Nature-based solutions in cities

MSc thesis

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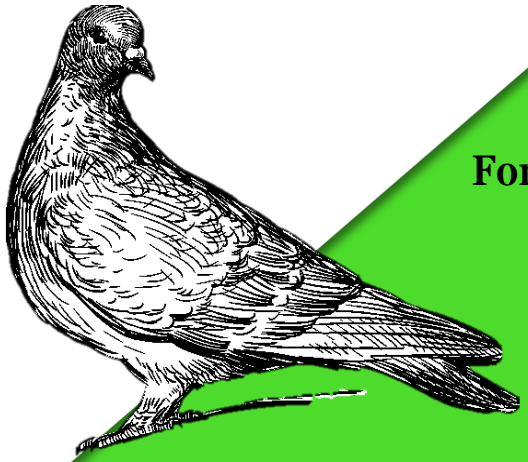

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"The struggle for a sustainable planet will be won or lost in our cities."

- Carina Borgström-Hansson, WWF

"Let nature work with you instead of trying to work against nature."

- Chunga Cha, KGBC

Summary

Nature-based solutions show to have a lot of potential, both in climate change mitigation and adaptation, and in addressing other environmental and societal issues. Regardless of this potential, implementation of nature-based solutions in cities often remains lacking or is unsuccessful. This research aims to investigate the causes of this limited implementation, and to look for ways in which implementation is improved or encouraged by a variety of actors. Two studies are conducted to achieve these objectives: a detailed case-study of Rotterdam and a more holistic study about the international context of nature-based solutions in cities. These studies are analysed using two different approaches: the first one is discursive institutionalism, trying to understand policy instrumentation by looking at discourse, in this study in form of storylines. The second is by looking at more mainstream policy implementation studies. This is done by investigating how challenges in implementation are solved in practice by using policy instruments.

The study shows a variety of links between nature-based solutions and the themes of climate change, the natural environment, the economy, and security. Climate change is the most important incentive to adopt nature-based solutions; however, solutions aiming for adaptation are more popular in both developed and developing countries, regardless of the necessity for climate change mitigation. The natural environment is a theme closely related to nature-based solutions, but ecological values are often not maximised due to departmentalisation within governments, lacking ecological knowledge and shared vision. Both the situation regarding the economy and security of a country are defining in the extent a city prioritises the use of nature-based solutions; overall, improved situations lead to more implementation, regardless of the potential nature-based solutions have for improving food, water, and livelihood security of inhabitants. An important finding of the study is the necessity to design nature-based solutions based on both the biophysical and social characteristics of the city, in order to maximise the positive effects on the city as a whole.

Based on the results of the study, a new categorisation of policy instruments used to increase the effective implementation of nature-based solutions is made. This categorisation combines instruments used by and affecting (inter)national and local governmental organisations, third-party organisations, and the public. The relations between actors is central in this categorisation, making it an addition to categorisations in literature which often only describe instruments used by one type of actor. The study shows that policy instrumentation can best be understood by using both a discursive approach and a more traditional approach. This more traditional approach combines problem and solution in a causal way, finding the most effective solution by understanding the goal of the instrument and the effects and applicability on the ground. Discourse, on the other hand, shows to be defining what the relations are between actors in policy instrumentation, both in scale and nature of the instrument. Together discourse and the more traditional approach can explain the underlying relations of policy instrumentation, specifically for implementation of nature-based solutions.

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List of keywords

Climate change adaptation: changes in social-ecological systems in response to actual and expected impacts of climate change, aiming to moderate harm or exploiting beneficial opportunities (Moser & Ekstrom, 2010).

Climate change mitigation: combatting climate change by addressing the causes of the problem, for example by decreasing emissions of greenhouse gasses (Grimm et al., 2008).

Climate security: a concept that emerged after the newly discovered link between climate change and the security of inhabitants, putting climate change higher on the international peace agenda (McDonald, 2013).

Discourse analysis: the examination of argumentative structures in documents and other written or spoken statements (Hajer, 1997), aiming to understand the social world by means of ideational and symbolic systems and orders (Arts & Buizer, 2009).

Discursive institutionalism: an approach that looks at how institutional practices are influenced by policy discourse (Arts & Buizer, 2009).

