public-private partnerships for continuous innovation Setting up cross-sectoral networks and partnerships tasked with (embedding of) innovation in institutional structures
	Institutional condition: *Institutional space for embedding strategic and operational innovations in mainstream practice*	Creating open mind-set for taking up innovations in tactical agendas and daily practices Allocating budget to developing and maintaining innovation, upscaling and replicating
Orchestrating capacity		
Strategic alignment	Institutional condition: *Long-term and integrated goals*	Developing long-term climate mitigation and adaptation, sustainability and resilience goals

Capacity conditions		Activities
	Social condition: *Involvement of multiple actors in shared strategy formulation and visioning*	Involving multiple actors from different city departments and private organisations in strategy formulation Public outreaching and participation
Mediation across scales and sectors	Network condition: *Connection nodes for pooling climate action*	Establishing central connection nodes for pooling climate efforts at multiple levels Establishing cross-departmental city offices for coordinating and knowledge brokering at multiple levels Designating theme-leads and contact persons within individual departments Identifying private and community-based activities to seek linkages
	Network condition: *Intermediary spaces for knowledge sharing and trust building*	Creating neutral co-creation spaces and knowledge partnerships to build trust for knowledge sharing and resource synergies across scales and sectors Participating in international city networks Establishing cross-departmental co-creation spaces for knowledge exchange, priority alignment and trust building
	Knowledge condition: *Pooling and integrating knowledge and resources across scales and sectors*	Identifying opportunities, synergies and trade-offs between different goals
Creating opportunity contexts	Institutional condition: *Framework conditions and financing mechanisms for long-term co-benefits*	Redefining responsibilities for carrying costs Creating competitions to leverage innovative, long-term and co-beneficial solutions

cities: While people are typically targeted through information, training and incentives, this is not able to achieve social change in for example energy, use, eating or transport patterns (Moloney and Horne 2015). The incorporation of the level of acceptable risk in planning (e.g. 1-in-100 year flood level) and the upgrade of zoning regulations are often insufficient for dealing with projected future climate change and can lock communities in mal-adaptive pathways (Torabi et al. 2018).

The next-step challenge in Rotterdam and NYC is to move beyond the initial conditions created by the formulation of a long-term and systemic strategic agenda, setting up partnerships and coalitions and the experimentation with innovative solutions. The governance capacities have mainly been created through informal governance processes like envisioning, experimentation, coalition building and learning. These have contributed to momentum for systemic, long-term, multi-actor and learning-based climate governance approaches. However, there is a need for strengthening institutional and organisational conditions for more decisive prioritisation of long-term climate investments and actions, better funded collaboration mechanisms and improved space for (learning from) experimentation. This resonates findings on polycentric urban climate governance, which highlight the need for balancing monocentric, centralised and polycentric, decentralised forces (Pahl-Wostl and Knieper 2014; Gordon and Johnson 2017). Despite the current discourse on a state hollowed out by austerity and captured by neoliberal forces, these conclusions highlight the critical role of governmental actors in coordinating, motivating and mandating climate action at multiple scales

(Frantzeskaki et al. 2014; Capano et al. 2015). For example, states shape polycentric governance and voluntary private commitments at local levels in both passive and active ways, including the implementation of policy instruments, mainstreaming climate change into policy sectors, facilitating diffusion of governance innovation and encouraging learning by establishing bodies with evaluative capacities (Jordan et al. 2018; Hodson et al. 2018).

We highlight three challenges for strengthening institutional and organisational conditions underpinning capacities for transformative climate governance in cities by moving beyond envisioning, beyond coalitions of the willing and beyond experimentation.

6.5.1 Beyond envisioning

Long-term and systemic visions provide a shared orientation for aligning priorities, motivating actors and designing co-beneficial climate solutions while taking the interests of multiple, including most vulnerable actors into account (Nevens et al. 2013; McPhearson et al. 2017; Shaw et al. 2014). However, this strategic orientation remains relatively meaningless to the policy and planning practices in individual policy sectors when it is not consistently and decisively translated into institutional frameworks and financing mechanisms that change incentive structures and organisational ways of working (den Exter et al. 2014; Wamsler 2015). While the strategic agendas in Rotterdam and NYC were translated into theme-specific action programmes, these programmes and regulations still remain patches within overall city policy and planning processes, which still perceive efforts to implement the strategic agenda as doing something extra. Systemic financing frameworks such as enabled by the Rebuild by Design competition helped to develop multi-beneficial projects in NYC, yet as long as business-as-usual is (financially) viable sustainable business models remain thin and climate-proofing is perceived as more expensive. This makes the strategic agenda vulnerable to changing political priorities and economic interests and perpetuates counteractive investments (Torabi et al. 2018; Rosenzweig et al. 2015).

This underscores how institutional and organisational rigidities, lack of clear mandates and conflicting political priorities are key barriers to integrated and bold climate action (Keskitalo et al. 2016; Homsey and Warner 2015). Ultimately, tough decisions about what goals are to be priorities need to be made and mainstreamed into institutional frameworks at multiple levels of governance (Moloney and Horne 2015). Although urban climate governance has proliferated despite an absence of leadership at national levels (Bulkeley and Betsill 2013), the nestedness of local climate governance in legal and institutional framework at regional, national and international levels requires alignment of priorities and legislation across governance levels (Dąbrowski 2017; Keskitalo et al. 2016). While in both Rotterdam and NYC regional and national governments support climate governance through research programmes, regulatory frameworks and incentives, national and regional policy frameworks in the Netherlands and the US often constrain long-term climate adaptation and sustainability investments. However, also positive examples of state regulation promoting urban climate governance actions abound. The Clean Air Act, which was passed in the US in 1970 and strengthened in 1990, enabled federal and state authorities to establish comprehensive regulations for air pollutants and reduced ground level ozone and lead air pollution in cities (Ross et al. 2012).

6.5.2 Beyond coalitions of the willing

In Rotterdam and NYC, a diversity of cross-sectoral, cross-scale and public-private partnerships and networks, including regional and national knowledge programmes, research partnerships, research-industry collaborations and private stakeholder platforms, participate in the generation of knowledge, the formulation of strategies and agendas and the development of innovative solutions. While the increasingly self-organising ways of delivering societal functions have spurred scientific and policy attention to bottom-up and decentralised governance modes, urban climate governance scholars find that coordination is required to accompany decentralised and hybrid climate governance implementation to enhance cooperation between city departments and across governance scales, start initiatives when needed, pool knowledge, information and guidance, and pool monitoring (den Exter et al. 2014; Pahl-Wostl and Knieper 2014).

In Rotterdam and NYC, the local governments take up key roles in coordinating climate action, having set up formal and informal cross-boundary coordination structures such as the cross-departmental resilience and sustainability offices to align, motivate and support climate action across scales and sectors in line with the strategic visions. Being positioned at the centre of horizontal and vertical integration local governments can ensure compatibility and coherence, act as primary organiser of dialogue among policy communities, deploy a monopoly of organisational intelligence and information and balance power differentials (Frantzeskaki et al. 2014; Amundsen et al. 2018). Enabling local governments to do so requires however a new type of organisational capacity to mediate between priorities across scales and sectors and the context of their application, assign action mandates and oversee progress (den Exter et al. 2014). While the coordination processes in Rotterdam and NYC facilitate trust building, interest mediation and cooperation, they are faced with time and resource constraints visible in the limited connection to actors and networks outside of the immediate climate and sustainability domains.

For what purpose and for whom coordination mechanisms are set up requires careful scrutiny (Gordon and Johnson 2017). The inclusion of a wide range of societal actors is critical to take different interests into account, make complex sets of goals like resilience understandable, ensure top-down priorities are aligned with local-level needs and tap into the multiple capacities of actors to achieve the deep structural and behavioural changes required (Brown 2017; McPhearson et al. 2017). Strategically building alliances between local communities and local governments could be a powerful way for ensuring local knowledge and needs are accounted for and for mobilising broader societal action (Chu et al. 2017). This was illustrated in NYC, where neighbourhoods with strong community organisations, such as Redhook, benefited from their substantial support in the aftermath of Hurricane Sandy when local, state and federal agencies struggled with providing relief (Cowan and Hogan 2014).

6.5.3 Beyond experimentation

Experimentation has been appraised as an open-ended way for trialling new, agile and responsive solutions to deal with the significant uncertainties and complexities of climate change and urban transformations and contribute to the radical changes necessary for achieving sustainability and resilience (Bulkeley et al. 2016; Castán Broto and Bulkeley 2013; Karvonen 2018). In Rotterdam and NYC, the creation of space for experimentation by lifting regulatory requirements and providing systemic

financing frameworks, has allowed to test new solutions in co-creative ways. However, the experiments often remain disconnected from mainstream urban governance processes, manifesting in 'pilot paradoxes' that embody stand-alone innovations, which do not inform policy and planning (van Buuren et al. 2018; Hölscher et al. 2018b).

The aspiration to inform and acquire new ways of problem-solving implies some sort of learning about what the tested innovations bring about in the policy mix of cities (Luederitz et al. 2017; Raven et al. 2017). Moving 'beyond experimentation' requires the dedication of time to identify, evaluate and translate lessons from specific innovations, such as about the viability, replicability and scalability, for their broader context (Turnheim et al. 2018; Ehnert et al. 2018). The institutionalisation of innovation partnerships like the RDM Campus in Rotterdam and the Rebuild by Design offices in the US help to translate lessons from experimentation and support on-going experimentation processes. However, current trends towards a 'projectification of funding', which is reinforced by governments' focus on cost-optimisation and effectiveness, does not allow moving beyond innovative initiatives (Ehnert et al. 2018). Replicating and scaling successful innovations requires the processes for knowledge mediation, for example between strategic and operational governance levels to adapt regulatory frameworks according to the lessons from innovation, identify proof-of-concept indicators and translate lessons into tactical agendas for context-specific (combinations of) solutions and to strategically connect experimentation processes to other on-going projects (Hölscher et al. 2018b).

6.6 Conclusions

We employ the notion of transformative climate governance in cities to epitomise the urgency and opportunity for delivering integrated and bold climate strategies and actions, which achieve the profound changes in urban systems needed to address climate change and sustainability challenges. There is a risk to give in to a somewhat naïve narrative of urban opportunities for delivering effective and transformative climate action when it is unclear how these opportunities can be harnessed in meaningful and just ways and over longer time frames. By comparing the capacities for transformative climate governance in Rotterdam and NYC we could identify institutional, knowledge, network and social conditions that were created as a result of the activities in both cities to govern climate change and that help moving towards integrated, experimental, reflexive and inclusive climate mitigation and adaptation approaches.

Envisioning, long-term goal and knowledge integration, experimentation and tapping into coalitions for change help to provide the basis (including guiding principles, urgency, actor networks, innovative solutions) for transformative climate governance. However, in both cities inclusive, integrated and experimental climate governance approaches tend to be still subordinate to business-as-usual interests and policy and planning approaches, which favour isolated, incremental and short-term responses. The challenge for strengthening transformative climate governance that crosses policy siloes and is able to deal with stranded assets, difficult choices and phasing-out established interests and practices will be to develop rigorous institutional and organisational conditions that decisively stipulate a prioritisation of climate change across scales and sectors, provide action mandates and enable wider outreach and learning.

There remains a tension between top-down law-enforcement on the one hand and the need to facilitate open-ended, experimental and flexible governance processes in the face of uncertainty. Likewise, top-down rule-making does not mean that it should not be based on knowledge co-production and deliberation between actors with different kinds of technical or contextual expertise. Applying the lens of governance capacities highlights the emergent character of how urban governance is enacted in a dynamic and provisional way: The mobile character of governance capacity characterises the creation of governance capacity as a learning process. Governance capacity thus becomes an "action-oriented and empowering concept", which helps "to identify requirements, design policies and devise purposive interventions" (Wolfram et al. 2017: 24).

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Chapter 7

Conclusions: Lessons and outlook on transforming urban (climate) governance

Chapter 7

Conclusions: Lessons and outlook on transforming urban (climate) governance

In this thesis, I have developed a transformative perspective on urban climate governance that addresses climate change as part of the quest for urban transformations towards sustainability and resilience. My main research problem and premise was that urban (climate) governance itself needs to be transformed so as to create institutional space and facilitate those actions that can purposefully contribute to navigating such sustainability and resilience transformations under climate change in cities. While urban climate governance already shows various features of more systemic, experimental and inclusive approaches, the key challenge is to operationalise and mainstream transformative climate governance vis-à-vis existing urban governance systems and practices. My aim was to contribute to an understanding about what transformative climate governance could look like and how it can be strengthened vis-à-vis existing urban governance regimes. I put forth transformative urban governance as an ideal-type and normative approach that allows actors to develop climate mitigation and adaptation actions in synergy with other policy priorities and goals and to contribute to urban transformations towards sustainability and resilience.

In this final chapter, I revisit my main research questions, discuss these results in light of current debates and insights on transforming urban (climate) governance, formulate recommendations for strengthening capacities for transformative climate governance and identify future research directions. My contribution centres on the development of a conceptual framework that defines and operationalises capacities for transformative climate governance and the generation of empirical insights about whether, how and by whom such capacities have been created in Rotterdam and NYC. I thus respond to the need for new frameworks as well as empirical knowledge about how and whether urban climate governance is both *transformed* and *transformative*. The lens of governance capacities provides a learning-based view to explain and evaluate how urban (climate) governance is changing by bridging between the diverse actors and activities driving the governance shift, the governance conditions that emerge as a result, as well as whether these indeed contribute to navigating urban transformation under climate change. In addition, the capacities perspective allowed me to synthesise insights from different research approaches related to questions of 'transformation governance' for the conceptualisation and operationalisation of capacities for transformative climate governance. The case studies of this thesis – Rotterdam and New York City – are examples of cities where climate change on the agenda has propelled new visioning processes to identify opportunities for enhancing liveability and economic competitiveness, testing innovative solutions and new partnerships. The case studies illustrate the applicability of the framework and generate empirical knowledge about how existing urban climate governance efforts are being developed and advanced, whether these efforts manifest in new capacities for transformative climate governance, and how the capacities can be strengthened vis-à-vis existing governance regimes.

My framework and results corroborate the need for transformations of urban governance. Developing transformative climate governance capacities in cities implies that urban climate governance *itself acts transformative*, because it challenges existing urban governance paradigms and institutionalised approaches that tend to make decisions in sectoral silos, favour short-term policies and interventions and view governance and planning as 'outside' processes able to control and direct urban change. While urban climate governance is a recognised term in scientific literature and policy and planning practice, climate change as a policy priority by itself seems to drive a change in urban governance by prompting more long-term, integrated, experimental and multi-actor approaches to address climate change in synergy with other policy goals across scales and sectors. 'Climate' governance is therefore not so much about climate mitigation and adaptation, but rather about the integration of multiple societal sustainability and resilience goals in the pursuit of transformations.

It is my hope that the capacities framework helps to not only explain and evaluate transformative (climate) governance in cities, but also to guide the proactive development of capacities. A disclaimer is that I have approached urban climate governance as a process resulting from specific attempts of and interactions between actors. My notion of such urban climate governance processes is normative, i.e. I believe that insights into means, activities and conditions of urban climate governance can improve existing forms of urban governance so as to better contribute to urban sustainability and resilience transformations (cf. Castán Broto 2017). This is to be complemented, and scrutinised by a critical perspective on governance that questions the political struggles of urban climate governance (ibid.; Bulkeley 2015; Jhagroe 2016). For instance, Bulkeley's (2015) critical engagement with questions about how climate governance is accomplished – in terms of the specific modes of power through which governing is conducted – starts from the idea that climate governance cannot be understood by merely looking at the activities, arrangements and structural conditions. In addition, as governance capacities can hardly be assessed for urban areas as a whole and are continually evolving, my results are limited to the specific types of interventions and interactions and points in time I have looked at in my case studies. I include reflections on these issues in Sections 7.2 and 7.3.2.

7.1 Revisiting the research questions: are capacities for transformative climate governance developing, and how can we know?

The main aim driving this thesis has been to explain the development of urban climate governance and to assess whether it indeed manifests in new capacities for transformative climate governance. The positioning of climate change within broader urban transformation processes underscores the urgency and opportunity in cities to achieve the profound changes needed in urban energy, transportation, water, land use, service delivery and lifestyles to address climate change and unsustainability in synergy (Romero-Lankao et al. 2018; Koch et al. 2016; Burch et al. 2018). The development of urban climate governance towards integrated, experimental and multi-actor approaches – which I have sketched in Chapter 1.2.1 of this thesis – raises many questions, including why, how, by whom and with what effects urban climate governance takes place.

In responding to the research questions of this thesis, I contribute to agency-based explanations of how, and by whom, urban climate governance is enacted as well as to a systemic evaluation of what conditions emerge as a result of these activities and whether these enable transformative climate governance. My vision of transformative climate governance systematically brings together the diffuse and dispersed picture of urban (climate) governance to see which capacity exists and where, and by whom, this capacity has been generated. In Rotterdam and NYC, the dispersed climate governance structure is visible in the multiple governing individuals, organisations, task forces and committees that have been the agency of capacity generation. The capacities framework that I developed in this thesis facilitates analysis and explanation from a meta-governance perspective that draws attention to the structuring of the multiple activities and interactions between these actors. From this perspective, I can also identify several capacity deficits in Rotterdam and NYC, which are visible in the limited outreach and implementation of the long-term climate, sustainability and resilience agendas.

7.1.1 How can capacities for transformative climate governance be conceptualised, explained and evaluated?

A growing number of scholars voice the urgency for a 'transformation of urban governance' to respond more decisively and systemically to on-going transformation dynamics and realise radical change towards sustainability and resilience in the long-term (McCormick et al. 2013; Frantzeskaki et al. 2017; Rink et al. 2018; WBGU 2016). In this context, the issue of climate change makes clear that isolated, sectoral and incremental approaches will not be able to address the root causes of high emissions and climate-related vulnerabilities, let alone to create stepping stones for radical changes towards sustainability and resilience (Romero-Lankao et al. 2018; Koch et al. 2016; Burch et al. 2018).

Understanding the development of urban climate governance vis-à-vis existing urban governance regimes and whether it results in transformative climate governance requires new frameworks and concepts that bridge between the diverse actors and activities driving the governance shift, the institutional and organisational governance conditions that emerge as a result, as well as whether these indeed contribute to navigating urban transformation under climate change. Research on urban (climate) governance has so far failed to deliver detailed and systemic explanations and evaluations of the roles of actors, interactions, mechanisms and processes in partnering for bringing transformative (climate) actions to realisation (Castán Broto 2017; Koop et al. 2017; Rink et al. 2018).

To respond to this knowledge gap and develop a systematic framework that is able to capture, explain and evaluate how the diffuse and dispersed picture of urban (climate) governance is evolving, I have developed a framework of capacities for transformative climate governance. The concept of governance capacities provides a lens to explain and evaluate the governance shift in view of transformative urban climate governance. Understood as an emergent property that is constantly mediated through the formal and informal collaboration and learning processes between multiple governance actors and how they interact with their institutional and organisational contexts, the notion of governance capacities facilitates explanation and evaluation of how and whether and whose capacities for transformative climate governance are developing (cf. (Innes and Booher 2003; González and Healey 2005). It allows to conceptualise transformative climate governance as a normative approach that delivers different governance functions and to trace how, and by whom, the capacities are developed and enacted, what conditions emerge as a result, whether these conditions mark a shift

towards transformative climate governance, what are capacity gaps, as well as how capacities can be supported.

In order to conceptualise and operationalise capacities for transformative urban climate governance, I turned to transformation research that covers multiple research strands and approaches providing knowledge about what urban transformation governance could look like. In a first step, I have positioned climate change and climate governance in the context of sustainability and resilience transformations and defined distinct output functions for transformative climate governance based on a review of sustainability transitions and resilience literatures (Chapter 3). This aided a systemic and problem-based understanding of urban climate governance to evaluate whether it delivers different output functions to address and respond to transformation dynamics. In a second step, I have defined capacities for transformative climate governance that conceptualise and operationalise an agency-based perspective on how conditions are developed for delivering the different output functions (Intermezzo A). The case studies of capacities for transformative climate governance in Rotterdam (Chapter 4) and NYC (Chapter 5) showed the utility of the framework for exploring the development of urban climate governance: the framework facilitated explanation of the activities by which multiple actors create new conditions for accomplishing transformative climate governance, assessing the effectiveness of and interrelations between the capacities for delivering systemic and problem-based mitigation and adaptation policies, and identifying capacity gaps (Table 7.1).