Ecosystem services: connecting ecology with economy and human well-being by looking at benefits people receive from ecosystems (Maes & Jacobs, 2017). Ecosystem services are divided in supporting services, provisioning services, regulating services, and cultural services (Raymond et al., 2009).

Environmental justice/equity: an equal distribution of and access to nature among all population groups (Wolch, Byrne, & Newell, 2014).

Green infrastructure: green zones in and around cities, providing ecosystem services (Maes & Jacobs, 2017); every natural area that is under a city's management and a municipality's responsibilities.

Grey infrastructure: infrastructure predominantly composed of concrete and steel (Dong, Guo, & Zeng, 2017).

Heat island effect: the phenomenon causing the air and surface temperatures in cities to be higher than those in rural surroundings (Bowler, Buyung-Ali, Knight, & Pullin, 2010).

Nature-based solutions: adding or improving urban green infrastructure, aiming to address problems related to for example climate change and food security. Ways to tackle challenges inspired by, supported by, or copied from nature (Kabisch, Korn, Stadler, & Bonn, 2017). They bring benefits to people and nature itself, and are sustainable and responsive to environmental change and hazards in the long-term (Eggermont et al., 2015).

Path dependency: a phenomenon where policy makers are adapted to certain issues and activities over time, making them reluctant to adopt new imperatives to tackle the issues at hand (Matthews, Lo, & Byrne, 2015).

Storylines: simplified interpretations of more complex discourses through the selection of certain components (Smith & Kern, 2009).

Sustainable development: development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland, Khalid, Agnelli, & Al-Athel, 1987).

Traditional solutions: in this study traditional solutions are defined as solutions to problems related to climate change that include the use of grey infrastructure, rather than the use of green or blue infrastructure.

Urban resilience: adaptation of urban areas to cope with effects of climate change and to be prepared to address the threats head-on (Gill, Handley, Ennos, & Pauleit, 2007).

Introduction

The International Panel on Climate Change stated in the first climate change assessment, in 1990, that *human activities may be inadvertently changing the climate of the globe through the enhanced greenhouse effect, by past and continuing emissions of carbon dioxide and other gasses which will cause the temperature of the Earth's surface to increase* – popularly termed "global warming" (Houghton, Jenkins, & Ephraums, 1990). Now, a rough 30 years later, the climate is almost undeniably changing, resulting in elevating temperatures, rising sea levels and extreme weather events. These events can be related to both heavy precipitation, like floods, storms and hurricanes, and to a lack of precipitation, like heat waves and extreme droughts (Younger, Morrow-Almeida, Vindigni, & Dannenberg, 2008).

Changes in climate have a significant impact on humans, in rural areas but also in cities, which are the focus of this study. Cities are dependent on importation of food and other resources from the surrounding rural areas; therefore, if climate change affects these areas and the production of resources decreases, inhabitants of cities will be affected as well (Hunt & Watkiss, 2011). But also considerable direct effects of climate change are experienced in urban areas (Kabisch et al., 2017). Models show that regions of high population growth coincide with regions of high urban heat island potential – meaning that air and surface temperatures in cities are often higher than those in rural surroundings (Bowler et al., 2010; Grimm et al., 2008). This results in an increase in temperature up to more than twice as large as from climate change alone (McCarthy, Best, & Betts, 2010).

The effects of climate change in urban areas pose threats to human health (Hunt & Watkiss, 2011) and environmental justice (Demuzere et al., 2014), for example by decreasing food yield (Kabisch et al., 2017; Younger et al., 2008) and water supply (Grimm et al., 2008; Hunt & Watkiss, 2011; Kabisch et al., 2017), and by increasing the risk of (forest) fires (Kabisch et al., 2017). Heat waves influence human health as they are linked with heat stroke, hyperthermia (Bowler et al., 2010), causing an overall higher mortality rate (Bowler et al., 2010; Norton et al., 2015; Younger et al., 2008). Additionally to the effects of heat, coastal cities – about 65% of all cities with more than 5 million inhabitants worldwide – are exposed to rising sea levels and increased hurricane frequency (Grimm et al., 2008; Hunt & Watkiss, 2011). Lastly, climate change affects urban built infrastructure, causing increased strains on materials and equipment, higher peak electricity loads and transport disruptions when a weather event occurs (Jabareen, 2013).