Firstly, the framework provides a *systemic* and *problem-based* perspective on urban climate governance in the context of urban sustainability and resilience transformations. The transformative perspective on climate change and climate governance that I developed in Chapter 3 draws attention to the systemic nature of climate change, i.e. how high emissions pathways and climate-related vulnerabilities are driven by and, in turn, amplify the unsustainable and mal-adaptive lifestyles, living and land use patterns in cities. Rather than focusing on individual and sectoral measures, the problem-based perspective starts by recognising the deeply embedded socio-economic root causes of high emissions, unsustainability and mal-adaptation causing climate change, unsustainability and vulnerability. This helps to address urban transformation dynamics more effectively by promoting fit-to-context approaches that account for synergies and trade-offs between multiple goals, including climate mitigation and adaptation but also health, equity, water safety, energy security etc., across scales and sectors.

The transformative perspective on urban climate governance thus enables evaluating whether urban (climate) governance develops problem-based and systemic climate mitigation and adaptation policies and interventions that contribute to sustainability and resilience across sectors and scales. For example, in Rotterdam and NYC, I found that while more systemic and long-term strategies and agendas were formulated, linking climate change, sustainability and resilience goals, these agendas are not mainstreamed into the overarching governance and planning practices in both cities. Similarly, despite some experimentation with innovative and multi-functional solutions, these often remain isolated and stand-alone initiatives and much business-as-usual results in contradictory investments (e.g. in building developments in flood-prone areas).

Table 7.1: Insights generated by the capacities framework and their application in examining contemporary and on-going governance processes in Rotterdam and New York cities

Insights		Example
Systemic and problem-based understanding of transformative climate governance	Evaluation of transformative climate governance: do the capacities enable fulfilling output functions?	In Rotterdam and NYC, climate mitigation and adaptation are integrated with long-term sustainability and resilience goals. However, the lack of mainstreaming of these goals results in contradicting investments and planning decisions.
Agency-based understanding	Explanation of shift in urban climate governance: what activities and actors develop new conditions manifest in capacities?	Activities like envisioning, long-term goal and knowledge integration, experimentation and tapping into coalitions for change provided the basic conditions for transformative climate governance capacities. Conditions include institutional, knowledge, network and social conditions like guiding principles, sense of urgency, actor networks, communication space.
Interrelations between capacities	Explanation of interrelations between capacities: when do different functions and capacities require more attention and how do capacities for functions interrelate?	Orchestrating capacity underpins the other capacities: the integrated and long-term strategies and goals on issues of climate, sustainability and resilience enabled the establishment of institutional conditions for a systemic and long-term orientation for climate risk management and planning and experimentation with multi-functional solutions within broader goals for wellbeing and liveability.
Capacity gaps	Identification and explanation of capacity gaps: what are shortcomings in fulfilling output functions and how they come about (e.g. challenges in developing conditions)?	The shortcoming of mainstreaming climate mitigation and adaptation across policy sectors and domains can be related to limited institutional and organisational conditions that decisively stipulate a prioritisation of climate change across scales and sectors, provide action mandates, streamline regulation and enable wider outreach and learning.

Secondly, the framework provides an *agency-based* understanding of how, and by whom, urban climate governance is enacted and what conditions result from urban climate governance activities. In particular, the structuration perspective on how governance capacities come about creates a bridge between 'what is the solution' and 'ability to realise the solution' by drawing attention to how climate change as the 'object' to be governed is defined in reference to the configuration of interactions and contestations between actors, problem definitions, solutions, interests and power relations (cf. Bulkeley 2015). This helps to explain the development of urban climate governance in terms of how the conditions manifesting in capacities for transformative climate governance were created. While the prevalent focus on institutional conditions helps to explain stability, enablers and constraints, paying

attention to agency emphasises how organisational processes and institutions themselves are shaped by creative entrepreneurial forces (cf. Garud et al. 2007).

I learned from my case studies that activities like envisioning, long-term goal and knowledge integration, experimentation, and tapping into coalitions for change provided the basic institutional, network, knowledge and social conditions (including guiding principles, sense of urgency, actor networks) for transformative climate governance. For instance, envisioning has resulted in new, long-term and integrated strategies and agendas that reframe climate change as opportunity for sustainability and resilience and that embody important conditions for the strategic alignment of interests across scales and sectors. The strategies provide shared narratives to mobilise actors and to set up and coordinate partnerships and alliances that exchange and pool knowledge and resources. The utilisation of momentum for change such as changing international narratives and the experience of extreme events (in particular Hurricane Sandy in NYC) have critically contributed to enabling this shift in perspective.

Thirdly, the distinction of four capacities facilitates a *differentiated understanding* of how the different output functions are fulfilled and how the capacities interrelate. Critical has been the integration of sustainability transitions and resilience approaches that provide complementary perspectives on governance in the context of radical, systemic change (see Chapter 3). Specifically, some level of confusion persists so far about the relationships between adaptive and transformative governance approaches, and scholars found that adaptive capacity can overshadow transformative capacity by prompting people to protect existing structures and practices even though this will cause higher costs and vulnerabilities in the long-term (Wilson et al. 2013). Rather than taking adaptation and transformation as somewhat opposite, or contradictory concepts, the transformative climate governance perspective brings both concepts back to their functional essence: i.e. protecting from risk and uncertainty (adaptation) and creating disruptive innovation and disruptions of the existing regime (transformation). Both types of processes are needed to deal with urban transformations under climate change in the short-, mid- and long-term (cf. Anderies et al. 2013; Torabi et al. 2018).

The perspective on four distinct capacities has enabled to identify how different types of conditions support each other in Rotterdam and NYC. In particular, orchestrating capacity underpins the cities' climate governance approaches to protect from uncertainty and risks and experiment with innovative solutions and approaches. Orchestrating capacity is in both cities manifest in the integrated and long-term strategies and goals on climate, sustainability and resilience issues. These have given way to putting in place institutional conditions for a systemic and long-term orientation for climate risk management and planning and experimentation with multi-functional solutions within broader goals for wellbeing and liveability in the cities. This reverberates the need for meta-governance of diffuse and distributed governance structures, settings and processes (Frantzeskaki et al. 2014).

Finally, the framework also makes it possible to identify *capacity gaps* and explain how these gaps come about. In this way, the dynamic lens of governance capacities draws attention to the on-going learning processes and to derive recommendations about how to address these gaps (cf. Wolfram et al. 2017). The revelation and assessment of capacity gaps builds on the identification of shortcomings in fulfilling the output functions and discussing these in relation to existing and needed governance conditions that facilitate or hinder delivering the functions. For example, in Rotterdam and NYC, the novel types

of climate governance approaches tend to be still subordinate to business-as-usual interests and policy and planning approaches. This shortcoming can be related to limited institutional and organisational conditions that decisively stipulate a prioritisation of climate change across scales and sectors, provide action mandates, streamline regulation and enable wider outreach and learning.

7.1.2 What actors, activities and structural conditions manifest in capacities for transformative climate governance?

Rotterdam and New York City were rich case studies to explore how new capacities for transformative climate governance are emerging in cities providing global leadership for climate action. In both cities, ambitious and cross-cutting climate, sustainability and resilience agendas and portfolios of innovative solutions for climate mitigation and adaptation have been developed and put into practice. This integration of goals has driven the development of an integrated, experimental and multi-actor approach to climate governance, which moves beyond single climate innovation programmes or solutions and crosses multiple policy sectors and domains (e.g. transport, energy, health, and justice).

I present the main findings regarding the delivery of transformative climate governance in Rotterdam and NYC in terms of the extent to which the different functions are delivered, which conditions and activities manifest in capacities to deliver the functions and what are capacity gaps, barriers and opportunities. Although Rotterdam and NYC differ in their size, geographic location and urban challenges, there are many similarities regarding the activities and conditions that manifest in the governance capacities to develop and implement transformative climate solutions (Chapter 6; Appendix C). In both cities, all capacities for transformative climate governance are emerging and manifest in novel approaches and initiatives to address climate change. What I could identify in particular, was that both cities – especially NYC – show a very diffuse and dispersed climate governance picture, which is visible in the multiple individuals, organisations, task forces and committees of governing that have been the agency of capacity generation. This underscores the need to strengthen orchestrating capacity for coordinating and aligning the diverse activities and processes.

The capacities lens draws attention to the dynamic interplay between actors, their activities and the conditions that are created as a result and that together manifest in the abilities to navigate urban transformations towards sustainability and resilience. Each capacity is distinct and draws on different conceptualisations about how to address specific transformation dynamics. Table 7.2 provides an overview of the key results for each capacity in terms of what governance functions the capacities allow to fulfil, as well as how it works to do so.

7.1.2.1 Delivery of transformative climate governance in Rotterdam and New York City

In Rotterdam and NYC, it is possible to see how a problem-based and systemic approach to addressing climate change is emerging. This has been especially driven by the integration of climate mitigation and adaptation within long-term sustainability and resilience goals and strategies. In both cities this integration reflects the recognition that climate mitigation and adaptation need to be approached as opportunities for improving liveability and wellbeing and that they are long-term concerns, thus requiring long-term perspectives. Because of the long-term and integrated perspectives, it is possible

Table 7.2: Capacities for transformative climate governance in Rotterdam and New York City: key conditions and activities

Institutional conditions	Knowledge conditions	Network conditions	Social conditions
Stewarding capacity			
What the capacity is about: Anticipating, protecting and recovering from uncertainty and risk			
How: Identifying long-term and systemic risks and facilitating continuous learning and fit-to-context self-organisation at decentral levels			
Conditions:			
Fit-to-context, flexible and knowledge-based institutions for dealing with different needs	**Co-production and integration of knowledge about systemic and long-term risks and uncertainty**	**Polycentric and multi-actor networks across scales and sectors to implement projects in line with context needs**	**Social capital and empowerment for local self-organisation**
Activities:			
Integrating long-term, systemic risks and uncertainties Adopting problem-based, fit-to-context and no-regret approaches Providing flexible regulation and incentives to facilitate fit-to-context risk protection Assigning and communicating responsibilities	Long-term forecasting of systemic risks and uncertainties Generating problem-based and context-specific knowledge Continuously updating plans and resilience and sustainability indicators Mandating knowledge generation to ensure access to data Establishing science-policy-community interface	Creating issue-specific, multi-level and multi-stakeholder programmes and partnerships Involving communities in joint and context-specific visioning, planning and implementation processes	Raising awareness about risks and response options Strengthening social networks to enable self-organised response and social resilience
Unlocking capacity			
What the capacity is about: Recognising and dismantling unsustainable path-dependencies			
How: Identifying lock-ins, undermining path-dependent structures, actors, networks and practices and creating support for phase-out			
Conditions:			
Dismantling of institutional path-dependency and competitive advantage of business-as-usual	**Linking past, present and future to identify path-dependencies and mal-adaptation**	**Support networks with an explicit mission for change**	**Social and political awareness and support for departing from business-as-usual**
Activities:			

Institutional conditions	Knowledge conditions	Network conditions	Social conditions
Setting standards and providing incentives for sustainable investments Integrating sustainability into public tendering Implementing regulation to control unsustainable practices	Road mapping, scenario analyses and modelling to explore phase-out options Conducting regular emissions inventories Mandating knowledge generation to ensure access to data	Setting up public-private partnerships for issue-specific action Setting up support networks with key stakeholders (groups) Identifying key stakeholders and groups to know whom to reach out to	Raising awareness about sustainable lifestyles, consumption and production Aiding/assisting sustainable investments and behaviour change Lobbying for political support
Transformative capacity			
What the capacity is about: Enabling, diffusing and embedding radical innovations			
How: Creating space for experimentation and learning, building support for innovation and embedding innovation in existing and new structures, cultures and practices			
Conditions:			
Space for experimentation as governance approach to learn about new solutions	**Learning institutions for harvesting knowledge from experimentation**	**Multi-actor and inclusive innovation and advocacy networks**	**(Trans-)local support for the innovation story**
Activities:			
Temporary lifting or avoiding existing regulations Creating open mind-set for taking up innovations in tactical agendas and daily practices Allocating budget to developing and maintaining innovation, upscaling and replicating Leadership for creating and using opportunities for change	Identifying proof-of-concept lessons from innovations to facilitate replicating and embedding Identifying opportunities from innovation for upscaling Identifying bricolage of solution elements to mainstream innovations into urban planning processes and decisions	Forming informal and formal 'coalitions of the willing' for strategic and operational innovation Involving communities in design and implementation of experiments Creating advocacy coalitions to carry the innovation story Setting up cross-sectoral networks and partnerships tasked with (embedding of) innovation Participating in regional, national and international networking, best practice and knowledge exchange	Mobilising political leadership to put new and ambitious goals on the agenda Piggy-backing and quickly expressing potential of a new solution Creating and advocating an inspiring innovation story Showcasing innovations as market potential for the city
Orchestrating capacity			
What the capacity is about: Coordinating multi-actor governance processes			
How: Developing and institutionalising shared, long-term and systemic visions, and connecting and mediating actors and networks across scales and sectors			
Conditions:			
Long-term nexus approach when drafting, implementing and financing (sectoral) policies and solutions	**Co-creation of social-technological-ecological systems knowledge**	**Formal and informal connection channels, network brokering and intermediary spaces**	**Co-ownership over shared and long-term visions**

Institutional conditions	Knowledge conditions	Network conditions	Social conditions
Activities:			
Developing long-term climate mitigation and adaptation, sustainability and resilience goals Redefining responsibilities for carrying costs Creating competitions to leverage innovative, long-term and co-beneficial solutions	Employing a systems perspective to aggregate knowledge about drivers, risks, opportunities and challenges Identifying opportunities, synergies and trade-offs between different goals Pooling and integrating knowledge and resources across scales and sectors	Establishing central and cross-cutting connection nodes for pooling knowledge, actions and resources Designating theme-leads and contact persons Identifying private and community-based initiatives Creating neutral co-creation spaces and knowledge partnerships to build trust for knowledge sharing	Involving multiple actors from different city departments and private organisations in strategy formulation Public outreaching and participation

to highlight the need for systemic and radical changes in both governance approaches and urban structures and practices, yet overall in both cities there is a challenge to move beyond the initial momentum for such changes and further anchor the approach in existing governance and planning regimes.

Outputs in terms of concrete policies and interventions are manifold. Both cities are implementing a green infrastructure plan, technical measures to protect from flooding (e.g. flood walls), regulations, incentives, and awareness raising programmes to enhance risk protection and energy efficiency, amongst others. Rotterdam has in particular gained international recognition through its high-profile proof-of-concept experiments – such as the Benthemplein water square, the multifunctional underground water storage facility at Museumplein car park and the Floating Pavilion in the City Ports area – that deliver co-benefits for climate adaptation, greening, recreation, community-building and economic development. In NYC, action is undertaken on awareness raising (for example through the NYC Cool Neighbourhoods programme combines green infrastructure, health training and supporting low-income households), community resilience projects and regulation to adapt flood zones and building codes. The Rebuild-by-Design (RbD) competition that was initiated by the Federal Department of Housing and Urban Development (HUD) after Hurricane Sandy has resulted in three innovative projects located in NYC: The BIG U integrates green infrastructure and liveability for flood protection in Lower Manhattan, the Living Breakwaters project envisions living reefs along Staten Island's south shore to accommodate flooding, and the Hunts Point Lifelines project in the Bronx integrates flood protection, recreation, health, local livelihood development and emergency management.

It was not my aim to meticulously assess some sort of value for how the functions were fulfilled, nor to analyse the outcomes and impacts on sustainability and resilience transformations for example in terms of amount of renewable energy produced, emissions reduced and risks avoided (see Chapter 2.4.3). In addition, as governance capacities can hardly be assessed for urban areas as a whole and are continually evolving, my results are limited to the specific types of interventions and interactions and

points in time I have looked at in my case studies. I provide the following qualitative conclusions about the delivery of the governance functions and how they are influenced by the corresponding capacities:

- **Stewarding function:** Stewarding influences which and how disturbances are anticipated and what responses are enabled. The main stewarding objectives of climate governance policies, plans and actions in Rotterdam and NYC are the protection and recovery of the population and infrastructure from climate impacts like flooding, storms and heat waves while contributing to liveability, economic development and social equity. While Rotterdam and the Netherlands have a long-standing policy tradition on ensuring water safety – which is reflected in the high levels of infrastructure protection in Rotterdam – NYC combines long-term infrastructure protection with community resilience and providing short-term emergency relief. In addition, the NYC government revised hurricane evacuation zones, placing a greater focus on the varying angles of approach for different storms, and employs regulatory instruments, including building codes and zoning, to ensure that building and area developments take future climate impacts into account. Conditions for stewarding have been created by developing a vast amount of knowledge on systemic risks and uncertainties relating to flooding, storms and health, establishing integrated, long-term and multi-level planning approaches, and supporting diverse social networks. However, both cities still face severe risks, and stewarding efforts are often not thoroughly undertaken due to an unclear distribution of responsibilities and a lack of mainstreaming of integrated and long-term risk management approaches.
- **Unlocking function:** Unlocking determines what and how drivers of unsustainability and path-dependencies are recognised and reduced. Unlocking climate governance efforts in Rotterdam and NYC focus on reducing emissions from buildings and energy while improving health, wellbeing and economic prosperity. Unlocking outputs include changes in regulation and physical structures and awareness raising to facilitate renewable energy production, energy efficiency in buildings and sustainable and safe transport. Conditions for unlocking manifest in the identification of and awareness raising on drivers of emissions in connection with drivers of air and noise pollution, waste and inequality, support networks with an explicit mission for change and social and political awareness and support for departing from business-as-usual. The main challenge for delivering the unlocking function relates to a lack of mainstreaming and prioritising of sustainability and climate concerns. Existing interests, incentive structures and regulations favour short-term economic interests and investments. Another key challenge in both cities is to reach out to more heterogeneous populations, for example in the case of buildings tis relates to different types of ownerships and energy structures.
- **Transforming function:** Transforming influences what type of new innovations are developed and how they are embedded into structures, cultures and practices. Transforming processes in Rotterdam and NYC are evident in the multiple strategic, operational, institutional and organisational innovations in how climate mitigation and adaptation are addressed. Strategic goals and agendas were redefined to position climate mitigation and adaptation as opportunity for sustainable and resilience and innovative, multifunctional solutions were implemented. The integrated goals were embedded in new cross-sectoral governance structures to coordinate multi-actor implementation. Despite these successes in innovating climate governance approaches, strategies and solutions in Rotterdam and NYC, these do not yet permeate city-wide planning and decision-making. In Rotterdam, innovative projects often

remain stand-alone initiatives, which are showcased internationally, rather than locally, to create business opportunities for local companies. Learning from experiments remains largely ad-hoc due to time constrains. While first-time innovations can benefit from lifted regulations and financial support, upscaling and replication are more constrained by existing regulations and short-term cost-benefit-calculations.

- **Orchestrating function:** Orchestrating serves to create synergies between climate governance and other policy sectors across scales in line with overarching visions for sustainability and resilience. Orchestrating in Rotterdam and NYC is evident in the city-wide long-term and integrated climate, sustainability and resilience goals and the starting streamlining and coordination of the activities of multiple actors and networks so as to contribute towards these goals across sectors and scales. Strategic visioning and alignment, partnership-building and mediation of knowledge and resources are time and resource-intensive. Despite the increasing diversity of networks, spaces and channels to coordinate and integrate systemic climate action in Rotterdam and NYC, these do not extend beyond a still relatively small group of key actors. As a result, in most governance practice climate mitigation and adaptation are still considered as 'doing something extra'. The absence of formal conditions for collaborative financing in line with the long-term and systemic goals makes the goals vulnerable to shifting priorities and hinders piggy-backing.

Despite the striking similarities in how urban climate governance has been developed and advanced in Rotterdam and NYC, there are differences in what types of goals are emphasised in relation to climate mitigation and adaptation and in the types of measures that are implemented. Rather than rendering climate governance in one city more 'effective' or 'successful', both cities signify different types of approaches as well as different socio-economic, institutional, political and cultural conditions and challenges.

One key difference is that while in Rotterdam and the Netherlands flood protection is a long-standing policy priority, in NYC, Hurricane Sandy marked a turning point through which climate adaptation and resilience became recognised as key issues. On the one hand, this means that in Rotterdam a high level of human and social capital – for example in terms of knowledge about risks and technological options, institutions and regulatory authority – is available. On the other hand, in NYC the experience of a very extreme event has enabled to decidedly prioritise climate adaptation and resilience, while in Rotterdam especially amongst urban inhabitants' awareness about risks has been identified as very low.

Second, the types of measures to address climate change differ. In Rotterdam, there is an emphasis on the local culture 'of doing things', which is evident in the multiple pilot projects such as the Benthemplein water square and the Floating Pavilion – these are used to showcase new types of solutions, market Rotterdam as a frontrunner and create opportunities for local businesses abroad. In NYC, many measures include regulatory measures such as building code and zoning plan adaptations and reporting mandates. This hints at different local cultures and willingness to exercise regulatory authority.

Third, the urban governance puzzle in NYC is considerably more complex than that in Rotterdam in terms of diversity of actors, organisation of the local government and multi-level governance

structures. This resonates in the vast conglomerate of cross-cutting networks and partnerships in NYC. In addition, the cross-cutting approach to addressing climate change is more formally institutionalised in NYC (e.g. resilience offices in individual departments). This implies that there is a higher organisational capacity in NYC and more access to social, human and financial capital.

A fourth difference relates to the political cultures in both cities as well as their multi-level governance contexts. The political playing field in NYC seems to be much more contested. This is for example visible in contestations between NYC and New York State – the latter blocked the implementation of congestion charges for entering the core of Manhattan for mainly political reasons. Similarly, until the early 2010s, the New York State government could not mention climate change as a reason to generate knowledge and formulate strategies and projects for sea-level rise and storm protection.

7.1.2.2 Activities and conditions manifesting in capacities for transformative climate governance

Each capacity manifests in diverse activities and conditions that were created as a result of these activities (see Appendix C for full overview including examples from Rotterdam and NYC). Together, the capacities underpin the shift towards a more integrated, multi-actor and experimental approach that enables the development of problem-based and systemic climate strategies and interventions.

I have identified four different types of governance conditions that were created across all capacities (Table 7.2). These conditions facilitate the enactment of the respective capacities, i.e. they enable the development and implementation of problem-based and systemic climate strategies and interventions. They resemble those conditions mentioned in governance capacity literature (see Section 1.3.1; Foster-Fishman et al. 2001; Rama et al. 2009), but delineate specific types of conditions marking a shift towards transformative climate governance, including opting for more diversity and flexibility of knowledge, networks, actors and institutions. The activities provide detailed explanations and transferable lessons of how the diverse conditions were created. The view on activities draws attention to the creation of capacities as learning processes that unpderin the shift in Rotterdam and NYC away from control-type activities towards more open and bold ways of addressing climate change.

- **Institutional conditions:** Institutional conditions (e.g. regulatory space for experimentation) influence how decisions are being made and how planning and management are conducted within each capacity. The capacities manifest in new types of institutional conditions that allow flexible, problem-based and systemic approaches.
- **Knowledge conditions:** Knowledge conditions (e.g. co-created knowledge about long-term and systemic risks) underpin decision-making and planning to facilitate context-specific and problem-based approaches and to facilitate on-going learning about the effects of interventions (e.g. learning from experimentation). The capacities manifest in new types of knowledge conditions that integrate multiple perspectives (e.g. scientific and community knowledge) and take long-term and systemic perspectives to create synergies and avoid trade-offs in the long-term.
- **Network conditions:** Network conditions (e.g. support networks that mobilise for change) create connections and partnerships between diverse types of actors for collaboration across scales, sectors and societal spheres. The capacities manifest in new and diverse types of

network conditions to generate knowledge, societal support and develop and implement interventions.

- **Social conditions:** Social conditions (e.g. co-ownership over long-term visions) relate to the societal awareness about, support for and ability to change behaviours and self-organise. The capacities manifest in new types of social conditions to create co-ownership and co-responsibility for addressing climate change, sustainability and resilience.

While similar conditions manifest in the different capacities, they serve distinct purposes in line with the respective capacity's functions. For example, while stewarding capacity is manifest in institutional conditions that enable fit-to-context decision-making, planning and management relating to risk and uncertainty, transformative capacity is manifest in the creation of institutional space for experimentation without being accountable to business-as-usual. Unlocking capacity is manifest in the dismantling of institutions, networks and discourses that perpetuate unsustainable path-dependency, for example by adapting institutions to reduce the competitive advantage of business-as-usual.

- ***Stewarding capacity:*** In both cities, stewarding capacity is visible in initiatives and plans to protect from long-term risks and uncertainties related to flooding, storm and health as well as to improve equity and wellbeing. Stewarding capacity is marked by a shift towards polycentric, flexible and knowledge-based approaches that allow long-term, fit-to-context and fit-for-purpose decision-making, planning and management. In both Rotterdam and NYC, conditions for stewarding have been created by developing a vast amount of knowledge on systemic risks and uncertainties, establishing integrated, long-term and multi-level planning approaches and supporting diverse social networks.
- ***Unlocking capacity:*** Unlocking capacity in Rotterdam and NYC is visible in the identification of and awareness raising on drivers of emissions in connection with drivers of air and noise pollution, waste and inequality, and the creation of new incentives and regulations to control unsustainable practices and support alternatives. The capacity is characterised by a new view about institutional 'sun-setting' to phase-out and/or reduce the competitive advantage of business-as-usual. Conditions for unlocking are primarily created by phasing-out or disincentivising business-as-usual and creating support networks and strategic alliances with a clear mission for change.
- ***Transformative capacity:*** Transformative capacity in Rotterdam and NYC is evident in the multiple strategic, operational, institutional and organisational innovations in how climate mitigation and adaptation are addressed. It resonates the application of experimentation as a full-fledged governance approach that does not only encompass the (continuous) innovation itself but also reflection and learning about what the innovation brings about in the policy and planning mix (e.g. for replication, scaling). Conditions for transformative capacity were created by leadership that made use of opportunities for change (e.g. Hurricane Sandy), providing (e.g. regulatory, financial) space and heterogeneous and inclusive networks for experimentation, reflection and learning and by spreading the innovation story locally, nationally and internationally to increase legitimacy of and support for the innovations and the experimental approach.

- ***Orchestrating capacity:*** Orchestrating capacity is evident in both cities in the city-wide long-term and integrated climate, sustainability and resilience goals and the large variety of nested, formal and informal institutions, networks and communication channels that were established at different levels of governance to streamline and coordinate the activities of multiple actors and networks. Orchestrating capacity has emerged as a key 'meta-capacity' for aligning and coordinating and ensuring collaboration through systemic knowledge and perspective that is brought into other departments, sectors etc. via formal and informal processes (e.g. institutionalising sustainability and resilience, cross-departmental task forces, informal spaces). Like with transformative capacity, political leadership has been a key driving force for putting the integrated view on climate, sustainability and resilience on the agenda and assigning a clear mandate and priority to these issues.

While the capacities result in distinct contributions to enabling transformative climate governance – in terms of enabling fulfilling different functions – there are many interactions between the capacities. In particular, transformative and orchestrating capacities have in Rotterdam and NYC emerged almost simultaneously through the creation of space and informal networks for strategic and operational innovation. In other words, the innovation of the approach to climate change, sustainability and resilience through transformative capacity has propelled new types of strategies, governance arrangements and institutional structures for cross-sectoral and cross-scale collaboration (orchestrating capacity). In this context, transformative and orchestrating capacity represent 'meta-level' capacities: what is innovated and how climate activities and networks are coordinated also affects stewarding and unlocking. For example, the integrated perspective on climate, sustainability and resilience was embedded in context-sensitive, problem-based and community-based approaches to manage risks and vulnerabilities. It also facilitates the generation of systemic knowledge on risks and drivers of unsustainability and path-dependency.

7.1.2.3 Actors enacting transformative climate governance in Rotterdam and New York City

The ways the governance capacities are created and enacted in Rotterdam and NYC underlines the decidedly multi-actor nature of urban climate governance. While the local governments, in particular the Climate and Sustainability Offices in Rotterdam and the Mayor's Office for Recovery and Resiliency (ORR) and the Mayor's Office for Sustainability (MOS) in NYC, are the main actors responsible for ensuring and overseeing climate-proofing safeguarding measures, they establish and collaborate with diverse networks and partnerships to enable cross-boundary and cross-sectoral implementation. As a result, in both cities a diversity of cross-sectoral, cross-scale and public-private partnerships and networks, including regional and national knowledge programmes, research partnerships, research-industry collaborations and private stakeholder platforms, participate in the generation of knowledge, the formulation of strategies and agendas and the development of innovative solutions. Table 7.3 provides an overview of the different types of actors and actor networks enacting urban climate governance in Rotterdam and NYC.

Actors from the local governments

In both cases, the local governments remain the critical actor leading efforts on climate, resilience and sustainability. There is of course no such thing as 'the' local government as a single entity; the local government is composed of actors working in various departments and offices and political parties. Overall, the local government exercises regulatory power, provides incentives, raises awareness and coordinates the diverse innovation and implementation processes in Rotterdam and NYC. The initiative and high-level political support from the Mayors and, in NYC, also from individual departments' Commissioners were critical for putting strategic and operational innovations for climate change, sustainability and resilience on the political and public agenda. Policy entrepreneurs were able to use opportunities for change – like the International Architecture Biennale in Rotterdam and hurricane Sandy in NYC – to develop climate adaptation and resilience plans.

The Sustainability and Resilience Offices that were established in both cities as cross-cutting bodies are central nodes for overseeing, initiating and drafting the strategies and their implementation. They channel information and knowledge, establish connections with on-going processes, motivate action, search for funding and lobby for support. They also participate in cross-scale partnerships and networks to align goals and mediate knowledge and resources across local, regional and national levels. In both cities, the transnational city network 100 Resilient Cities funds the formal position of a Chief Resilience Officer that is tasked with establishing a comprehensive resilience vision for minimising the impact of unforeseen events, work across departments and with the local communities. In NYC, also different departments take the lead in coordinating cross-sectoral and cross-scale action on specific topics: For example, Emergency Management Department (EMD) coordinates NYC's disaster and emergency planning and response operations. Other city departments, including the Department of Parks and Recreation (DPR) and the NYC Department of Health and Mental Health' (Health Department), contribute to creating knowledge on emergency planning, coastal resilience and ecosystem services.

Actors from regional and national governments

Climate governance in Rotterdam and NYC is nested within legal and institutional framework at regional and national levels, which requires alignment of priorities and legislation across governance levels. For example, in both cities water and flood safety are shared responsibilities across national, regional and local governmental bodies. In NYC, effective flood-zoning policies and building codes require cooperation among the Federal Emergency Management Agency (FEMA), the NYC Department of Buildings (DOB) and the NYC Planning Department. However, national and regional policy frameworks in the Netherlands and the US often constrain long-term climate adaptation and sustainability investments.

In both cities, regional and national governments support climate governance through research programmes, regulatory frameworks and incentives. In the Netherlands, the Dutch government initiated multi-actor research programmes like Knowledge for Climate to generate knowledge on climate impacts in high-impact regions in the Netherlands, including Rotterdam. The Federal Department of Housing and Urban Development (HUD) initiated the Rebuild-by-Design (RbD) competition to develop and implement innovative projects for rebuilding, community resilience and sustainability in the Sandy-affected region, which resulted in three innovative projects located in NYC.

Table 7.3: Actors and actor networks enacting urban climate governance in Rotterdam and New York City

Actor (network)	Examples	Activities
Local government	Sustainability and Resilience Offices Chief Resilience Officers Mayor Policy entrepreneurs	Initiating and agenda-setting for action on climate change, sustainability and resilience Streamlining, motivating and supporting action on climate change, sustainability and resilience Implementing regulations and incentives for risk protection and phase-out Investing in infrastructure and leading-by-example (e.g. investments in renewable energy on municipal properties) Ensuring good governance principles and inclusive decision-making
Regional and national governments	Rijkswaterstad (Rotterdam) Regional Waterboards (Rotterdam) Federal Emergency Management Agency (FEMA) (NYC) Federal Department of Housing and Urban Development (HUD) (NYC)	Initiating and agenda-setting for action on climate change, sustainability and resilience Implementing regulations and incentives for risk protection and phase-out Investing in infrastructure Ensuring good governance principles and inclusive decision-making
Knowledge partnerships	100 Resilient Cities Dutch Knowledge for Climate research programme (Rotterdam) New York City Panel on Climate Change (NYC) Science and Resilience Institute @ Jamaica Bay (SRI@JB) (NYC)	Generating, integrating and communicating knowledge Sharing best practices Creating safe space for knowledge exchange and trust building
Public-private partnerships	Rotterdam Centre for Resilient Delta Cities (RDC) (Rotterdam) RDM Campus (Rotterdam) NYC Green Codes Task Force (NYC) Special Initiative for Rebuilding and Resiliency (SIRR) (NYC) New York-New Jersey Harbor Estuary Program (HEP) (NYC)	Connecting diverse actors to each other and mediating interests Pooling resources and developing and implementing interventions Lobbying for political and societal support
Non-profit and community-based organisations	Rotterdam Milieucentrum (Rotterdam) Municipal Art Society (MAS) (NYC) Environmental Justice Alliance (EJA) (NYC) Red Hook Initiative (NYC)	Generating knowledge Awareness raising Criticising and lobbying for political and societal support

Actor networks and partnerships

In Rotterdam and NYC, a diversity of cross-sectoral, cross-scale and public-private partnerships and networks, including regional and national knowledge programmes, research partnerships, research-industry collaborations and private stakeholder platforms, participate in the generation of knowledge, the formulation of strategies and agendas and the development of innovative solutions. The types of networks differ across the different capacities: for example, while stewarding capacity builds in particular on knowledge and community-based networks and partnerships, unlocking capacity manifests in particular in public-private partnerships that create support and advocacy for change. While I distinguish between knowledge and public-private partnerships, knowledge partnerships typically also (but not necessarily) involve public and private actors. However, research institutes have a key role in these partnerships as their main aim is to generate and integrate knowledge.

Knowledge partnerships include collaborations and programmes that bring together actors from local, regional and national governments, academia, businesses and local communities to generate issue-specific knowledge at different scales (e.g. regional, communities). For example, the Dutch Knowledge for Climate supported knowledge generation on water safety risks in unembanked areas in Rotterdam. The NYC Panel on Climate Change (NPCC) is a collaboration of research institutes in NYC to report on climate risks and adaptation needs. The New Jersey-New York Harbor Estuary Program (HEP) is a federally authorised programme that brings together federal, state and local agencies and citizen groups to define common goals and priorities for action around the management of the shared harbour and estuary. Knowledge partnerships also serve to create trust among different actors and to mediate interests by acting as the moderating actor facilitating knowledge sharing, trust building and community engagement. The Science and Resilience Institute @ Jamaica Bay (SRI@JB) in NYC mediates scientific and community knowledge between universities, local communities and public agencies by creating an informal space to share ideas and concerns, doing transdisciplinary research and introducing research results into the discussion.

Public-private partnerships have diverse contributions to climate governance in Rotterdam and NYC; they serve to mediate interests between diverse actors, pool resources and develop and implement interventions, and lobby for political and societal support. In the NYC Green Codes Task Force, for example, allowing for the involvement of key actor groups (e.g. large homeowner associations) to make recommendations for the building and construction code changes was critical for the buy-in to the adaptation of building codes in the Greener Greater Buildings Plan (GGBP) (NYC 2009).In Rotterdam, the Floating Pavilion Partnership brought together actors from knowledge institutes, the local government, private companies and local communities to create knowledge on floating developments and implement the Floating Pavilion pilot project. Institutionalised partnerships like the RDM Campus in Rotterdam continue the development of innovations like floating constructions.

Non-profit and community-based organisations

Non-profit and community-based organisations contribute to generating knowledge, raising awareness and criticising existing policies and business-as-usual. Particularly in NYC there is a strong culture of community-based organisation, which can be explained in part by the liberal political culture that is less reliant on government's decisions and support. The role played by this type of organisations

was especially illustrated in NYC, where neighbourhoods with strong community organisations, such as Redhook, benefited from their substantial support in the aftermath of Hurricane Sandy when local, state and federal agencies struggled with providing relief.

Community engagement and participatory planning processes are increasingly recognised as a powerful way for ensuring local knowledge and needs are accounted for, to gain support and mobilise broader societal action. The implementation of a first water square in Rotterdam failed because there was no community support; the Benthemplein square on the other hand is successfully used as a community square because local groups co-designed it. The Rotterdam Resilience Strategy has identified community initiatives that could be connected to the city's resilience efforts. The NYC Parks Department engages communities in maintaining the city's green, for example through the GreenThumb programme. The RbD-competition, which was initiated by HUD after hurricane Sandy and resulted in three resilience projects in NYC, demanded far-reaching expert and community engagement to ensure local support and relevance. However, despite these starting collaborations, overall community-based organisations feel insufficiently included by the local governments in Rotterdam and NYC.

7.1.3 What are capacity gaps, barriers and opportunities for transformative climate governance in cities?

The explanation and evaluation of capacities for transformative climate governance in Rotterdam and NYC indicate several barriers and gaps, but also opportunities and promising avenues for transforming urban (climate) governance. Overall, in both cities the capacities for transformative climate governance still represent niches within the overall governance architecture in both cities and they are not yet strong enough to achieve the bold and radical changes necessary for contributing to transformations towards sustainability and resilience.

I identify the following overarching features of the approaches in both cities, which indicate opportunities for transforming urban (climate) governance:

- **Integrated actions to reduce emissions, adapt to climate impacts and improve overall sustainability and resilience:** In both cities, actions and interventions are developed and implemented in an integrated way, which means relations between climate and other policy priorities and goals are identified to create synergies and avoid trade-offs.
- **Experimental approach to develop innovative, multi-functional and long-term solutions:** In Rotterdam and NYC, space has been created to experiment with novel practices, approaches and solutions. This has facilitated the development and implementation of multi-functional innovations that depart from control-style policies and interventions and deliver on long-term benefits and emphasise learning.
- **Multi-actor involvement and coordination in defining and implementing climate mitigation, climate adaptation, sustainability and resilience goals and agendas:** While in both cities actors from the respective local governments are taking a leading role in developing and implementing climate-related initiatives and projects, they establish and collaborate with diverse networks and partnerships to enable cross-boundary and cross-sectoral implementation.

- **New role for systemic and multifaceted knowledge for knowledge-based decision-making and planning:** Decision-making and planning in both cities builds on a vast knowledge base about long-term risks, uncertainty and historical, present and future drivers of unsustainability and climate change risks and vulnerabilities. The type of knowledge that is generated builds on integrating multiple perspectives (e.g. from actors across sectors and scales as well as from diverse societal spheres).
- **Fit-to-context and fit-for-purpose approaches to make decisions and plan in line with context and issue-specific needs:** Rather than taking sectoral approaches to planning and decision-making, fit-to-context and fit-for-purpose are adopted that put problem-based and systemic approaches into practice: e.g. in specific neighbourhoods, related to specific issues (e.g. buildings) and taking cross-scale dynamics into account.

Despite the successful development of more integrated, multi-actor and experimental approaches to urban climate governance in Rotterdam and NYC, there are several shortcomings with regard to their potential to deliver the output functions. These shortcomings can be related to gaps in the capacities, i.e. to missing conditions or challenges for developing and enacting upon the conditions to deliver the output function. Table 7.4 provides an overview of shortcomings of climate governance in Rotterdam and NYC and related capacity gaps and challenges.