The biophysical characteristics of urban areas increase the effects of climate change. Vegetated areas that provide shading, evaporative cooling and rainwater interception are often replaced by built surfaces (Gill et al., 2007). Asphalted surfaces lead to an increased surface runoff, transported via storm-water pipes, leaving little moisture in the urban landscape (Gill et al., 2007; Matthews et al., 2015). This, and the lack of vegetated areas in general, leads to a decrease in evaporative cooling, with rising temperatures (Gill et al., 2007; Norton et al., 2015) and a higher risk of floods as a result (Hunt & Watkiss, 2011). To decrease these effects, a new concept is on the rise: urban resilience.

Urban resilience to climate change

The worldwide urbanisation rate is continuously increasing: 95% of global population growth is taking place in cities in the developing world (Grimm et al., 2008). This results in an estimated 6 billion urban dwellers in 2050 (McCarthy et al., 2010). Because of this, the adaptation of urban areas to cope with the effects of climate change and to be prepared to address the threats head-on becomes increasingly important (Gill et al., 2007; Jabareen, 2013; Matthews et al., 2015). In other words, cities need to become more resilient towards climate change, as they are extra vulnerable to the effects of climate change and house a large part of the global population. To achieve this urban resilience, it is essential for cities to adopt both mitigation and adaptation strategies (Grimm et al., 2008; Hunt & Watkiss, 2011).

With the emergence of the concept of urban resilience, increasing attention is also given to addressing climate change mitigation – addressing the causes of climate change – on a regional city scale. A main reason for this is that urban centres, especially those in the developed world, are the primary source of greenhouse-gas emissions (Grimm et al., 2008). The UN Intergovernmental Panel on Climate Change has described the relationship between the existence and growth of multiple sectors that are often found in cities, and the continuously changing climate. These sectors include energy supply, transportation, industry, land use, and agriculture (Younger et al., 2008). Additionally, energy use in cities is relatively high due to high densities of businesses and residents, yet it will only increase due to a climate change induced larger need for cooling and heating (Hunt & Watkiss, 2011). Designing and implementing possible responses to climate change becomes more relevant on the city-level, as the risks (and opportunities) are more relevant to local public and private actors (Hunt & Watkiss, 2011).

Used mitigation strategies in cities include expansion of the provision of renewable energy (Byrne & Jinjun, 2009), decreased use of motor vehicles, and increased energy efficiency in buildings (Younger et al., 2008). Adaptation strategies include the improvement of coastal retreat and the better integration of emergency service responses into planning systems (Byrne & Jinjun, 2009; Matthews et al., 2015). However, a new concept in addressing the issue of climate change, both in mitigation and adaptation, is becoming increasingly popular, using urban nature to make cities more climate change resilient: nature-based solutions.

Green infrastructure and nature-based solutions

A new paradigm has emerged, believing that humans are no longer isolated from nature in unsustainable exploitation of resources, but co-exist with nature while wisely using ecosystem services. This paradigm results in more awareness regarding nature's benefits to human wellbeing and the necessity to protect and conserve green spaces (Kronenberg, 2016). This trend is also seen in urban areas, where increased attention is paid to the potential role of green infrastructure (Bowler et al., 2010; Demuzere et al., 2014; Gill et al., 2007). Green infrastructure is identified as

green zones in and around cities, providing ecosystem services (connecting ecology with economy and human well-being by the benefits people receive from ecosystems, including food production and recreation (Maes & Jacobs, 2017). In this study, green infrastructure is perceived as every natural area that is under a city's management and a municipality's responsibilities. This includes both green spaces within the city, as well as in the close city surroundings.

Improving and adding to urban green infrastructure supports biodiversity conservation (Demuzere et al., 2014; Kabisch et al., 2017), which is important as the ongoing urbanisation trend will put ever-greater demands on nature's ecosystem services (Grimm et al., 2008). Therefore, green infrastructure gains attention in the policies of cities that are trying to address problems related to sustainability and the environment (Foster, Lowe, & Winkelman, 2011). To reframe policy debates on matters related to the environment and sustainability – such as biodiversity conservation and climate change adaptation and mitigation –, the concept of nature-based solutions (NbS) is introduced (Potschin et al., 2015). With nature-based solutions, urban green infrastructure is improved or added in urban areas in order to address (environmental) problems, including problems related to climate change and food security. They are defined as ways to tackle challenges that are inspired by, supported by, or copied from nature (Kabisch et al., 2017). These solutions bring benefits to people and nature itself, and are sustainable and responsive to environmental change and hazards in the long-term (Eggermont et al., 2015).