In particular, there seems to be a disconnect between the urban climate governance activities and the existing urban governance regimes in both cities. This signifies a lack of mainstreaming and prioritising climate-related concerns in city-wide policy and planning processes. The majority of existing incentive structures and regulations still favour short-term economic interests and investments, pre-empting co-beneficial protection from long-term risks and decisive phase-out of the root causes of emissions and sustainability. This perpetuates counteracting investments (e.g. building developments in flood-prone areas) and undermines the contribution of innovative solutions into the policy mix as they remain disconnected from mainstream policy and planning. This is visible in challenges for stewarding and unlocking capacity to mainstream and prioritise climate-related concerns. Regarding transformative capacity, the innovative climate strategies, approaches and solutions often remain isolated and stand-alone and do not yet permeate city-wide planning and decision-making.

As discussed in Chapter 6 in relation to these shortcomings and capacity gaps, actors in Rotterdam and NYC are currently confronted with moving beyond the initial momentum for integrated and experimental approaches to climate governance. The next-step challenge in Rotterdam and NYC is to move beyond the initial conditions created by the formulation of a long-term and systemic strategic agenda, setting-up partnerships and coalitions and the experimentation with innovative solutions. There is a need for strengthening institutional and organisational conditions for more decisive prioritisation of long-term climate investments and actions, better funded collaboration mechanisms and improved space for (learning from) experimentation.

In particular, this requires rethinking how orchestrating processes can be structurally supported and provided with a legitimate mandate to create long-term and integrated framework conditions that counter short-term economic interests and clarify responsibilities. Here, gaps in orchestrating capacity as a 'meta-capacity' to ensure alignment, coordination and mediation across the other capacities are pivotal: In Rotterdam and NYC, the dispersed climate governance structure is visible in the multiple

Table 7.4: Shortcomings and related capacity gaps and challenges

Shortcoming	Main capacity gap	Challenges
Beyond visions: mainstreaming	Orchestrating capacity: Institutionalising visions into regulatory frameworks and organisational structures across sectors and scales	No mainstreaming of long-term climate and sustainability concerns; contradictory rules, disincentives for long-term climate action and counteracting investments and trade-offs Unclear responsibilities for stewarding, unlocking and transforming Moving beyond technological and short-term solutions (e.g. behavioural change) No space for experimentation, replication and scaling
Beyond coalitions of the willing: outreach	Orchestrating capacity: Reaching out to wider actors and actor groups (e.g. across departments, community organisations)	Low levels of awareness and support – climate action as 'doing something extra' Feeling of exclusion (community-based organisations) Reaching out to heterogeneous populations (e.g. buildings with diverse energy structures) Breaking open existing actor networks
Beyond experimentation: learning and uptake of innovation	Transformative capacity: Learning from and evaluating experiments	Replicating and scaling of experiments Connecting experiments to overarching vision Maintaining space for experimentation and replication and scaling

individuals, organisations, task forces and committees of governing that have been the agency of capacity generation. Orchestrating capacity facilitates the structuring of the multiple activities and interactions between these actors. I identified several orchestrating deficits in Rotterdam and NYC, which are visible in the limited outreach and implementation of the long-term climate, sustainability and resilience agendas. The next step challenge is to institutionalise and operationalise transformative climate (meta-)governance to decisively stipulate a prioritisation of climate change, sustainability and resilience in mainstream urban governance structures, practices and processes.

However, strategic visioning and alignment, partnership-building and mediation of knowledge and resources are time and resource-intensive. Despite the increasing diversity of networks, spaces and channels to coordinate and integrate systemic climate action in Rotterdam and NYC, these do not extend beyond a still relatively small group of key actors. The limited mainstreaming results in trade-offs – not only between urban climate governance and business-as-usual governance and planning practice but also between resilience and sustainability goals. For example, in Rotterdam charging stations for electric cars were set up in a flood-prone area which increases vulnerability to power outages during flood events.

7.2 So what? Lessons on and recommendations for transforming urban (climate) governance

This thesis started out by mapping existing urban climate governance efforts, including their features and shortcomings vis-à-vis contemporary urban governance systems. In the last decade, climate action in cities has become formally recognised as a vital part of the global response to climate change and pressing sustainability problems (Kabisch et al. 2018; WBGU 2016; van den Heijden 2018; 2019; Winnington et al. 2016). However, in view of multiple interconnected problems and challenges, urban climate governance needs to be *transformative*, i.e. it needs to address climate change within the broader context of urban transformations towards sustainability and resilience. The cross-cutting nature of climate change and urban transformations challenges existing urban governance paradigms, demanding a shift away from short-term, sectoral and incremental decision-making. Indeed, urban climate governance has already shown to influence urban governance systems by spurring new organisational structures, collaborations and learning-based policy and planning processes. The shortcomings of urban climate governance to date signify the inability of existing, still dominant and highly entrenched, urban governance regimes to deal with the systemic, contested and uncertain nature of urban transformations under climate change.

In this section I reflect on how my findings inform ongoing theoretical and empirical debates on transforming urban (climate) governance. Transformative urban governance has been approached generally as a departure from incremental and short-term approaches towards those taking strategic long-term perspectives as starting point and facilitating learning, participation, knowledge co-production, long-term thinking, experimentation and flexibility (Wolfram et al. 2017; Loorbach et al. 2015; WBGU 2016). However, how this governance should be structured and arranged, which actors will be involved and how the necessary governance shift can be achieved so far remain unanswered questions (Rink et al. 2018). From my empirical analysis, I can confirm many processes, activities and conditions that have been identified in literature related to urban transformation and climate governance, including those contributing to innovation, risk protection and coordination. The combined perspective of the capacities framework allows to identify relationships between these, as well as to identify capacity gaps for delivering functions. The key message from my case studies is that the developing capacities still represent niches within the overall landscape of urban governance in cities. Particularly orchestration underpins the other capacities and the mainstreaming and operationalisation of transformative climate governance. These results also challenge theoretical research and empirical practice further to develop (understanding about) the conditions that overcome existing capacity gaps. The agency-oriented insights from my comparative case study about activities, conditions and gaps make it possible to formulate recommendations on how to invest in and strengthen capacities in cities.

7.2.1 Key lessons on transforming urban (climate) governance

Since climate change has become firmly embraced as a key concern to be taken up in cities in the early 1990s, urban climate governance has come to be characterised by several distinct features that have contributed to devising and implementing climate strategies and actions in more systemic, long-term, inclusive and open-ended ways (Section 1.2.1; Johnson et al. 2015; Castán Broto 2017; Bulkeley 2010).

However, so far urban climate governance efforts are still not undertaken in a structured way that contributes to radical emissions reductions and protection from long-term, severe and uncertain risks, let alone to creating stepping stones for broader transformations. In particular, urban climate governance has to compete with existing urban governance regimes that are following different targets and operational processes (Rink et al. 2018).

The insights from Rotterdam and NYC show that even in cities that have become recognised internationally as frontrunners in addressing climate change, sustainability and resilience, this type of integrated and experimental approaches still only take place at the fringes of urban governance. In both cities, an initial momentum has been created by envisioning long-term and integrated strategies and goals and by experimenting with novel solutions and approaches. Yet, urban climate governance efforts are not able to overcome existing governance lock-ins and barriers resulting from the sectoral organisation of existing governance regimes, vested political and economic interests, short-term incentive structures and limited experience with integral and long-term decision-making. This obstructs effective urban climate governance that is able to ensure protection from long-term risks and diminish unsustainable path-dependencies while enhancing social and environmental wellbeing. Despite the long-term and far-reaching ambitions, actual interventions are often still incremental and technocratic and unable to create the required shifts in lifestyles, infrastructures, market patterns and institutions (Romero-Lankao et al. 2018; Torabi et al. 2018; Nordgren et al. 2016). In Rotterdam and NYC, this becomes visible in the challenge to instigate truly political discussions about sensitive issues such as planned retreat, stranded assets and lifestyle changes, which affect powerful economic interests (e.g. of building developers) as well as the intrinsic values and identities of local communities.

The review and empirical analysis of urban climate governance activities and shortcomings vis-à-vis existing governance regimes raise in particular the challenge of how to mainstream and operationalise capacities for transformative climate governance. Many of the processes that are already conceptualised to facilitate innovation, learning and flexible responses to risks, are reflected in Rotterdam and NYC. The crux is to not only better enable and institutionalise the existing approaches, but also to proactively advance and develop new conditions to overcome existing capacity gaps. This requires to move beyond experimentation, coalitions of the willing and visioning (see Chapter 6).

From the perspective of governance capacities, the question is about how to invest in and strengthen the governance conditions that enable actors to deliver transformative (climate) governance. The analysis of capacities for transformative climate governance in Rotterdam and NYC reveal diverse institutional, knowledge, social and network conditions, including co-ownership over long-term and integrated strategies, long-term financing mechanisms, space for experimentation, systemic knowledge and coordination channels and spaces (Table 7.2). For example, it becomes clear that experimentation to develop disruptive innovation can only be successful when there is (institutional, regulatory, financial) space and heterogeneous networks for trialling innovative solutions, approaches and ideas, and learning about what these innovations mean for existing governance and planning practice. This resonates the ongoing discourse on 'moving beyond experimentation' that criticises the disconnect between innovative urban climate experiments and formalised and mainstream urban policy and planning processes (van Buuren et al. 2018; Turnheim et al. 2018; Ehnert et al. 2018).

The insights from Rotterdam and NYC also show that there are still shortcomings and capacity gaps (Section 7.1.3; Table 7.4). These indicate mismatches between the conditions for transformative climate governance and existing urban governance regimes. For example, while cross-cutting strategies, structures and networks (e.g. Sustainability Offices, cross-departmental task forces) were established, these are so far not able to transcend the vast activities of the local governments in both cities. As a result, the sectoral organisation into individual departments with different priorities and planning and budgeting procedures as well as short-term political and economic interests often prevail and counteract long-term and systemic climate, sustainability and resilience efforts.

The novelty of the capacities framework and my research is that by stressing governance functions and linking these to governance conditions and activities, I am able to explain and evaluate both what 'makes' capacity and what are capacity gaps. I highlight four critical lessons from my theoretical and empirical research on proactively experimenting cities. These lessons resonate the conditions that fundamentally underpin transformative climate governance. I suggest that these need further attention and investment to address existing shortcomings and proactively develop capacities for transformative climate governance and achieve effective change. The lessons are forward-looking: I stress not only the activities and conditions that have proven to work, but which are next step for research and practice in view of existing shortcomings and gaps.

7.2.1.1 Lesson #1: shift from 'climate' governance towards problem-based and open-ended transformative governance

One of the starting points of this thesis was that because climate change is a cross-cutting issue climate mitigation and adaptation cannot be addressed as isolated and sectoral issues but need to be approached in synergy with other policy priorities and goals. The emergence and development of urban climate governance has in many cities evolved from add-on climate mitigation and adaptation strategies and policies towards integrating climate change across policy domains, sectors and scales (Aylett 2015). In Rotterdam and NYC, though climate change has been a driver of integrated policies and interventions this has rather spurred long-term 'sustainability' and 'resilience' goals and interventions beyond merely climate-related ones.

This raises the question about what urban 'climate' governance is: developing the capacities for transformative climate governance implies a transformation of urban governance itself and thus developing capacities for transformative urban governance (rather than climate governance). This will eventually make urban 'climate' governance obsolete and highlight the synergies and trade-offs across policy domains and goals. In this way, it is truly moved beyond addressing climate change as an isolated issue: for instance, stewarding is about protecting from climate risks and uncertainty in relation to other vulnerabilities and disturbances rather than adding climate change to a check-list of 'things to do' in planning – the latter has not proven effective so far (den Exter et al. 2014; Aylet 2015). It enables asking different types of – very political – questions about what goals need to be integrated and prioritised in linking systemic problem definitions to long-term visions. Urban transformations will involve hard choices about long-term and short-term trade-offs, sunk costs and abandonment of revered living patterns and lifestyles. Climate mitigation and adaptation risk to impinge on other policy priorities, such as equity, for example by decreasing accessibility of energy (rising energy prices) or of

living in specific neighbourhoods (e.g. gentrification through green infrastructure) (Rink et al. 2018; Elmqvist et al. 2018).

7.2.1.2 Lesson #2: investing in orchestrating capacity for initiating, mobilising, overseeing and mediating polycentric governance systems

I have derived orchestrating capacity from the need for encouraging, coordinating and assisting the dispersed activities of polycentric actor networks in alignment with shared long-term goals (see Chapter 3 and Intermezzo A; Hodson and Marvin 2010; Loorbach 2014; Chaffin et al. 2016). The term 'orchestrating' has been employed in global climate governance literature similar to meta-governance as an indirect, or soft, mode of governance (Abbott et al. 2015; Abbott 2017). Orchestration is critical for initiating, mobilising, overseeing and integrating urban (climate) governance processes, decisions and investments in line with long-term, systemic and inclusive objectives and across scales and sectors. In Rotterdam and NYC, orchestrating processes help to initiate, mobilise for and oversee a shared long-term and systemic agenda by co-creating and integrating policy priorities and goals, building trust, identifying priority areas, mandating action and mediating knowledge and resources across scales and sectors. However, within overall city policy and planning processes action for climate, sustainability and resilience is still perceived as doing something extra – this signifies gaps in orchestrating capacity. Orchestration needs to be decisively enforced through 'hard' policy instruments and regulatory frameworks, as well as investing in organisational capacity for co-creation and mediation.

My conceptualisation and results imply that orchestrating can, and should, take more direct, formal and coercive forms in order to mainstream climate, sustainability and resilience across scales and sectors. A key barrier for the operationalisation and implementation of systemic and long-term action is that climate change, sustainability and resilience goals and strategies are not consistently and decisively translated into institutional frameworks, governance approaches, financing mechanisms and practices that change incentive structures, organisational ways of working and individual behaviours (den Exter et al. 2014; Wamsler 2015). The disconnect between the ambitious goals and strategies and urban governance regimes makes the strategic agenda vulnerable to changing political priorities and economic interests and perpetuates counteractive investments (Torabi et al. 2018; Rosenzweig et al. 2015).

This resonates calls for a return to the true meaning of polycentric governance: polycentricity was not meant as a panacea for spontaneously emerging and concerted self-organisation that will by itself result in effective problem-solving (Jordan et al. 2018; Galaz et al. 2011). Rather, it requires careful balancing between monocentric, centralised and polycentric, decentralised forces (Pahl-Wostl and Knieper 2014; Gordon and Johnson 2017). For example, in addition to streamlining actions across scales and sectors, polycentric governance requires ensuring good governance principles, giving voice to vulnerable actors and monitoring and evaluation (Pahl-Wostl and Knieper 2014).

I therefore argue for strengthening orchestrating capacity in a way that does not only rely on employing soft instruments (e.g. network building, communication) for facilitating bottom-up self-organisation in line with common goals but that is also daring in developing 'hard' policy instruments and frameworks. On the one hand, there is a need for strengthening the organisational capacity for co-creation and spreading a shared narrative as well as for building and mediating between multiple actor

networks. This addresses the existing governance lock-ins hindering mainstreaming climate change due to a lack of staff time, lack of collaboration between siloed local government agencies and lack of government jurisdiction in key policy areas (Aylett 2015). As shown in my case studies, orchestrating is time consuming and requires dedicated staff to establish formal and informal communication channels (e.g. inter-departmental working groups, intermediary spaces), cultivate trust, start initiatives when needed and pool resources and knowledge.

On the other hand, the difficulty of generating funding for the implementation of systemic and long-term solutions, competing priorities and interests implies the need for consistent and decisive translation of systemic and long-term goals into overarching institutional frameworks and financing mechanisms that change incentive structures and organisational ways of working (den Exter et al. 2014; Wamsler 2015). This brings certainty to investments; for example, urban stakeholders such as utility and housing companies, landlords, tenants' associations and consumer protection organisations are currently confronted with uncertainties and risks regarding future energy needs, security of energy supply, cost effectiveness and climate protection effects (Rink et al. 2018). Systemic financing frameworks such as enabled by the Rebuild by Design competition helped to develop multi-beneficial projects in NYC, yet as long as business-as-usual is (financially) viable sustainable business models remain thin and climate-proofing is perceived as more expensive. Westley et al. (2011) emphasise that such framework conditions should be open and flexible rather than resembling rigid rules and that direct and indirect incentives are more effective than scare tactics – for example, by linking renewable energy schemed to jobs or green tourism.

Despite the current discourse on a state hollowed out by austerity and captured by neoliberal forces, these conclusions highlight the critical role of governmental actors in coordinating, motivating and mandating climate action at multiple scales (Frantzeskaki et al. 2014; Capano et al. 2015). Governmental actors at local, regional and national scales shape polycentric governance and voluntary private commitments at local levels in both passive and active ways, including the implementation of policy instruments, mainstreaming climate change into policy sectors, facilitating diffusion of governance innovation and encouraging learning by establishing bodies with evaluative capacities (Jordan et al. 2018; Hodson et al. 2018). As illustrated in Rotterdam and NYC, local governments seem to retain important roles in catalysing urban climate governance efforts, by institutionalising long-term climate and sustainability agendas, driving and motivating experimentation and investing in infrastructure (Castán Broto and Bulkeley 2013; Bulkeley 2010; Amundsen et al. 2018). Being positioned at the centre of horizontal and vertical integration local governments can ensure compatibility and coherence, act as primary organiser of dialogue among policy communities, deploy a monopoly of organisational intelligence and information and balance power differentials (Frantzeskaki et al. 2014; Amundsen et al. 2018). Researchers have in particular highlighted the role of governance entrepreneurs or policy champions, who frame climate and other concerns as policy issues and change how climate governance is accomplished (e.g. by creating new distributions of authority and information, spreading new worldviews) (Huitema et al. 2018; Romero-Lankao et al. 2018). The nestedness of local climate governance in legal and institutional framework at regional, national and international levels requires alignment of priorities and legislation across governance levels (Dąbrowski 2017; Keskitalo et al. 2016; Fuhr et al. 2018). For example, on the national level energy transformation policies represent the main instrument to implement the targets of climate policies at local levels, the German 'Energiewende' being probably one of the most prominent examples (Rink et

al. 2018). Such policies need to ensure integration with multiple priorities and targets, for instance to secure energy supply, cost effectiveness and accessibility (ibid.).

7.2.1.3 Lesson #3: unlocking and innovating existing governance institutions and actor networks

A key challenge is the institutionalising of transformative climate governance capacities vis-à-vis existing urban governance regimes that favour short-term interests and siloed decision-making. The lock-ins visible in existing urban governance regimes counteract transformative governance approaches for systemic, long-term and innovative decision-making and planning (see Section 1.2.3). As a result, most governance activities still resemble business-as-usual approaches, and more often than not favour a 'governance-for-growth approach' that veils the fundamental changes needed for achieving urban sustainability and resilience (Rink et al. 2018). In Rotterdam and NYC, this is visible in counteracting investments (e.g. in building developments in flood prone areas) and narrow institutions that demand 're-building in kind'. For example, any action towards sustainable energy in the port of Rotterdam premise the unabated continuation of industrial activities. This impedes measures that decisively challenge existing economic structures, interests and behaviour – business cases for sustainable energy investments remain thin and unappealing because of complex regulations, permit requirements and the need for technical expertise.

This underscores how institutional and organisational rigidities are key barriers to integrated and bold governance action (Keskitalo et al. 2016; Homsey and Warner 2015). Existing urban regimes – in terms of existing urban institutions and actor networks – need to be strategically dismantled and innovated. This requires unlocking of existing institutions and actor networks as well as anchoring of new governance conditions for innovation, for example by breaking open existing governance networks, challenging existing assumptions and narratives and building support networks with an explicit mission for change (Kivimaa and Kern 2016; Bosman et al. 2018; Loorbach 2014). It requires an explicit reflexive attitude towards the question about what types of actors should be involved (rather than simply involving those that 'have always been there') or whether something should be done simply because this is the convention and has been done before.

Scholarship is only starting to look into processes of regime destabilisation (Kivimaa and Kern 2016; Bosman et al. 2018; Turnheim and Geels 2012) and moving beyond experimentation (Turnheim et al. 2018; Ehnert et al. 2018) – better insights into either are critical for helping understanding dismantling existing urban governance regimes and for strengthening new ones. Instructive could be recent work in sustainability transitions research on discursive regime destabilisation processes, focusing for example on how narratives or negative storylines (e.g. about dominant polluting industry, unsustainable behaviour, climate risks) promote decline (Rosenbloom 2018; Roberts and Geels 2018). Some scholars focus on disruptive 'institutional work' for de-institutionalising by undermining assumptions and beliefs about practices, disassociating moral foundations and disconnecting sanctions (Maguire and Hardy 2009; Fuenfschilling and Truffer 2016; Beunen and Patterson 2016). Others emphasise the "need for governments to exert authority over market actors to initiate more rapid transitions through controversial measures such as phase out policies and directly intervening in markets" (Johnstone and Newell 2018: p. 75). Overall, these works focus on phase-out policies (Geels et al. 2017; Rogge and Johnstone 2017) and political coalitions and movements (Hess 2018).

While governance experimentation has received much attention as an open-ended way for trialling new, agile and responsive solutions (Bulkeley et al. 2016; Castán Broto and Bulkeley 2013; Karvonen 2018), further strengthening the capacities for transformative climate governance requires attention to processes for embedding and institutionalising innovations. Currently, researchers question whether and how urban climate governance innovations become institutionalised and bring about enduring change (Patterson and Huitema forthcoming; van der Heijden et al. 2019). Moving 'beyond experimentation' requires the dedication of time to identify, evaluate and translate lessons from specific innovations, such as about the viability, replicability and scalability, for their broader context (Turnheim et al. 2018; Ehnert et al. 2018).

7.2.1.4 Lesson #4: giving voice to communities and building social support and strategic alliances

Urban transformations towards sustainability and resilience are about deep and radical changes in ways of thinking, doing and organising, and in ways of knowing and relating (Loorbach et al. 2017; Frantzeskaki et al. 2018a). Ultimately, the effectiveness of many climate, sustainability and resilience strategies and actions depends on production and consumption patterns, including consumer choices, values and lifestyles (O'Brien 2018; den Exter et al. 2014). This requires the inclusion of a wide range of societal actors in co-defining and co-managing responsibilities to take different interests into account, make complex sets of goals like resilience understandable, ensure top-down priorities are aligned with local-level needs and tap into the multiple capacities of actors to achieve the deep structural and behavioural changes required (Brown 2017; McPhearson et al. 2017).

In Rotterdam and NYC, the capacities manifest in new types of social conditions to create co-ownership and co-responsibility for addressing climate change, sustainability and resilience. Community engagement and participatory planning processes are increasingly employed to access local knowledge, gain support and foster resilient neighbourhoods. Awareness raising activities increase knowledge about risks and support for innovation and changing practices. However, despite the promise of the diversity of actors and networks, the interactions among actors and the effectiveness of their actions continue to be constrained by conflicts, organisational culture and structure and limited experience with, resources for and knowledge about devising effective participatory climate governance mechanisms (Castán Broto 2017; McPhearson et al. 2017; Brown 2017). In Rotterdam and NYC, community-based organisations feel excluded from and do not trust decision-making. In addition, mere awareness raising have so far proven ineffective in changing behaviours, because they do not address the underlying cognitive processing (Moloney and Horne 2015; Seto et al. 2016).

Recent research highlights in particular the role of civil society – understood broadly as encompassing grassroots organisations, community-based organisations, advocacy groups, professional associations – in pioneering new practices and filling the void left by a changing welfare state by providing services (Frantzeskaki et al. 2018b). For example, there are numerous examples of measures implemented by urban households and communities to adapt to changing environmental conditions and specific threats (e.g. innovation in water collection, shift to drought-resilient crops), but it is unclear how to scale these up and connect them with local and regional policies (Romero-Lankao et al. 2018). Strategically building alliances between local communities and local governments could be a powerful way for ensuring local knowledge and needs are accounted for and for mobilising broader societal

action (Chu et al. 2017; Archer et al. 2014). This was illustrated in NYC, where neighbourhoods with strong community organisations, such as Redhook, benefited from their substantial support in the aftermath of Hurricane Sandy when local, state and federal agencies struggled with providing relief (Cowan and Hogan 2014).

However, the activities of civil society can lead local governments to avoid or limit their responsibility in taking daring action or providing basic services (Frantzeskaki et al. 2018b). In addition, in Rotterdam and NYC local communities and community-based organisations still often feel excluded from the strategy development and implementation processes that are driven by the local governments. This raises questions about the (uneven) (re-)distribution of roles and responsibilities between different actors that have different decision-making authorities and resource basis (Hölscher et al. 2017a). As stated in the introduction to this chapter, I did not explicitly consider the political dimension of capacity building. This perspective includes important questions about how innovative climate projects are framed and narrated, whose interests are driving climate-related strategies and solutions and how the development of capacities depends on political leadership, prioritisation and political systems (cf. Jhagroe 2016).

7.2.2 Recommendations for transforming urban (climate) governance

By approaching urban climate governance from an agency-based perspective, I was able to dig deeper into how, by whom and why urban climate governance is developing. The insights gained about actors and activities enable me to formulate recommendations about how key conditions for transformative (climate) governance can be created and strengthened. The recommendations respond to the basic questions: what do actors need to be equipped with to develop and execute the capacity conditions? In doing so, the recommendations address strategic objectives – i.e. they outline how actors can be able to develop conditions for fulling different types of governance (sub-)functions.

The empirical insights on actors and activities highlight the role of diverse actors (Section 7.1.2.3; Table 7.3). Drawing on the insights from my case studies, which heavily focused on the activities of actors from the local governments in Rotterdam and NYC, my recommendations are directed towards actors from local governments. In particular, I address institutional and policy entrepreneurs that can put climate change, sustainability and resilience on a city's agenda, challenge sectoral ways of working and establish collaborations across sectors and scales.

The comparative case study of Rotterdam and NYC, as examples of proactively experimenting cities, has generated insights for two types of recommendations: about how capacities for transformative climate governance have been started up, as well as about next steps to strengthen the capacities (Table 7.5). The starting up of capacities relates to the development of initial momentum, the formulation of systemic and long-term goals and the generation of systemic knowledge. The acceleration of capacities extrapolates in particular from the gaps in both cities and the lessons outlined above (Section 7.2.1) to strengthen the conditions of transformative (climate) governance vis-à-vis existing urban governance regimes.

These recommendations are not exhaustive, and they do not come without words of caution in light of the limited generalisability from my two qualitative case studies. Cities have very different contexts

Table 7.5: Recommendations for developing capacities for transformative climate governance

Strategic objective	Recommendation
Starting up capacities for transformative climate governance	
Co-create integrated climate, sustainability and resilience goals across scales and sectors	Identify key themes and problems for urban transformation (e.g. health, flooding) and find connections to the existing political agenda and emerging opportunities (e.g. experience of crises, global debates) for pushing these themes and making clear that the provide positive pathways for urban development. Create cross-cutting organisational capacity (e.g. Sustainability Office) for convening diverse actors (different sectors, scales and societal spheres) for shared strategy formulation and visioning. Ensure that the process design is inclusive (e.g. involving local community organisations) and open to build trust. Create intermediary spaces (e.g. cross-departmental and public-private task forces and working groups) for knowledge sharing, strategy formulation and trust building on specific sub-topics (e.g. urban heat, green infrastructure).
Create space for experimentation as governance approach for innovation and learning	Assign experimentation zones and spaces that are freed from existing regulations, service delivery goals. Change the way of tendering for innovative projects by integrating long-term, systemic and inclusive approaches into the process design. Identify frontrunners to form informal 'coalitions of the willing' for trialling new ideas, solutions and practices. Involve communities in design and implementation of experiments.
Generate long-term and context-specific systems' knowledge that brings together a variety of insights and needs	Create issue-specific and multi-stakeholder research programmes and partnerships for knowledge generation across scales and sectors. Develop systemic models of change based on an understanding of cities as complex and open urban systems (e.g. identify feedback loops between different strategic goals causing synergies and trade-offs). Mandate knowledge generation to ensure widespread access to data (e.g. energy audits). Develop resilience and sustainability indicators based on system model and monitor progress in line with long-term dynamics and goals.
Create support networks and partnerships with an explicit mission for change	Identify and connect to key actor groups and organisations working on strategic goals to increase lobbying efforts. Collaborate with key actor groups for issue-specific interventions (e.g. intermediation between communities and local government, awareness raising and information provision on energy efficiency options). Frame and tell the city's innovation story to increase momentum and (trans-)local societal and political awareness and support for strategic goals and experimentation as a way for re-invention.
Accelerating capacities for transformative climate governance	
Motivate, mandate and support the uptake of strategic goals into tactical and operational management approaches across scales and sectors	Identify counteracting framework conditions and financing mechanisms and change funding schemes and incentive structures to enable long-term and integrated financing in line with long-term goals (e.g. new tendering procedures). Reflect on and (re-)define responsibilities for taking action and provide incentives and mandates for doing so (e.g. providing more money to departments who take up integrated action, allow for integrated financing).

Strategic objective	Recommendation
	Re-school civil servants to internalise inter-sectoral and problem-based thinking.
Invest in organisational and institutional capacity for mediating knowledge, interests resources across scales and sectors	Invest in human resources (i.e. number of staff) and staff training into developing an extensive communications infrastructure across scales and sectors (e.g. Chief Resilience Officer, informal task forces, individual officers within departments). Strategically build alliances with and support intermediaries (e.g. research institutes, NGOs, community-based organisations) that take up specific roles (e.g. spreading information, organising service delivery, knowledge integration).

and thus face different types of enabling and disabling conditions for urban climate governance (Castán Broto 2017). In particular, larger cities and economically important cities like Rotterdam and NYC often have particular weight through their consumption, size of local government or cultural influence (McCormick et al. 2013). As there are no blueprint solutions for transformative climate governance, guidance must be developed from case study specific evidence (Chaffin et al. 2016). In addition, investing in these conditions, or in governance capacity more generally, is no recipe for success: governance capacity is an enabler for effective change, but no precondition (Koop et al. 2017).

In general, besides generating concrete empirical-based recommendations I suggest actors from city governments to use the capacities framework as an analytical tool to reflect on existing governance structures and practices. For example, the framework can be used to reflect on the extent to which the governance functions are address: what kind of long-term and integrated goals can be developed, is knowledge generated in a systemic and inclusive way, is there space to learn from experimentation? It can also be used to reflect on the existing governance structures and practices, whether they facilitate or hinder long-term and systemic decision-making and planning, and which structures and practices need to be strengthened. This is where I foresee the main value of the framework for practical implementation – rather than providing prescriptive guidelines and recommendations that might differ from city to city, it in this way the framework can be used to open up reflexive space to tend to individual city's needs.

7.2.3 Informing theory of governance for urban transformation

Governance has become a critical means for analysing and supporting concrete ways to steer urban transformations towards sustainability and resilience (McCormick et al. 2013; WBGU 2016; Frantzeskaki et al. 2018a). The theoretical work of this thesis, fed with empirical insights from the case studies, contributes to a consistent and empowering conceptual frame to identify and strengthen conditions that need to be put in place for enabling transformative urban (climate) governance.

On the one hand, my capacities framework advances understanding about what kind of governance can spur the changes and disruptions in existing urban regimes necessary for overcoming unsustainable path-dependencies and mal-adaptation, while also enabling flexible responses to and protection from unavoidable risks, shocks and uncertainty. I have achieved this by synthesising

different theoretical transformation research approaches, in particular sustainability transitions and resilience. I have selected both approaches because they have developed concepts and approaches to understand complex systems change and the role of agency and governance in supporting (or hindering) desirable change (see Section 1.3.2 and Chapter 3). Due to their different entry points to understanding and intervening in system change both approaches offer complementary insights for agency and governance of system transformation: on persistent structural and cultural constraints underlying shifts towards more sustainable systems of service provision and lifestyles (sustainability transitions) and on capacities for responding to uncertainty and disturbance (resilience).

The synthesis of both approaches into the capacities framework advances the debates about whether and how sustainability transitions and resilience approaches can enrich each other's explanations of and governance propositions for navigating desirable system change. When I started this study, there have been general debates about complementarities between both approaches (Olsson et al. 2014; Smith and Stirling 2010; Pereira et al. 2015; van der Brugge and van Raak 2007; Foxon et al. 2009), yet these debates had not extended beyond a fairly uncritical comparison of both approaches. I partially attribute it to the then only starting explorations about how concepts such as sustainability and resilience, adaptation and transformation, as well as socio-technical systems and social-ecological systems complement or contradict each other (Smith and Stirling 2010; Anderies et al. 2013; Wilson et al. 2013).

The perspective I developed in the capacities framework is largely based on the premise that the different concepts and frameworks of sustainability transitions and resilience approaches complement each other. For example, rather than taking adaptation and transformation as opposite concepts, the framework brings both concepts back to their functional essence: i.e. responding to risk and uncertainty (adaptation) and creating disruptive innovation and disruptions of the existing regime (transformation). Bringing the concepts and frameworks of both approaches back to their functional essence helped me to identify different governance functions that are needed in their own right to mobilise and respond to different types of transformation dynamics (Chapter 3). This distinction into governance functions and corresponding capacities provides a systematic structure for synthesising diverse scientific insights on governance conditions and agency and for formulating agency-oriented propositions that facilitate the creation of conditions for delivering the functions (Intermezzo A). Ultimately, it makes more clear what different types of conditions are required and diverse actions need to be taken to address complex, contested and far-reaching problems like climate change in a systemic way. I therefore also want to stress that the growing interest in transformations in climate governance literature – which is also embodied in the latest IPCC Special Report on 1.5 °C (IPCC 2018) – should be more explicitly connected to theories of transformation governance. It seems that while a transformation discourse has started to prevail in the climate change field, there is still a lack of clarity about what the ontologies and insights from approaches like sustainability transitions and resilience, which are explicitly concerned with transformative change, contribute to the field. The capacities framework facilitates such process by providing a frame to integrate theories of transformative change.

On the other hand, the capacities framework enables explaining the structuration of governance for transformation – i.e. what types of conditions manifest in the capacities and how actors interact with and change these conditions. The structuration perspective underlying the capacities framework

provides an explicit view on the concrete activities and mechanisms that are put forth by sustainability transitions and resilience approaches and that can be undertaken and supported for empowering transformative (urban) governance in practice. Sustainability transitions and resilience approaches emphasise the role of institutions and agency in facilitating or hindering transformative change (Fünfschilling and Truffer 2014; Westley et al. 2013). The specific novelty of the framework is that it combines the structuration perspective with different types of governance functions. This allows synthesising, structuring and enriching the diverse theoretical contributions and empirical insights about agency and structural conditions underpinning governance for transformation by explaining and evaluating how transformative climate governance functions are fulfilled.

The applications of the capacities framework have shown that the theoretical conceptualisation holds in explaining and evaluating the development of urban climate governance (Section 7.1.1; Table 7.1). The empirical insights reverberate the importance of well-researched processes for innovation and stewarding, including leadership and polycentric networks. Unlocking and orchestrating functions and capacities are so far less researched and conceptualised – in this sense, the framework is state-of-the-art. The applications of the framework thus enabled generating novel insights about activities and conditions for unlocking and orchestrating and feeding these back into theory. This is where I identify most need for future research – gaps in unlocking and orchestrating capacity are both visible in scientific literature and governance practice (see Section 7.1.3 and Section 7.3).

7.3 Future research directions

As exploratory research the results of this thesis open up a variety of future research directions. The research directions I highlight here are not exhaustive, and they merely reflect my main results, personal interests and view on limitations of this study.

On the one hand, the conceptual capacities framework provides a basis for exploring different types of questions and foci related to governance for transformation and transformation of governance. As an important step in advancing and applying the framework further, I suggest its application in different research modes – both in descriptive-analytical like in this thesis and transformative research approaches (Wittmayer and Hölscher 2017). On the other hand, I identify directions for further advancing empirical knowledge about the development and implications of urban climate governance and transformative urban governance.

7.3.1 Advancing and applying the capacities framework

The capacities framework provides a novel heuristic to look at governance as an open-ended process driven by agency and to do so in relation to the fulfilment of defined governance functions. This thesis has shown that the structuration perspective on how capacities are emerging enables explaining, evaluating and supporting the development of urban climate governance. In addition, the framework is grounded in different research strands interested in a transformation of governance. This makes the framework versatile to different research contexts and questions relating to 'transformation of governance' for 'governance for transformation' (Intermezzo A; Patterson et al. 2016). I have already applied the framework to different research questions and in different modes (see also Chapter 2.1.3).

First, the capacities framework can be applied to different research questions related to what type of governance facilitates navigation of sustainability and resilience transformations and how such governance can be worked towards to. In the Rotterdam case study chapter (Chapter 4), I positioned the framework within global climate governance literature. In the NYC case study chapter (Chapter 5), the framework was grounded within literature on governance for urban sustainability and resilience transformations. This strengthens the theoretical and analytical value of the framework: the conceptualisation of the framework holds across different literatures and questions about the transformation of governance at multiple scales and in relation to other sectors.

I have already applied the framework to other research questions. For example, parts of the framework were applied to nine case studies of coupled infrastructure innovations to identify the actors and activities driving the innovation of coupled infrastructures (Hölscher and Wittmayer 2018). From these insights, we were able to formulate action-oriented guidelines and recommendations for federal, regional and local actors. I also used the framework to analyse in retrospect whether and how transition management supports the development of new kind of governance capacities (Hölscher 2018; Hölscher et al. 2017b). I could identify which process design steps and activities created conditions for systemic and innovative approaches to sustainable urban planning, including system analysis, visioning and the creation of ownership.

Next to the application to different research questions, the capacities framework has the potential to support transformative research approaches, which aim to co-create concrete and actionable strategies and solutions in transdisciplinary research settings. For example, the framework can support action-oriented research to facilitate the co-creation of governance capacities in specific contexts when it is integrated in practice-based governance frameworks such as transition management (cf. Hölscher 2018). This type of research can address the need for social science knowledge in the face of climate change and for solution-oriented approaches on how society can change course from dangerous climate scenarios (Norgaard 2018). In the IMPRESSIONS project, the framework was applied to understand the available capacities in different socio-economic scenarios (Pedde et al. 2019; Hölscher et al. 2017c). For example, in one scenario a strong economic and political elite capitalises power and resources but puts in place decisive and top-down sustainability a strategies and actions. In another scenario, institutional and organisational capacities for sustainability and collaboration are weak. This subsequently supported stakeholders in workshops to formulate transformation pathways to achieve long-term visions for a sustainable and resilient future. The framework was also applied to analyse the capacities developed in the pathways, which yielded insights into the actors, activities and conditions that underpin how the pathways achieve the shifts towards the vision. The framework could also directly guide pathways development by indicating questions about what types of capacities need to be developed and how this could be done (e.g. how can unsustainable practices be phased-out, how can we achieve coordination and collaboration across sectors?) (Frantzeskaki et al. 2019; Tábara et al. 2018).

7.3.2 Advancing knowledge and reflection about urban (climate) governance for transformation

This research raises several issues that require further attention for advancing understanding the development of urban climate governance, whether and how it enables transformative (climate) governance and what its implications are on governance regimes at multiple scales.

Urban climate governance literature is still devoid of systematic comparative studies, which reveal what is good practice in multiple cities, or what is good practice one city but does not yield similar results in another (van der Heijden et al. 2018). I suggest the capacities framework as a tool to derive more in-depth, widespread in localities and generalisable results on how and what new forms of climate governance are emerging and how effective these are for addressing climate change and steering transformation dynamics. I recognise that governance capacities are context-dependent, emergent and can hardly be assessed for urban areas as a whole (Wolfram 2016; González and Healey 2005). Nonetheless, I purport that investigating governance capacities aids a deeper, integrated and empirically-based understanding of the most important enabling and limiting conditions that determine governance capacity as well as how conditions are created and changed (Koop et al. 2017). The application of the framework to different contexts and scales can yield generalisable results on activities, opportunities and challenges for building capacities for transformative climate governance and thus reveal pathways for increasing governance capacities in relation to different contextual needs, institutional conditions and resources (ibid.). Such work needs to explicitly consider the 'urban divide' between and within many cities: between cities in the developing and industrialised world, between large and small cities and within cities between rich and poor (McCormick et al. 2013).