Because of high potential benefits and co-benefits, nature-based solutions are often seen as a more efficient and cost-effective way to address climate change threats (Kabisch et al., 2017). Problems with flooding, for example, are nowadays often solved by using urban grey infrastructure, like large-storage detention tanks. A solution like this is pursued at great cost and is only serving the purpose of water management (Gaffin, Rosenzweig, & Kong, 2012). Nature-based solutions can be used for water management, while providing additional ecosystem services that benefit health and wellbeing of both humans and nature (Eggermont et al., 2015).

The multi-problem-solving capacity of nature-based solutions is perceived as a way to solve the ongoing debate between the interests (and continuing growth) of the economy and the environment (Matthews et al., 2015). The solutions based on new or improved green infrastructure are relatively quick to implement, are comparatively inexpensive and may seem more appealing to the public than traditional solutions based on grey infrastructure (Matthews et al., 2015). Examples of nature-based solutions are green roofs and walls (Demuzere et al., 2014; Gill et al., 2007; Kabisch et al., 2017; Norton et al., 2015), green spaces (e.g. parks) (Demuzere et al., 2014; Gaffin et al., 2012; Kabisch et al., 2017), street trees (Gaffin et al., 2012; Gill et al., 2007; Kabisch et al., 2017; Norton et al., 2015), open green spaces (e.g. sporting fields and golf courses; Norton et al., 2015), green railway lines, and greenways (or green streets; Gaffin et al., 2012; Gill et al., 2007).

Developed versus developing cities: climate security

Existing research on the implementation of nature-based solutions has mainly focused on cities in developed countries (e.g. the United Kingdom (Hunt & Watkiss, 2011; Matthews et al., 2015), the United States (Byrne & Jinjun, 2009; Hunt & Watkiss, 2011) and Australia (Norton et al., 2015)). However, one may argue that highest priority for research should be given to the urban areas where the vulnerability of the population is highest (Gill et al., 2007). These highly vulnerable areas are defined by a population that grows faster than the physical capacity of the city, an adaptation deficit to climate change, and great (future) exposure to the effects of climate change (Hunt & Watkiss, 2011; McCarthy et al., 2010). Examples are regions like the Middle East, North and South Africa and Western Asia (McCarthy et al., 2010). With the continuously changing climate, it becomes urgent for cities in these regions to become more resilient.

A growing number of scientific studies explore the link between climate change and the risk of acts of violence (e.g. Barnett & Adger, 2007; Scheffran, Brzoska, Kominek, Link, & Schilling, 2012). This led to the emergence of the concept of climate security (McDonald, 2013). The threat to national security puts climate change mitigation higher on the international peace agenda. This also means that cities in more developed countries should no longer overlook the importance of climate change mitigation, as the main challenges that these cities face – for example linked to security of food and livelihood – are linked to the changing climate. This does not necessarily have to lead to a drastic shift in policy: studies show that simultaneously mitigating near-term climate change and improving human health and food security is a possibility, for example by cutting emissions of certain greenhouse gasses (Shindell et al., 2012). Additionally, conflict is often induced by economic inequalities and poverty, which can be caused by falling agricultural productivity and a growing scarcity of water due to environmental degradation and climate change (Stewart, 2002). As a result, nature-based solutions can be a part of tackling the problems causing these inequalities, contributing to solving conflict at the source.

Perceptions and storylines

Four themes are discussed in the previous paragraph, appearing to be important when discussing both the potential of and the factors hindering the use of nature-based solutions: climate change, the natural environment, the economy, and security. These are the themes that are used in this research to investigate how nature-based solutions are perceived by a variety of actors. The way actors perceive things are based on how an individual observes, understands, interprets, and evaluates a phenomenon. Perceptions are related to beliefs, attitudes, values, norms, preferences, and motivations (Bennett, 2016). To properly analyse these perceptions, the study focusses on storylines that link nature-based solutions with the previously mentioned themes; these are defined as simplified interpretations of more complex discourses that actors use to impose their view of reality on others (Brink & Metze, 2006). For more information on discourse and storylines, see the theoretical framework of the research.