However, the framework (so far) does not allow a rigorous assessment of the extent capacities for transformative climate governance actually contribute to sustainability and resilience transformations. Jordan et al. (2015) call for a rigorous assessment of the effectiveness of existing climate governance approaches. The framework leaves room for formulating indicators to assess certain capacity levels or can be linked to evaluation schemes, which, for example, enable the assessment of the impact and directionality of climate experiments (Luederitz et al. 2017). By connecting capacity levels to outputs and impacts, more critical discussions are possible about the effectiveness of urban climate governance. For example, despite the increasing rhetoric of equity and justice in local action plans and city metrics, action is still focused towards environmental and economic outcomes (Castán Broto 2017).

A particular issue raised in this thesis is the role of orchestrating (Section 7.2.1). There is an urgent need to better understand how the diffuse urban governance landscape can be coordinated and, relatedly, how climate, sustainability and resilience goals and agendas can be more decisively mainstreamed in existing urban governance regimes. Insights are in particular limited because of the relative novelty of the phenomena of cross-cutting agendas and working processes. In this thesis, I have proposed orchestrating as a mode of governance that encompasses both formal and informal processes as well as hard and soft instruments to align and mediate between actors and networks. The existing shortcomings of urban climate governance and the challenges of mainstreaming, which are visible in proactively experimenting cities like Rotterdam and NYC, indicate a need for improving understanding

about how to decisively prioritise long-term and integrated action and how to create organisational and institutional space for coordinating (Aylett 2015; den Exter et al. 2014).

Central to debates on transformation of governance is the hybridisation of actors (Patterson et al. 2016; Avelino and Wittmayer 2017). A more consistent theory and approach is needed about who is taking up actions, why and using which strategies – as well as about what are existing urban governance regime networks that need to be dismantled (Section 7.2.1). In Rotterdam and NYC, the local government remains the critical actor leading efforts on climate, resilience and sustainability, but closely collaborates with private businesses and civil society organisations. Rather than there being one sole authoritative position, actor or institution, heterogeneous groups of individual actors, organisations and actor networks across sectors and jurisdictions, both in and outside of government, have important roles in urban governance with implications on how climate change, sustainability and resilience are addressed (Castán Broto 2017; Hodson et al. 2018). Additionally, many diverse types of actions and strategies will be needed to trigger transformative climate governance processes, including coordinated actions by local governments, innovation in the private sector, experimentation and pressure from civil society (Romero-Lankao et al. 2018). For example, the regulatory authority of governments can mandate and incentivise action, academic organisations provide knowledge support, the private sector and development agencies often drive a large part of a city's economic and land use decisions, and community-based organisations that are trusted in local neighbourhoods can help raising awareness and influencing behaviours (Romero-Lankao et al. 2018; Simmons et al. 2018; Hildén et al. 2017).

Related to the actor question above, the level of inclusivity and the (re-)distribution of roles and responsibility among diverse actors raises questions about the power dynamics and the politics of governance (Castán Broto 2017; Avelino and Wittmayer 2017). While acknowledging its importance, this research has somewhat evaded this question. Transformative urban (climate) governance requires rethinking what it means to design and practice climate mitigation and adaptation in a holistic and inclusive way that takes socio-economic, political and developmental dimensions into account (Luque-Ayala et al. 2018). As climate change and sustainability issues are pervasive and socially constructed phenomena, they challenge heterogeneous sets of actors from different sectors and jurisdictions, holding different values and interests and having varying levels of power and influence over problem framings and solutions (Castán Broto 2017; Hodson et al. 2018; Romero-Lankao et al. 2018). According to Castán Broto (2017: p. 9), positive views of the proliferation of actors in urban governance contrast with perspectives that "see this profusion of actors as the root cause of a dilution of responsibilities". In this context, the re-organisation of what were considered governments' task vis-à-vis civil society and businesses raises questions about the (re-)distribution of responsibilities between actors that might have different decision-making authorities and resource bases (Hölscher et al. 2017a; Avelino and Wittmayer 2017). Increasing community self-organisation and market self-regulation might also veil the need for alignment of action to foster synergies and deal with trade-offs and to more traditional governmental instruments such as regulation (Pahl-Wostl and Knieper 2014; Frantzeskaki et al. 2018b).

Finally, the above also demands more profound insights on the (political) feasibility of building the capacities. For example, whether there will be investments in developing the capacities is dependent on political leadership and political prioritisation. Each development pathway – be it one of business-

as-usual or one of transformative change – creates its own set of winners and losers, yet so far, development preferences are often shaped by powerful interests that determine the direction and shape of change (IPCC 2018).

7.4 A vision for transformative urban governance

I develop and employ transformative climate governance to envision an integrated, experimental and inclusive approach that addresses climate change in synergy with sustainability and resilience goals and is attuned to the dynamics of urban transformations under climate change. I have shown that the capacities framework helps explaining why particular capacities emerge, and I have argued that the framework is beneficial for advancing both governance theories and practice. Now I want to reflect on the vision that is ultimately underlying the framework, and what in my view this vision means for urban governance practice. What would urban governance with the full-fledged capacities actually look like, and, in particular, how do the capacities relate to existing urban regimes?

The very basic starting point of my vision is that sustainability and resilience are employed as long-term, holistic, process-oriented and inclusive goals for developing and implementing any governance intervention (Section 1.1.3; Table 1.2). I recognise that sustainability and resilience are extremely vague and ambiguous concepts, yet their value lies precisely in the questions they unveil upon defining them: What do sustainability and resilience mean in a city? Which elements of sustainability and resilience should be prioritised? How can value conflict and burden sharing be dealt with? I believe that making a vision of governance for long-term sustainability and resilience explicit, and decisively prioritising and pursuing it, is one of the most critical elements of urban governance. Putting it very bluntly, and paraphrasing one of my interviewees, it does not matter if we talk about 'sustainability', 'liveability' or 'resilience', or about 'sustainability governance', 'transformative governance' or 'climate governance'. Rather, it is about the values of everybody residing in cities and their aspirations for the future and how these relate to the conditions and dynamics in cities.

One of the main motivations for putting the vision for sustainability and resilience central to orienting decision-making and planning is that I attribute many of today's political, economic, social and environmental problems to the dearth of visions about a world that would be wonderful to live in. As put by Donatella Meadows already in the late 1990s: "If we don't know where we want to go, it makes little difference that we make great progress", yet the "best goal most of us who work toward sustainability offer is the avoidance of catastrophe" (Meadows 1996). The need for a vision and envisioning processes in urban governance is not a new recognition, and there are many examples of urban visions. However, in light of today's tendencies (not only in cities, but also on global levels) to ignore the need for future-oriented, inspirational thinking in favour of seeking to maintain what has been come to know and valued in the past and reducing complexity, the need for long-term and systemic visions cannot be overstated.

In this sense, while I suggest sustainability and resilience as long-term orientations *replacing* the short-term modus operandi of existing urban governance regimes, the capacities framework provides a basic frame and direction for questioning existing governance structures and practices and for developing

conditions that enable governance in line with the long-term vision. This will not be so much about dismantling all existing sectoral organisations or firing laying off employees. I rather see the influence on urban governance on a meta-level: investing in the capacities to achieve a long-term and common vision will change the cultures, types of knowledge and networks that guide decision-making and planning. It turns attention to process in as much as outcome, including how inclusive policy and planning processes are or what they feed back to policy and process learning. In particular, it implies a more inwardly-looking and reflexive approach to how to set up urban governance structures and conditions so as to allow desirable governance processes. Of course, as I argue above, I also see the need for more decisive changes in existing governance structures. The challenge will be to avoid merely adding an additional dimension on existing urban governance regimes, but to maintain, create and disrupt whatever governance conditions facilitate or hinder long-term and systemic decision-making and planning.

Whether a (governance) vision for sustainable and resilient urban and global futures can be achieved, and more specifically whether the capacities for doing so will be created, depends to a large degree on the existing political system and the attitudes of people choosing political leaders. What I hope the capacities framework and the generated empirical insights bring to this vision is the guidance of concrete reflection on how to co-create the conditions for collectively developing and actively working towards shared visions.

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Appendices

Appendix A. Interview guides

1) Goal of the interviews

The goal of the interviews was to collect knowledge about the perceptions of urban climate governance practitioners in Rotterdam and New York City: how do they view the responses to address climate change, sustainability and resilience, what and who is driving (changes in) the responses, and what (future) challenges and opportunities are.

2) Selection of interviewees

- Interviewees were selected using key informants who had conducted recent research in each city or who had been or is active in the climate governance in each city and using the snowball technique during interviews, a list of potential interviewees who are active in each city's climate governance.
- This list includes people from a wide range of areas – including local government, researchers, practitioners, community organisations. An effort was made to include various perspectives, cover multiple levels of governance and governance sectors (e.g. transport, health, water).
- The interviews focused on the particular roles of the respondent in climate governance in the respective city.

3) Interview design

- The interviews were designed to last an hour on average.
- The interviews were semi-structured, in an effort to allow the rich experiential insight of interviewees to emerge by allowing their narratives to flow.
- An interview guide provided a set of key questions with which to prompt interviewees onto the topic of interest and also contain a short introduction to the research and an icebreaker.
- The general topics of the interview were prompted using the interview guide. Questions were paraphrased or adjusted and their order is adapted to suit the flow of the conversation.
- Since the interviewees were selected to represent a broad variety of functions some of the interview questions in the interview guide or topical areas of climate governance were placed more focus on than others.
- The interviewees were informed that the interview is to be recorded after his/her consent.

Interview guide

(A) Introduction & Icebreaker	
A.1 Introduction	Short overview of the research objectives and explanation about the purposes of the interview Overview of the interview set-up The respondent is informed that the interview is recorded if s/he gives her/his consent.
A.2 Icebreaker	A.2.1: Can you briefly tell me about your past and present roles in the climate governance in X? A.2.2: Could you give me three words that describe the climate governance philosophy in X at the moment for you? Was there any notable change in climate governance in X in the past years?
(B) Stewarding capacity	
B.1 Generating knowledge about system dynamics	B.1.1: What are the main risks and vulnerabilities that are addressed by climate governance in X? B.1.2: What kind of knowledge do you generate on risks and vulnerabilities? How is it generated? With whom?
B.2 Strengthening self-organisation	B.2.1: How do you support the management of climate risks? What institutional structures are in place to manage climate risks (think of self-organising networks, multi-level governance partnerships)?
B.3 Monitoring and continuous learning	B.3.1: How do you ensure learning so that past experiences are taken up into practices and responses?
(C) Unlocking capacity	
C.1 Revealing drivers of unsustainable path-dependency and mal-adaptation	C.1.1: What are the main drivers of unsustainability and unsustainable path-dependencies you address through your operations and actions? C.1.2: How do you recognise drivers of unsustainability and risks? (e.g. emissions accounting, air pollution monitoring)
C.2 Undermining vested interests and incentive structures	C.2.1: How do you try to promote the phase-out of unsustainable practices, structures and values (e.g. challenging existing assumptions, breaking open actor networks, creating incentives)?
C.3 Breaking open resistance to change	C.3.1: How do you try to create support for the phase-out of unsustainable practices, structures and values?
(D) Transformative capacity	
D.1 Enabling novelty creation	D.1.1: What has been novel/innovative? D.1.2: How do you enable the creation or establishment of innovation/innovative solutions?
D.2 Increasing visibility of novelty	D.2.1: How do you create support for the innovation/increase visibility of the innovation? What type of support, from whom?
D.3 Anchoring novelty in context	D.3.1: What is the follow-up of innovation? What learning processes are in place? Are lessons learned translated into new policies or mainstreamed across the organisation?
(E) Orchestrating capacity	
E.1 Strategic Alignment	E.1.1: Are there common and overarching long-term goals that cover different priorities and needs?

	E.1.2: How are common goals defined? Who is involved in these processes? E.1.3: How do you deal with conflicts/lack of support?
E.2 Mediating across scales and sectors	E.2.1: How do you reach out to other actors coordinate and align different strategies and goals across scales and sectors/departments? E.2.2: How do you promote collaboration and integrate and exchange knowledge, experience and resources across scales/sectors/departments?
E.3 Creating opportunity contexts	E.3.1: How do you create opportunities for funding/implementation of (joint) strategies and projects?
(F) ***Opportunities and barriers***	
	F.1: What influences your work/climate governance in X in both positive and negative ways? F.2: Have there been some key milestones, events, decisions, people, groups that have been key in shaping the development of climate governance in X? With what effects? F.3: What do you think is the biggest issue for climate governance in X in the future? What do you think will it take to address this?
(G) Closure	
	Do you have any final remarks, comments or questions?

Appendix B. Overview of interviews

Case study	Interviews in total	Interviewees according to societal sphere	Period interviews were conducted
Rotterdam	28	Local city government (11) Regional government (1) National government (1) Knowledge institutes (4) Local businesses and architects (6) NGOs and community-based organisations (3) Politicians (2)	03 – 06/2015
NYC	38	Local city government (12) Regional government (4) National government (2) Knowledge institutes (7) Local businesses, architects and business platforms (6) NGOs and community-based organisations (7)	10/2015 – 01/2016

Appendix C: Transformative climate governance capacities in Rotterdam and NYC

C.1 Stewarding capacity in Rotterdam and NYC

Capacity conditions	Activities	Examples Rotterdam	Examples NYC
Generating knowledge about system dynamics			
Knowledge condition: *Long-term, systemic and context-specific knowledge about risks and uncertainties*	Long-term forecasting of systemic risks and uncertainties across scales	The flood safety assessments for the Rotterdam Adaptation Strategy (RCI 2012) make risk forecasts on flood safety in relation to adaptive transport, urban water system, heat stress. The forecasts look at the region instead of focusing solely on the city, to take the whole flood system into account.	The Hazard Mitigation Plan considers how climate change may change the physical, social and economic vulnerabilities from natural and non-natural hazards including coastal storms, disease outbreak, drought, flooding and cyber threats (NYC 2014a).
	Generating problem-based and context-specific knowledge in vulnerability hot spots	The Dutch Knowledge for Climate research programme supported knowledge generation on water safety risks in unembanked areas in Rotterdam.	The Science and Resilience Institute at Jamaica Bay (SRI@JB) collects and aggregates knowledge on resilience in Jamaica Bay from universities, local communities and public agencies by doing transdisciplinary research and introducing research results into the discussion.
	Identifying and prioritising high-risk areas for directing investments	The Resilience Strategy identifies critical infrastructures such as hospital roads that require special protection in case of floods and emergencies (Gemeente Rotterdam 2016).	OneNYC identifies the initiative to study a model for social empowerment zones, which aim to increase residents' resiliency in under-resourced neighbourhoods by targeting funds and capacity-building support to critical local service providers in these areas.
Network condition: *Knowledge partnerships*	Creating issue-specific and multi-stakeholder research programmes and partnerships for knowledge generation across scales and sectors	The Dutch Knowledge for Climate research programme (2007-2014) brought together knowledge institutes and policy stakeholders to research flood risks, climate proofing and adaptation strategies in high-impact regions including Rotterdam.	NYC Parks and Recreation Department collaborates with knowledge institutes such as the Urban Field Station and Natural Areas Conservancy as well as local communities to monitor the social and ecological values of nature in the city (Forgione et al. 2016).
	Formalising research partnerships and networks	Rotterdam Climate Proof was established as part of the Rotterdam Climate Initiative (RCI) to develop knowledge about	Mayor Bloomberg established the NYC Panel on Climate Change (NPCC) as a formal collaboration between researchers from local

		climate risks and adaptation strategies.	universities to report on climate risks and adaptation needs.
Institutional condition: *Knowledge mandates*	Mandating knowledge generation to ensure access to data	The province of South Holland demands regional and local authorities to assess water safety risks in unembanked areas and the need for additional protective measures. It developed a risk application guide to support municipalities.	To make NYC eligible for FEMA funding, the Emergency Management Department (EMD) coordinates the elaboration of the cross-departmental Hazard Mitigation Plan on reducing risks from, for instance, coastal erosion and storms, extreme temperatures, flooding and cyber threats (NYC 2014a).
Strengthening self-organisation for stewarding			
Institutional condition: *Flexible, problem-based and fit-to-context planning and management approaches*	Integrating long-term, systemic risks and uncertainties into planning and management approaches	The flood risk management approach identifies acceptable risks levels and multiple adaptation steps over time.	The city government integrated climate change projections into emergency management and preparedness.
	Adopting problem-based, fit-to-context and no-regret planning and management approaches	The Dutch Room for the River programme provides funding and sets up collaboration to give the river more room to be able to manage higher water levels in the long-term. In Rotterdam, a project develops the Meuse river as a tidal park to connect multiple goals (e.g. greening, biodiversity, recreation, economic activity).	The Department of Planning's Resilient Neighborhoods studies engage ten communities across the five boroughs to derive recommendations for adaptive land use planning based on a range of coastal hazards and climate change projections. This will include updates to local land use regulations and citywide zoning to promote resiliency investments in buildings and infrastructure.
	Providing flexible regulation and incentives to facilitate fit-to-context risk protection	The Rotterdam city government recommends to dry-proof and flood-proof buildings, e.g. by not building water-vulnerable infrastructure in ground floors.	The Department of Planning implemented the Flood Text to encourage flood-resilient building construction throughout designated floodplains by removing regulatory barriers that hinder or prevent the reconstruction of storm-damaged properties and enabling new and existing buildings to comply with higher flood elevations issued by FEMA.
	Clearly assigning and communicating responsibilities of actors	Regional and local authorities assess the safety situation in outer-dike areas and the need for additional protective measures. The province of South Holland developed a risk application guide	To implement the NYC Special Initiative on Recovery and Resilience's (SIRR) plan, the city needs assistance and funding from the U.S. Army Corps of Engineers to implement various beach renourishment and floodgate

		that supports municipalities in determining water safety risks.	repair projects, review by FEMA of flood-related building standards, and FEMA's authorization of a more flexible building classification in the National Flood Insurance Program (NYC 2013).
Network condition: *Multi-scale and cross-sectoral networks and partnerships for risk planning and management*	Establishing issue-specific, multi-level and cross-sectoral collaborations to develop and implement projects in line with context needs	Funded by the Dutch Room for the River programme, a project develops the Meuse river as a tidal park to connect multiple goals (e.g. greening, biodiversity, recreation, economic activity). It is implemented by the port authority, the city government and environmental organisations.	The NYC Departments of Environmental Protection and Parks and Recreation collaborate to implement and maintain green infrastructure projects together with the Mayor's Office of Recovery and Resiliency.
	Involving communities in joint and context-specific visioning, planning and implementation processes	Actors from the city government's water management department set up together with knowledge institutes action-oriented research consisting of workshops, interviews and a societal cost benefit analysis to determine suitable adaptation strategies and governance arrangements in different neighbourhoods of Rotterdam (Noordereiland and Kop van Feijenoord).	The NYC Parks and Recreation Department (DPR) encourages stewardship of local communities and citizens. The Young Street Tree Pruning project continues with 10.000 trees pruned in 2014. In 2014, DPR led 85 small scale stewardship workshops throughout the year as well as spring and fall stewardship days and planting events.
Social condition: *Social capital and actor empowerment*	Raising awareness about risks and response options	The province of South Holland obliges local governments to inform inhabitants of unembanked areas about their flood risks. However, inhabitants are responsible for their flood safety, but they have limited awareness due to lack of information.	To ensure that citizens understand their flood risk and flood insurance purchase requirements, it is frequently conducting outreach meetings and developing public education campaign materials, including advertisements on public transportation, radio and community events.
	Strengthening social networks to enable self-organised response and social resilience	The Rotterdam Milieucentrum supports awareness raising and provides information about protection options.	The Redhook Initiative is a community organisation that supported recovery from Hurricane Sandy (Cowan and Hogan 2014).
Monitoring and continuous learning			
Knowledge condition: *Institutional and social memory*	Drawing on past experience and learning about new solutions	The adaptive strategy is based on different adaptation pathways that involve multiple adaptation steps over time. They show co-benefits and robustness in the long-term, while requiring short-term and mid-term adaptation in line with new knowledge.	The updated NPCC report (2015) covers new topics including public health, with a focus on extreme heat events. These additions were made following new available knowledge about health risks from climate change. As a result, protection from acute and chronic

		heat was prioritised and an urban heat island working group was set up.
Continuously updating plans and resilience and sustainability indicators	-	The Hazard Mitigation Plan is considered a living document that will be updated every five years (NYC 2014a). OneNYC reports in detail about the progress on diverse indicators and measures.

C.2 Unlocking capacity in Rotterdam and NYC

Capacity conditions	Activities	Examples Rotterdam	Examples NYC
Revealing unsustainable path-dependency and mal-adaptation			
Knowledge condition: *Identifying and exploring systemic drivers*	Identifying systemic social and economic drivers of unsustainability and path-dependency	The Sustainability Strategy (Gemeente Rotterdam 2015) connects emissions reductions to energy production and efficiency, mobility, air and noise pollution, waste and economic development to reveal common drivers of unsustainability and synergies.	The NYC Health Department's data on the health benefits of reducing air pollution substantiated the DEP's push to regulate the phase-out of high sulphur heating oil, which also reduced emissions.
	Road mapping and scenario analyses to explore phase-out options	CO_2-Roadmapping is used to reveal the contributions of (combinations of) diverse measures to reduce transport emissions in Rotterdam.	The plan 'One city: built to last' (NYC 2015b) presents a roadmap that presents different ways to reduce emissions from buildings by 80% by 2050.
	Conducting regular emissions inventories	The sustainability monitoring reports disclose the emissions from different sectors in Rotterdam, such as mobility, port and buildings.	The city government releases annual inventories of GHG emissions to identify emissions sources and how savings could be achieved.
Network condition: *Knowledge partnerships*	Establishing public-private knowledge partnerships to identify drivers and explore phase-out options	The energy cooperative Blijstrom researched together with different partners from the city government, 21 homeowner associations and TU Eindhoven how one building block can become energy neutral.	The NYC Green Codes Task Force brought together multiple public and private actors to make recommendations for the building and construction code changes in the Greener Greater Buildings Plan (GGBP).
Institutional condition: *Knowledge mandates*	Mandating knowledge generation to ensure access to data	-	The GGBP (NYC 2009) mandates benchmarking on building energy and water consumption and energy audits to generate insights on and monitor the carbon intensity of buildings and identify target areas for policies and cost-effective upgrades.

Undermining vested interests and incentive structures			
Institutional condition: *Support for sustainable business cases and investments*	Setting standards for sustainable investments	The Green Award certificate has been introduced for inland vessels and in 2013 500 ships had obtained this certificate.	The NYC Department of Buildings (DOB) plans to implement ambitious performance standards for new construction that cost-effectively achieve highly efficient buildings, looking to Passive House, carbon neutral, or "zero net energy" strategies to inform the standards.
	Providing incentives for sustainable investments	The city government initiated CityLab010 as a public-private platform to create new collaborations and work out concrete actions for contributing to sustainability and to support the search for funding sources.	The Carbon Challenge seeks to encourage businesses, universities and other private organisations to cut GHG emissions.
	Integrating sustainability into public tendering	The city government invested in zero emissions buildings and solar panels on public properties.	The NYC Department of Citywide Administrative Services integrates sustainability and renewable energy into public tenders to invest in zero emissions buildings.
Institutional condition: *Control of unsustainable practices*	Implementing regulation to control unsustainable practices	The city council passed a ban of old vehicles from entering the city centre to reduce air and noise pollution and dis-incentivise the use of more fossil-intensive cars.	The NYC Department of Buildings passed regulations to phase out highly polluting fuel oil and passed the city's Zone Green Zoning Text amendment.
Breaking open resistance to change			
Social condition: *Societal and political awareness and support*	Raising awareness and providing assistance for sustainable investments and behaviour change	The Energy Atlas enables residents to find out whether their roof is suitable for solar panels.	GreeNYC's marketing campaigns and the launch of the Green Light New York (GLNY) education centre for building professionals raised awareness of building owners and tenants about energy use and retrofitting.
	Lobbying for political support	The city council supported the plans of the Sustainability Office and implemented the ban of old vehicles from the city centre.	The Mayor's Office of Sustainability's direct link to the Mayor and the city council was important to lobby for political support and achieve building code changes.
Network condition: *Key support networks and partnerships*	Setting up public-private partnerships for issue-specific action	The energy cooperative Blijstrom reaches out to the houseowner associations to obtain support for energy efficiency investments by holding evening courses on how to become energy neutral.	To implement the efficiency changes in buildings, the Mayor's Office of Sustainability reaches out to and collaborates with homeowner associations as important partners.

	Setting up support networks with key stakeholders (groups)	The public-private Rotterdam Climate Initiative (RCI) streamlines, supports and encourages initiatives for energy conservation, sustainable energy and CO_2-capture.	To update and gain support for the Waterfront Plan (NYC Planning 2011), the Planning Department collaborated with the NYC Waterfront Alliance, which brings together more than 800 activists, businesses, NGOs and civil society organisations.

C.3 Transformative capacity in Rotterdam and NYC

Capacity conditions	Activities	Examples Rotterdam	Examples NYC
Enabling novelty creation			
Social condition: *Leadership for creating and using opportunities for change*	Mobilising political leadership to put new and ambitious goals on the agenda	In 2007, the Mayor of Rotterdam put climate mitigation and sustainability on the agenda as a result of international momentum and the C40 membership. The goal to reduce CO_2-emissions in Rotterdam by 50% in 2025 compared to 1990 was formulated.	The NYC Department of Transport's Commissioner proactively put sustainability on the department's operating agenda, set up a NYC Sustainability Office and pushed for sustainable transport projects.
	Making use of momentum and opportunities for change	Water policy entrepreneurs from the city government used the International Architecture Biennale in Rotterdam in 2005 to create space for an informal, cross-departmental process to push the climate agenda forward. This resulted in the launch of the Rotterdam Climate Proof programme.	Hurricane Sandy provided the opportunity for the Mayor's Office of Recovery and Resiliency, politicians, city departments, NGOs and community organisations to push for a more ambitious climate agenda. The Special Initiative for Rebuilding and Recovery (SIRR) was established to develop a resilience plan (NYC 2013).
	Piggy-backing and quickly expressing potential of a new solution	The architecture company that develops the climate-proof Zomerhofkwartier turned a small plot into a rain garden to quickly express the idea of a rain garden they want to build in a public parking area.	The NYC Department of Environmental Protection (DEP) explores potentials for integrating green infrastructure projects into sewer maintenance work.
Network condition: *Multi-actor innovation networks*	Forming informal 'coalitions of the willing' for strategic and operational innovation	To redevelop the old city ports (Stadshavens) area an informal visioning process was organised that invited heterogeneous actors and allowed out-of-the-box thinking. New operational partnerships were set up, e.g. to implement the floating pavilion (Frantzeskaki et al. 2014).	SIRR brings together multiple public and private actors to develop a programme for reducing the city's vulnerability to coastal flooding and storm surge and for rebuilding communities affected by Sandy (NYC 2013). This facilitated knowledge exchange and trust building.

	Involving communities in design and implementation of experiments	Local communities were involved in the design of the Benthemplein water square – this ensured support for the implementation and for the utilisation of the square also as a community space.	The Rebuild by Design competition demanded far-reaching expert and community engagement to access local knowledge, identify local needs, gain support and ease conflicts.
Institutional condition: *(Regulatory, financial) space for innovation*	Temporary lifting or avoiding existing regulations	During the implementation of the floating pavilion regulatory constraints emerged, because it was unclear which regulations would apply for example for fire safety. The explicit positioning of the project as a pilot helped to create space for navigating regulations.	The leaders of the Living Breakwaters Rebuild by Design project strategically selected sites with less regulatory constraints (e.g. avoiding imminent domains) and fewer jurisdictions and intensively communicated with multiple stakeholders to mediate interest conflicts.
Increasing visibility of novelty			
Social condition: *(Trans-)local support for the innovation story*	Creating and advocating an inspiring innovation story	The Rotterdam Adaptation Strategy (RCI 2012) tells an inspiring and visually appealing story about climate adaptation options in Rotterdam and invites initiatives to connects to it.	Various actors from the city government (actively promote the city's overarching sustainability and resilience visions.
	Showcasing innovations as market potential for the city	The Climate Adaptation Office presents its innovative solutions (e.g. Floating Pavilion, Benthemplein water square) as a unique tourist attraction.	The 'Highline', a greened old train track in West Manhattan, is an example of re-use of space for recreation, green space that transforms abandoned and disused space into high value public space and has generated billions in tax revenue and become a tourist attraction.
Network condition: *Advocacy coalitions*	Creating advocacy coalitions to carry the innovation story	The Rotterdam Centre for Resilient Delta Cities (RDC) was established as a public-private network organisation with local businesses that seek collaborations abroad for applying their experience with realising innovative solutions.	The NYC Cool Neighborhoods Programme (NYC 2017) has a buddy system for heat preparedness as a way to build coalitions in communities for social cohesion and networking that is intended to save lives of most vulnerable during heat waves.
	Participating in and hosting local, regional, national and international networking, best practice and knowledge exchange events for visibility	The Global Centre of Excellence on Climate Adaptation and the Climate Adaptation Academy were launched in Rotterdam. These contribute to international city alignment and knowledge exchange.	Many climate change information and debate events are held in NYC. Actors from the NYC government participate in international climate adaptation conferences to share its work.
Anchoring novelty in context			

Knowledge condition: *Learning for replication and upscaling*	Identifying proof-of-concept lessons from innovations to facilitate replicating and embedding	The experiences from the Benthemplein water square were taken up in future applications by identifying success principles while making sure that there is no one-size-fits-all solution.	The Rebuild by Design competition resulted in the establishment of a working group within the Federal Federal Department of Housing and Urban Development (HUD) to oversee and reflect on the process. The team did extensive studies on challenges (e.g. policies, cooperation, coordination) and translated lessons into follow-up competitions.
	Identifying opportunities from innovation for upscaling	The architecture firm De Urbanisten that implemented the Benthemplein water square builds on the water retention function covered by the square and the developed network to develop a climate-proof city quarter, the Zomerhofkwartier, in the area.	The Department of Environmental Protection (DEP) reflects on lessons from green infrastructure projects and engages in inter-city knowledge exchange to identify strategies for upscaling and replicating green infrastructure across NYC. Recent NYC Stormwater Resiliency 2018 research programme builds on past lessons to develop recommendations for future investments at citywide scales for flood resiliency (NYC DEP 2018).
	Identifying bricolage of solution elements to mainstream innovations into urban planning processes and decisions	The Rotterdam Adaptation Strategy (Gemeente Rotterdam 2012) includes prototypes for proof-of-concept solutions.	The Green Infrastructure Plan operationalises green infrastructure approaches to be implemented in NYC.
Network condition: *Self-sustaining innovation networks*	Formalising operational public-private partnerships for continuous innovation	The RDM Campus is a learning alliance between different public bodies, private sector partners and scientific institutes to test innovative solutions and ideas in practice.	Cross-departmental and public-private task forces on specific topics (e.g. heat island) are tasked with generating knowledge, integrating goals and developing innovative projects.
	Setting up cross-sectoral networks and partnerships tasked with (embedding of) innovation in institutional structures	The creation of the Rotterdam Climate Initiative and the Climate and Sustainability Offices in Rotterdam enables to integrate strategies and solutions across sectors and scales.	The Department of Environmental Protection's (DEP) Commissioner established a Resilience Office to formulate a green infrastructure plan and implement infrastructure projects for flood protection while showcasing the importance of green space for health, air quality and recreation.
Institutional condition: *Institutional*	Creating open mind-set for taking up innovations in tactical		The Department of City-wide Administrative Service (DCAS) provides training to building

space for embedding strategic and operational innovations in mainstream practice	agendas and daily practices		operators on energy reporting to ensure that the data is correct.
	Allocating budget to developing and maintaining innovation, upscaling and replicating	De Urbanisten, the architecture company that planned the Benthemplein water square, sought funding for upscaling the square to a climate-proof city quarter by piggy-backing on on-going road maintenance work and negotiating responsibilities for carrying costs for water safety (e.g. with the water boards).	The Department of Environmental Protection has as water utility its own funding to implement green infrastructure projects.

C.4 Orchestrating capacity in Rotterdam and NYC

Capacity conditions	Activities	Examples Rotterdam	Examples NYC
Strategic alignment			
Institutional condition: *Long-term and integrated goals*	Developing long-term climate mitigation and adaptation, sustainability and resilience goals	The integrated climate change, sustainability and resilience plans in Rotterdam (e.g. Gemeente Rotterdam 2015, 2016) provide official overarching frameworks for aligning priorities and projects in the city towards long-term and systemic goals.	The integrated climate change, sustainability and resilience plans in NYC at city-wide and departmental levels (e.g. NYC 2007; 2010; 2015a) provide official overarching frameworks for aligning priorities and projects in the city towards long-term and systemic goals.
Social condition: *Involvement of multiple actors in shared strategy formulation and visioning*	Involving multiple actors from different city departments and private organisations in strategy formulation	In the context of the IABR in 2005, space was created for cross-departmental reflection to develop a reframing from water as threat to connecting water and adaptation to opportunities. This initiated a formal trajectory to renew the first water plan from the late 1990s that has been mainly driven by the maintenance department of the city administration and there have been conflicts with the city development department.	OneNYC was formulated building on a collaborative process involving actors from multiple city departments and private organisations.
	Public outreaching and participation	The Sustainability Strategy (Gemeente Rotterdam 2015) involved public outreaching.	OneNYC involved public outreaching and Mayor's Office of Recovery and Resilience (ORR) has engaged in multiple public outreach and workshops to seek participation and in traditionally underrepresented neighborhoods of the city.
Mediating across scales and sectors			

Network condition: *Connection nodes for pooling climate action*	Establishing central connection nodes for pooling climate efforts at multiple levels	The Chief Resilience Officer is a key contact point for pooling all resilience efforts in the city; it was created through the participation in 100 Resilient Cities.	
	Establishing cross-departmental city offices for coordinating and knowledge brokering at multiple levels	The Sustainability and Climate Adaptation Offices facilitate strategy development, oversee and streamline implementation processes, channel information and knowledge, establish connections to other on-going processes, assign responsibilities and search funding for implementation and lobbying for support.	The Mayor's Offices of Sustainability (MOS) and Recovery and Resilience (ORR) facilitate strategy development, oversee and streamline implementation processes, channel information and knowledge, establish connections to other on-going processes, assign responsibilities and search funding for implementation and lobbying for support.
	Designating theme-leads and contact persons within individual departments	Each Climate Office's member is placed in different city departments to ensure the Office's agenda is taken up in each department's initiatives.	The NYC Emergency Management Department (EMD) coordinates NYC's disaster and emergency planning and response operations involving a variety of city departments.
	Identifying private and community-based activities to seek linkages	The Rotterdam Resilience Strategy has identified community initiatives that could be connected to the city's resilience efforts (Lodder et al. 2016).	The city government develops a comprehensive, interactive web-based platform to map community organisations and activities, identify gaps and duplication of efforts, as well as opportunities for integrating existing community-based and government initiatives.
Network condition: *Intermediary spaces for knowledge sharing and trust building*	Creating neutral co-creation spaces and knowledge partnerships to build trust for knowledge sharing and resource synergies across scales and sectors	To develop visions and concrete solutions for the re-development of the old city ports area, a co-creative transition management process was set up that brought together a variety of actors (Frantzeskaki et al. 2014).	The Science and Resilience Institute at Jamaica Bay (SRI@JB) in NYC mediates scientific and community knowledge between universities, local communities and public agencies by creating an informal space that is not politicised to share ideas and concerns, doing transdisciplinary research and introducing research results into the discussion.
	Establishing cross-departmental co-creation spaces for knowledge exchange, priority alignment and trust building	The participation in the Rockefeller Foundation's 100 Resilient Cities programme supported the development of a resilience strategy and facilitates knowledge exchange between cities.	Cross-departmental, public-private task forces take up specific themes such as water, buildings and heat island. Different departments take the lead in developing and implementing the formulated initiatives. For example, the NYC Department of Environmental Protection (DEP) takes up the lead on green

			infrastructure investments and collaborates with the Parks and Recreation Department (DPR).
Knowledge condition: Pooling and integrating knowledge and resources across scales and sectors	Identifying opportunities, synergies and trade-offs between different goals	The identification of co-benefits between climate adaptation and health enables to piggy-back no-regret solutions for dealing with the urban heat island effect.	The discussions in the Urban Heat Island task force revealed trade-offs between restricting air conditioning to reduce emissions and the vulnerability of especially low-income populations against heat waves.
Creating opportunity contexts			
Institutional condition: *Framework conditions and financing mechanisms for long-term co-benefits*	Redefining responsibilities for carrying costs	The Benthemheim water square received funding from the water boards although it was a city project, because the project took care of the water boards' responsibility to ensure water retention capacity.	In the implementation of the Rebuild by Design projects, multiple responsibilities and jurisdictions need to be considered and it is debated, who will carry costs when there are multiple benefits.
	Creating competitions to leverage innovative, long-term and co-beneficial solutions		The Rebuild by Design competition piloted a new process framework for developing innovative and co-beneficial solutions. The competition asked for innovative projects to support long-term rebuilding, community resilience and sustainability in the Sandy-affected region. The US Federal Department of Housing and Urban Development (HUD) provided partial funding to the winning proposals.

Samenvatting

Steden bieden veel kansen voor effectieve klimaatactie: ingrepen die direct gericht zijn op de bronnen van CO_2-uitstoot en klimaatgerelateerde kwetsbaarheden, en tegelijkertijd de luchtvervuiling verminderen, lokale gemeenschappen versterken en de openbare ruimte verbeteren. Ondanks groeiende ambities, plannen en experimenten op het gebied van klimaatsturing wereldwijd zijn steden er tot nu toe nog niet in geslaagd de radicale en effectieve acties te ondernemen die nodig zijn om emissies te verminderen en zich te beschermen tegen de effecten van klimaatverandering, laat staan om manieren te vinden voor het verbeteren van sociale en ecologische welzijn op de lange termijn.

Dit proefschrift draagt bij aan het verklaren en evalueren van de manier waarop stedelijke klimaatsturing (governance) wordt ontwikkeld en aangepakt, in hoeverre deze inspanningen zich manifesteren in de capaciteiten voor transformatieve (klimaat)sturing en hoe dergelijke capaciteiten kunnen worden versterkt. De huidige kloof tussen geïdentificeerde kansen en de praktijk in de stad wijst op een een mismatch tussen historisch gegroeide stedelijke sturingssystemen en hedendaagse complexe problemen zoals klimaatverandering. De tekortkomingen van stedelijke klimaatsturing zijn symptomen van lock-ins. Hierdoor is beleidsvorming tot nog toe nauwelijks veranderd en lopen inspanningen vast in een complex web van uiteenlopende verantwoordelijkheden, inadequaat nationaal beleid en dominant paradigma's van economische efficiëntie. In dit proefschrift stel ik dit probleem centraal: hoe kan verandering van stedelijke (klimaat)sturing worden ondersteund om zo transformatieve klimaatsturing in steden te faciliteren?