Challenges hindering implementation

Ever since nature-based solutions gained attention in environmental policy, multiple studies are done on the potential effects of green infrastructure and NbS, both regarding biophysical features and social benefits (Bowler et al., 2010; Foster et al., 2011; Gaffin et al., 2012). Regardless of these studies and the increasing awareness of the importance of improved urban resilience to climate change, actual implementation of nature-based solutions is still lacking (Matthews et al., 2015). In fact, there is a decreasing trend in green spaces in cities all over the world, both in developed and developing countries (Haaland & van den Bosch, 2015). Matthews et al. (2015) tries to understand this lacking implementation by looking at challenges, dividing them in political challenges, management challenges, societal challenges, and biophysical challenges.

The first category, political challenges, includes challenges regarding the political context and structures of governance in which planning decisions are made, influencing successful implementation of NbS in the decision-making phase (Byrne & Jinjun, 2009). For example, some political challenges, like a lack of awareness among policy makers about the high-quality benefits of NbS (Cilliers, Cilliers, Lubbe, & Siebert, 2013; Kabisch, 2015; Kabisch et al., 2017), can result in policy makers to choose for conventional techniques, rather than to look further at the benefits of green infrastructure (Maes & Jacobs, 2017). This is called path dependency: policy makers being adapted to certain issues and activities over time, making them reluctant to adopt new imperatives to tackle the issues at hand (Matthews et al., 2015). Additionally, due to a variety of governmental responsibilities, urban green areas often have to make way for other urban development projects, including the creation of housing, industrial areas, and grey infrastructure (Haaland & van den Bosch, 2015). A real economic incentive for planners to preserve green infrastructure is lacking, while there are often no strict regulations to prevent its removal (Haaland & van den Bosch, 2015). To increase implementation of NbS, larger temporal and spatial scales should be considered in the policy-making process, as well as the integration of diverse values and benefits for society that NbS have to offer (Maes & Jacobs, 2017).

The second category, management challenges, includes factors that influence the management of nature-based solutions after implementation (Byrne & Jinjun, 2009). An example is related to the disconnect between short-term actions and long-term policy goals: green infrastructure may be improved to reach short-term goals, but responsibilities, human resources, and funding for maintenance often remain unspecified in the long-term (Cilliers et al., 2013; Kabisch, 2015; Kabisch et al., 2017). An increase in local government responsibilities may put NbS further down the policy agenda, resulting in a lack of budget for implementation (Byrne & Jinjun, 2009). Another management challenge resulting in ineffective implementation of NbS, especially in smaller cities, are the low levels of environmental and management expertise, as well as resources for improving green infrastructures (Cilliers et al., 2013).

The third category, societal challenges, consists of challenges about public involvement. The perceptions of the public on the costs and benefits of green infrastructure are based on personal experiences and on how green spaces are perceived (Matthews et al., 2015). They are of great influence on decision-making processes (Byrne & Jinjun, 2009). Nature-based solutions have a potential for win-win situations, where environmental, social, and economic interests are met while also promoting sustainability; however, trade-offs will have to be made between the ecosystem and stakeholders' expectations (Eggermont et al., 2015). There is a need to ensure participation of public stakeholders in green space planning (Eggermont et al., 2015; Kabisch, 2015), as well as to communicate all strategies to all actors that may be affected by a policy (Kabisch, 2015). Research shows that residents do not necessarily value ecosystem services as important (Cilliers et al., 2013), causing a necessity to improve these perspectives in order to gain more public support. Another societal challenge is that urban areas with low green space cover are often inhabited by residents with lower socio-economic statuses (Haaland & van den Bosch, 2015). Making the distribution of and access to nature more equal among different areas with a city is therefore desirable.