Mijn doel is bij te dragen tot een beter begrip van hoe transformatieve klimaatsturing eruit zou kunnen zien en hoe het kan worden versterkt ten opzichte van bestaande stedelijke sturingsregimes. Ik herpositioneer klimaatsturing binnen de bredere ambitie om stedelijke transformaties te navigeren in de richting van duurzaamheid en veerkracht. Ik beargumenteer dat het ontwikkelen en beter begrijpen van nieuwe sturingscapaciteiten een vereiste zijn om institutionele ruimte te creëren voor acties die gericht kunnen bijdragen aan de transformatie die nodig is om klimaatverandering en onduurzaamheid in steden aan te pakken. De bijdrage van dit proefschrift is zowel theoretisch als empirisch van aard: ik ontwikkel een raamwerk van capaciteiten voor transformatieve klimaatsturing, en haal inzichten uit de praktijk om te vergelijken of, hoe en door wie dergelijke capaciteiten zijn gecreëerd in Rotterdam (Nederland) en New York City (Verenigde Staten).

Een transformatieperspectief op stedelijke klimaatsturing

Ik neem eerst een stap terug door transformatieve klimaatsturing te conceptualiseren en operationaliseren als een ideaaltypische en normatieve benadering voor het aanpakken van klimaatverandering in de context van stedelijke transformaties. Mijn centrale uitgangspunt is dat klimaatverandering moet worden gezien als een symptoom en aanjager van onduurzame padafhankelijkheden en het bepekte aanpassingsvermogen in stedenbouw, leefpatronen en landgebruik. Het transformatieperspectief vestigt de aandacht op de complexe dynamiek, onenigheden en onzekerheden die inherent zijn aan het aanpakken van klimaatverandering. Het idee

van stedelijke transformatie stelt in staat om te begrijpen wat de diverse endogene en exogene oorzaken van stedelijke transformaties zijn en hoe deze leiden tot veranderde stedelijke functies, nieuwe lokale behoeften en nieuwe interacties tussen steden en hun omgeving. Aan de ene kant is het een voorbeeld van de onhoudbaarheid van de huidige stedelijke ontwikkelpaden. Het besef dat de activiteiten en het gedrag in steden in grote mate bijdragen aan klimaatverandering wakkert de urgentie aan voor radicale en duurzame verandering. Anderzijds zullen de gevaren als gevolg van klimaatverandering (bijv. veranderende temperatuurpatronen, hittegolven, droogte, zeespiegelstijging en zware stormen) toenemen in ernst en frequentie en zullen deze gevaren stedelijke infrastructuren, de gebouwde omgeving, ecosystemen en leefpatronen fundamenteel uitdagen. Duurzaamheid en veerkracht zijn een oriëntatiepunt voor het sturen van lopende stedelijke transformatieprocessen in de gewenste richting: stedelijke transformaties naar duurzaamheid en veerkracht zijn radicale en structurele veranderingen in stedelijke systemen gericht op het verbeteren en behouden van stedelijke functies voor milieukwaliteit, sociale rechtvaardigheid, menselijk welzijn en economische haalbaarheid op de lange termijn, ook in het geval van schokken en crises, en zonder negatieve gevolgen voor andere regio's.

Vanuit dit perspectief zijn klimaatmitigatie en –adaptatie onderdeel van de zoektocht naar bredere maatschappelijke transformaties naar duurzaamheid en veerkracht, die de uitstoot van broeikasgassen drastisch reduceren, de aanpassing aan onherroepelijke gevolgen van klimaatverandering vergemakkelijken en het sociale en ecologische welzijn binnen planetaire grenzen vergroten. Door klimaatmitigatie en –adaptatie in te bedden in het streven naar de transformatie naar duurzame en veerkrachtige steden, is het mogelijk dit te integreren met andere doelen die streven naar maatschappelijk en ecologisch welzijn en bij te laten dragen aan de radicale veranderingen die nodig zijn om deze doelen te bereiken. Dit is wat ik transformatieve klimaatsturing noem [in het Engels: transformative climate governance]: transformatieve klimaatsturing stelt actoren in staat om klimaatmitigatie- en adaptatieacties te ontwikkelen in synergie met andere beleidsprioriteiten en -doelen, om zo bij te dragen aan stedelijke transformaties naar duurzaamheid en veerkracht.

Capaciteiten voor transformatieve klimaatsturing

Om te kunnen verklaren hoe klimaatsturing in steden zich ontwikkeld en te kunnen beoordelen of deze sturing inderdaad transformatiegericht is, is het noodzakelijk om te begrijpen hoe en door wie stedelijke klimaatsturing wordt vormgegeven, welke nieuwe sturingscondities als gevolg hiervan ontstaan en evalueren of deze bijdragen aan transformaties naar duurzame en veerkrachtige steden. In dit proefschrift bepleit ik dat transformatieve klimaatsturing de ontwikkeling van nieuwe sturingscapaciteiten vereist; capaciteiten die de complexe, onzekere en betwiste dynamiek van stedelijke transformatieprocessen, die niet op conventionele manieren kunnen worden gestuurd of voorspeld, meer serieus nemen.

Het sturingscapaciteiten-perspectief biedt een eenvoudig conceptueel raamwerk dat *agency* ('wie'), de interactie met de sturingscondities ('hoe') en de uitkomsten en resultaten van sturing ('wat') met elkaar verbindt. Sturingscapaciteiten manifesteren zich in de collectieve vaardigheden van actoren om structurele sturingscondities te mobiliseren, creëren en veranderen, evenals de condities die hieruit voortvloeien die collectieve actie kunnen stimuleren of bemoeilijken. Zo faciliteert dit conceptuele raamwerk een lerende oriëntatie op hoe stedelijke (klimaat)sturing verandert en met welk doel, door een brug te slaan tussen de diverse actoren en activiteiten die verandering in sturing tot stand brengen, de sturingscondities die daaruit voortvloeien en of deze bijdragen aan het navigeren van stedelijke

transformatie in de context van klimaatverandering. Sturingscapaciteiten zijn actiegericht en *empowerend*. Door activiteiten op actorniveau te koppelen aan de manier waarop zij bijdragen aan het opbouwen van sturingscondities voor transformatieve klimaatsturing, is het mogelijk om vast te stellen welke kansen er zijn gecreëerd en benut, met welke uitdagingen rekening gehouden moet worden, welke capaciteiten missen en hoe capaciteiten kunnen worden versterkt.

Theoretische bijdrage: raamwerk van capaciteiten voor transformatieve klimaatsturing

Ik heb een raamwerk ontwikkeld van capaciteiten voor transformatieve klimaatsturing dat dient als een systematisch analytisch hulpmiddel om te deconstrueren hoe de activiteiten van actoren nieuwe sturingscondities creëren en om te evalueren of deze condities, en activiteiten, bijdragen aan transformatieve klimaatsturing. Het raamwerk is actiegericht en *empowerend* omdat het tevens in staat stelt om de condities te identificeren die nodig zijn om transformatieve (klimaat)sturing mogelijk te maken.

Het raamwerk onderscheidt vier kritische capaciteiten:

- **Zorgzame capaciteit (stewarding capacity)** gaat over anticiperen op en reageren op verstoringen, risico's en onzekerheid.
- **Ontsluitende capaciteit (unlocking capacity)** herkent en doorbreekt de mechanismen die onduurzame padafhankelijkheden in stand houden en aanpassingsvermogen inperken.
- **Transformatieve capaciteit (transformative capacity)** maakt de ontwikkeling van innovaties en de inbedding in structuren, culturen en werkwijzen mogelijk.
- **Orkestrerende capaciteit (orchestrating capacity)** creëert synergiën tussen klimaatsturing en andere beleidssectoren op verschillende schaalniveaus, in lijn met overkoepelende visies op duurzaamheid en veerkracht.

Empirische bijdrage: capaciteiten voor transformatieve klimaatsturing in Rotterdam en New York City

De case studies in dit proefschrift – Rotterdam en NYC – zijn voorbeelden van steden die wereldwijd leiderschap tonen en een norm stellen voor de adaptatie en mitigatie van de effecten van klimaatverandering. Dit doen zij door middel van ambitieuze en transversale klimaat-, duurzaamheids- en veerkrachtdoelstellingen en -agenda's en een portfolio van innovatieve en systemische oplossingen.. De case studies illustreren de toepasbaarheid van het theoretische raamwerk en genereren empirische kennis over hoe bestaande inspanningen op het gebied van klimaatsturing in steden worden ontwikkeld en aangepakt, of deze inspanningen ook nieuwe capaciteiten voor transformatieve klimaatsturing met zich meebrengen; en hoe de capaciteiten kunnen worden versterkt ten opzichte van bestaande sturingsregimes.

In beide steden zijn de vier capaciteiten voor transformatieve klimaatsturing in opkomst en manifesteren zich in nieuwe benaderingen en initiatieven die systemisch, langdurig, op leren gebaseerd en co-creatief zijn. Dit werd vooral gedreven door de integratie van klimaatmitigatie en -aanpassing binnen langetermijndoelstellingen en -strategieën voor duurzaamheid en veerkracht. Deze integratie weerspiegelt de erkenning dat klimaatmitigatie en -aanpassing moeten worden benaderd als kansen om de leefbaarheid en het welzijn te verbeteren en dat het om langdurige uitdagingen gaat, waardoor perspectieven op de lange termijn nodig zijn. Vanwege de lange termijn en geïntegreerde perspectieven zijn beide steden in staat om de behoefte aan systemische en radicale

veranderingen te benadrukken. Daarentegen is het in beide steden een uitdaging om verder te gaan dan het aanvankelijke momentum voor dergelijke veranderingen en de aanpak verder te verankeren in bestaand bestuur en planningsregimes.

Elke capaciteit manifesteert zich in diverse bestuurlijke condities, die werden gecreëerd als een resultaat van de activiteiten van verschillende actoren en die klimaatsturing een transformatief karakter geven: institutioneel (bijv. regelgevingsruimte voor experimenten), kennis (bijv. gezamenlijk ontwikkelde kennis over lange-termijn en systeemrisico's), netwerk (bijv. ondersteunende netwerken die mobiliseren voor verandering, bemiddelingsstructuren) en sociale condities (bijvoorbeeld gezamenlijk commitment voor langetermijnvisies). De activiteiten bieden gedetailleerde uitleg en overdraagbare lessen over hoe de verschillende condities zijn gecreëerd.

- **Zorgzame capaciteit:** In beide steden is er zorgzame capaciteit zichtbaar in initiatieven en plannen om enerzijds te beschermen tegen langetermijnrisico's en onzekerheden met betrekking tot overstromingen, storm en gezondheid en anderzijds om gelijkheid en welzijn te verbeteren. De zorgzame capaciteit wordt gekenmerkt door een verschuiving naar polycentrische, flexibele en op kennisgebaseerde benaderingen die lange-termijn en context-specifieke besluitvorming, planning en management mogelijk maken. Er zijn condities voor zorgzaamheid gecreëerd door een enorme hoeveelheid kennis te ontwikkelen over systeemrisico's en onzekerheden, geïntegreerde langetermijnplanning en planningsbenaderingen op meerdere niveaus vast te stellen en diverse sociale netwerken te ondersteunen.
- **Ontsluitende capaciteit:** Ontsluitende capaciteit is zichtbaar in Rotterdam en NYC in de identificatie en bewustwording van bronnen van emissies in connectie met bronnen van luchtvervuiling en geluidshinder, verspilling en ongelijkheid, en het creëren van nieuwe prikkels en voorschriften om niet-duurzame praktijken te beheersen en alternatieven ondersteunen. De capaciteit wordt gekenmerkt door een nieuwe kijk op institutionele 'sun-setting' om het concurrentievoordeel van business-as-usual geleidelijk af te bouwen en / of te verminderen. De condities voor ontsluiting worden primair gecreëerd door het afbouwen of het ontmoedigen van normaal gebruik en het creëren van ondersteunende netwerken en strategische allianties met een duidelijke missie voor verandering.
- **Transformatieve capaciteit:** Transformatieve capaciteit in Rotterdam en NYC komt tot uiting in de vele strategische, operationele, institutionele en organisatorische innovaties in de aanpak van klimaatmitigatie en aanpassing. Het toont zich in de toepassing van experimenten als een volwaardige sturingsaanpak die niet alleen de (continue) innovatie zelf omvat, maar ook reflectie en leren over wat de innovatie tot stand brengt in de beleids- en planningsmix (bijvoorbeeld voor replicatie, schaalvergroting). Condities voor transformatieve capaciteit werden gecreëerd door leiderschap dat gebruikmaakte van kansen voor verandering (bijv. orkaan Sandy), die ruimte bood voor experimenten (bijv. regelgevende en financiële ruimte), en door het innovatieverhaal te verspreiden om legitimiteit van en ondersteuning voor de innovaties en de experimentele aanpak te vergroten.
- **Orkestrerende capaciteit:** De capaciteit is duidelijk zichtbaar in beide steden in de stadsbrede lange-termijn- en geïntegreerde doelen voor klimaat, duurzaamheid en veerkracht en de grote verscheidenheid aan geneste, formele en informele instellingen, netwerken en communicatiekanalen die op verschillende niveaus van sturing zijn gevormd om de

activiteiten van meerdere actoren en netwerken te stroomlijnen en te coördineren. Orkestrerende capaciteit is van cruciaal belang voor het afstemmen en coördineren en het zorgen voor samenwerking door middel van systemische kennis en perspectief dat wordt ingebracht in andere afdelingen, sectoren, enz. door middel van formele en informele processen (bijvoorbeeld institutionalisering van duurzaamheid en veerkracht, interdepartementale taakgroepen, informele ruimtes).

De manieren waarop de sturingscapaciteiten worden gecreëerd en toegepast in Rotterdam en New York onderstrepen het uitgesproken multi-actor karakter van stedelijk klimaatsturing. Hoewel de lokale overheden, met name de Klimaat- en Duurzaamheidsbureaus in Rotterdam en het *Mayor's Office for Recovery and Resiliency* (ORR) en het *Mayor's Office for Sustainability* (MOS) in NYC, de belangrijkste actoren zijn die instaan voor het waarborgen van en toezicht houden op het klimaatbestendig maken van (veiligheids)maatregelen, zetten ze diverse netwerken en partnerschappen op om grensoverschrijdende en sectoroverstijgende implementatie mogelijk te maken. Daardoor zijn in beide steden een verscheidenheid aan publiek-private partnerschappen en netwerken uit diverse sectoren en op verschillende schaalniveaus, waaronder regionale en nationale kennisprogramma's, onderzoekspartnerschappen, samenwerkingsverbanden tussen onderzoek industrieën en private stakeholderplatformen, betrokken bij het genereren van kennis, het formuleren van strategieën en agenda's en het ontwikkelen van innovatieve oplossingen.

Ondanks de succesvolle ontwikkeling van meer geïntegreerde, multi-actor en experimentele benaderingen van stedelijke klimaatsturing in Rotterdam en NYC, zijn er verschillende tekortkomingen met betrekking tot hun potentieel om de outputfuncties na te komen. Over het algemeen vertegenwoordigen in beide steden de capaciteiten voor transformatieve klimaatsturing nog steeds niches binnen de algemene sturingsarchitectuur. Dit betekent een gebrek aan het mainstreamen en prioriteren van klimaatgerelateerde problemen in stadsbrede beleidsprocessen en planningsprocessen. Het merendeel van de bestaande stimuleringsstructuren en -regelingen begunstigen nog steeds economische belangen en investeringen op de korte termijn. Hierdoor dragen deze structuren en regelingen niet bij aan de bescherming tegen de risico's op de lange termijn noch aan de doorslaggevende uitfrasering van de oorzaken die ten grondslag liggen aan de emissies en onduurzaamheid. Dit bestendigt averechtse investeringen, bijvoorbeeld bouwontwikkelingen in gebieden die gevoelig zijn voor overstromingen en ondermijnt de bijdrage van innovatieve oplossingen aan de mix van beleid, omdat ze niet verbonden zijn met regulier beleid en planning.

En dan? Lessen over en aanbevelingen voor het transformeren van stedelijk (klimaat)sturing

De toetsing en empirische analyse van activiteiten en tekortkomingen in stedelijk klimaatsturing werpen met name de uitdaging op van hoe de integrale, multi-actor en experimentele aanpak van klimaatverandering, duurzaamheid en veerkracht kan worden ingebed in bestaande sturingsregimes. Het perspectief op capaciteiten en capaciteitshiaten in termen van zwakke of ontbrekende condities ten opzichte van bestaande sturingsregimes, maakt het mogelijk lessen te trekken over de belangrijkste condities die (moeten worden versterkt om) systemische, langetermijn- en innovatieve initiatieven voor klimaatsturing mogelijk te maken. Ik belicht vier kritische lessen uit mijn theoretische en empirische onderzoek naar pro-actief experimenterende steden. In deze lessen weerklinken de condities die fundamenteel de basis vormen voor transformatieve klimaatsturing. Ik stel dat deze verdere aandacht en investeringen nodig hebben om bestaande tekortkomingen aan te pakken en proactief capaciteiten te ontwikkelen voor transformatieve klimaatsturing om effectieve verandering

tot stand te brengen. De lessen zijn toekomstgericht: ik benadruk niet alleen de activiteiten en condities waarvan is bewezen dat ze werken, maar die een volgende stap zijn voor onderzoek en praktijk met het oog op bestaande tekortkomingen en lacunes.

- **Les #1:** Aangezien klimaatverandering een transversaal onderwerp is, zijn er probleemgestuurde benaderingen nodig die zich richten op meerdere interacterende en interfererende dynamieken en doelen. Bijgevolg zal de ontwikkeling van de capaciteiten voor transformatieve klimaatsturing de stedelijke 'klimaat'-sturing uiteindelijk overbodig maken en de (noodzaak tot prioritering van en bemiddeling tussen) synergieën en compromissen tussen beleidsdomeinen en doelen benadrukken.
- **Les # 2:** Orkestratie is van cruciaal belang voor het initiëren, mobiliseren, overzien en integreren van stedelijke (klimaat)sturingsprocessen, beslissingen en investeringen in overeenstemming met langetermijn-, systeem- en inclusieve doelstellingen, over schalen en sectoren heen. Orkestratie moet op doortastende wijze worden afgedwongen met 'harde' beleidsinstrumenten en regelgevingsraamwerks, en door investeringen in organisatorische capaciteit voor co-creatie en bemiddeling.
- **Les #3:** Transformatieve (klimaat)sturing in steden vereist het strategisch ontmantelen en vervangen van die aspecten van bestaande stedelijke sturingsregimes die korte-termijn en silo-gerichte besluitvorming bevorderen. Dit vereist ontsluiting van bestaande instellingen en actorennetwerken, evenals innovatie en verankering van nieuwe sturingsaanpak.
- **Les #4:** Uiteindelijk hangt de effectiviteit van transformatieve (klimaat)sturing af van ingrijpende veranderingen in marktstructuren, consumentenkeuzes en levensstijlen. Dit vereist sociale steun en betrokkenheid door het geven van een stem aan gemeenschappen en het bouwen van sociale netwerken en ondersteuning.

Dit proefschrift presenteert uiteindelijk een normatieve 'sturingsvisie' over hoe stedelijke sturing moet worden ontworpen om de urgente uitdaging van klimaatverandering binnen het volgende decennium aan te pakken en een betere toekomst op te bouwen die nieuwe kansen biedt voor het welzijn van mens en milieu. Het ontwikkelen van transformatieve klimaatsturing capaciteiten in steden impliceert dat stedelijk klimaatsturing zelf transformatief werkt, omdat het korte metten maakt met bestaande stedelijke sturingsparadigma's en geïnstitutionaliseerde benaderingen die beslissingen beperken tto sectorale silo's, de voorkeur geven aan korte-termijnbeleid en -interventies en sturing en planning beschouwt als 'losstaande' processen die stedelijke verandering kunnen controleren en dirigeren.

Of een (sturings)visie op duurzame en veerkrachtige stedelijke en mondiale toekomsten kan worden bereikt, en meer specifiek of de capaciteiten om dit te doen zullen worden gecreëerd, hangt in grote mate af van het bestaande politieke systeem en de houding van mensen die politieke leiders kiezen. Wat ik hoop dat het capaciteitenraamwerk en de opgedane empirische inzichten toevoegen aan deze visie is het leiden van concrete reflectie over hoe de condities te co-creëren voor het gezamenlijk ontwikkelen en actief werken aan gedeelde visies.