Challenges in the fourth category are related to the biophysical characteristics of the built environment (Byrne & Jinjun, 2009). Examples are trade-offs in implementation and maintenance (Demuzere et al., 2014), like the need for irrigating vegetation when water supplies are low (Gill et al., 2007), and a disconnect between urban design visions and the biological and physical possibilities of a city (Norton et al., 2015). For example, narrow footpaths, traffic constraints and a lack of sunlight caused by high buildings make the creation of green spaces difficult, as well as the existence of bad soils, heavily wired with cables and pipes (Haaland & van den Bosch, 2015). Improving the biophysical conditions is therefore important to support effective implementation and maintenance of nature-based solutions.

Problem statement, research objective and research questions

Problem statement

Using nature-based solutions in cities to increase resilience to climate change has well-researched benefits, yet the implementation remains lacking or is not successful in most cities. Especially in developing countries, nature-based solutions are not used to their full potential for climate change mitigation and adaptation. Regardless of this wasted potential, little research is done on what hinders successful implementation (Matthews et al., 2015). Understanding the factors that influenced implementation of nature-based solutions in the past may lead to more successful implementation in the future. Additionally, very little research is done on how implementation of nature-based solutions differs in various parts of the world. This while the differences in priorities between cities may lead to differences in how nature-based solutions are used.

To fill this knowledge gap, the research focuses on both how nature-based solutions are perceived by a variety of actors, and on which challenges make implementation difficult. This is done by doing two studies: a case-study and an international study. Looking at these factors can give a better view on why nature-based solutions are or aren't used in city planning, and how issues regarding the economy, security, climate change, and the natural environment relate to this. Answering these questions will not only shed light on the troublesome implementation of nature-based solutions, it also has the potential to open new doors and raise awareness to ways of addressing problems related to climate change and national security in an integrated, sustainable manner.

When more is known about why implementation of nature-based solutions is often lacking, the question remains how these challenges can be addressed. Little existing research focusses on the instruments that are used in practice to implement nature-based solutions, and how these instruments are selected and designed. Therefore, this study aims to give an overview of policy instruments, and to add to the ongoing debate about the selection of policy instruments.

Research objective

The research aims to understand the unsuccessful implementation of nature-based solutions in cities. This is done by assessing the ways nature-based solutions are perceived by varying actors, related to a variety of societal and environmental issues. Based on this research, new insights could be drawn on how to reframe nature-based solutions, which has potential to make nature-based solutions more well-known and used in practice. Additionally, the research aims to identify the most important challenges in implementation. Lastly, the research explains policy instrumentation for implementation of nature-based solutions by identifying the variety and investigating the selection of policy instruments that are used. A clear overview of possibilities in this regard could help cities tackle similar challenges, supporting successful implementation of nature-based solutions worldwide.

Research questions

To address the problem as discussed in the introduction, the research aims to answer a main research question: *what hinders the successful implementation of nature-based solutions in cities, and how are policy instruments designed and selected to improve implementation?* To answer this research questions, three sub-questions are conducted:

- What storylines shape perceptions of nature-based solutions in cities from varying actors, and how do these storylines connect nature-based solutions to the themes of climate change, the natural environment, the economy, and security?
- What are the most important challenges hindering implementation of nature-based solutions?
- What policy instruments are used in practice to implement nature-based solutions, and what determines instrument selection?

Theoretical framework

Discourse analysis

Research shows that managers may be aware of the benefits of nature-based solutions in urban areas but that these are not used due to cuts in municipality budgets, unawareness and differing government responsibilities (Byrne & Jinjun, 2009). This leads to path dependency and inaction, leaving the potential of NbS in strengthening urban resilience unexploited. The views of policy makers and other relevant actors on nature-based solutions are crucial for successful implementation, as this is the level on which decisions regarding city planning are made. Institutional analysis is too narrow to identify how certain policies come into being, as it does not explain how differences in perceptions, resulting in for example ideological conflicts and power relations, influence policy-making and implementation (Jacobs, 2006). Additionally, in institutional analysis the role of ideas in changing policies is completely ignored, only trying to explain these changes with the rationalist argument that policy makers only define success by looking at the "effectiveness on the ground" of the policy (Arts & Buizer, 2009).

To approach the research questions, the theory of discourse analysis is used. This is defined by Hajer (1997) as the examination of argumentative structures in documents and other written or spoken statements, as well as the practices through which these utterances are made. Arts & Buizer (2009) add to this that discourse analysis aims to understand the social world by means of ideational and symbolic systems and orders. It's based on the belief that history and humans are driven by knowledge production and (collective) interpretation of the world, rather than by objective interests, social norms and rational calculations (Arts & Buizer, 2009). These knowledge and interpretations are transferred from one person to another using language; with discourse analysis, it becomes possible to get a better understanding of the policy process by looking at the language of communication. It explains how this is used to pursue political and organisational objectives, and how it affects the interpretation of policy documents by audiences (Jacobs, 2006).

The argumentative structures from the definition of Hajer (1997) are called discourses, which he defines as an ensemble of ideas, concepts and categories through which meaning is given to social and physical phenomena. Discourses are produced and reproduced through an identifiable set of practices (Hajer in Brink et al., 2006). They form the linguistic level in which social action and exchange of stories, plans, questions and answers take place (Linde, 1986). A discourse is typically used to structure the contributions of participants to a discussion, allowing for a better understanding of controversies in terms of argumentative rationality that people bring to said discussion (Brink & Metze, 2006). However, it should always be conceived of as an interrelation with the wider context – the practices in which the discourse is produced, reproduced and transformed (Brink & Metze, 2006; Linde, 1986). A discourse includes not only the spoken or written ideas and text, but also the explicit representation of the ideas – how it's said –, the context in which these are transferred – where and when things are said –, and the agency – who said it to

whom (Schmidt, 2008). A discourse is often shared by a group of actors, sharing an identifiable set of practices and a set of storylines to express the discourse, all over a given period of time. This group of actors is called a discourse coalition (Brink & Metze, 2006).

Storylines in discourses

How a (political) problem is defined relates to the particular narrative in which it is discussed (Brink & Metze, 2006). A narrative is defined as a recapitulation of past experience and its meaning (Linde, 1986). These narratives are, when discussing them, summarised in storylines: simplified interpretations of more complex discourses through the selection of certain components (Smith & Kern, 2009). Storylines are a medium that actors use to impose their view of reality on others, suggesting certain social positions and practices (Brink & Metze, 2006). They frame issues by presenting ways in which they should be understood and tackled, according to the communicator (Smith & Kern, 2009). Discourse coalitions adhere around storylines, adding to their development and contributing towards the institutionalisation of them in changed policy practices (Smith & Kern, 2009). However, actors in a coalition do not always have the same interpretation of the same storyline; in fact, interpretive flexibility of storylines is essential for the forming of coalitions (Hajer, 1997). Storylines combine elements of varying discourses and backgrounds into one whole; because of this, storylines explain how people from varying backgrounds still find ways to communicate with each other (Brink & Metze, 2006). Discourse coalitions will try to find ways to further sustain, reproduce and contest specific understandings of a policy problem, in order for the discourse to persist and grow (Teräväinen, 2010).

However, in order for storylines to make a change in policy, institutionalisation – the translation into (binding) norms and rules – is key (Smith & Kern, 2009). Incidents or crises can undermine the legitimacy of current policies, which results in the opening-up of space for other perspectives, casting the existing institutions in a different light (Smith & Kern, 2009). This emergence of new storylines can re-order understandings, resulting in policy development and political change (Hajer, 1997). Because of this, policy storylines can be used as a device to analyse how discursive developments influence policy, and how policy actors construct meaning around problems and act upon them (Smith & Kern, 2009). The translation of (parts of) discourses into institutions is called discursive institutionalism; this will be discussed in the next paragraph.

Discursive institutionalism

According to Hajer (1997), current institutions embody the discursive developments of the past, and institutional power is continuously reproduced through discourse. The political debate often draws on many different discourses. However, when a discourse coalition succeeds more in promoting their understanding of the world than others, certain discourses can become dominant (Brink & Metze, 2006). This may lead to interests of certain (groups of) actors to become more or less represented in policy responses (Detraz & Betsill, 2009). For a discourse to become dominant,

there are two conditions that should be met: the condition of discourse structuration and the condition of discourse institutionalisation. The first means that the discourse dominates the way actors in a given social unit conceptualise the world. The latter means that the discourse is reflected in institutional practices and that policy process is conducted according to the ideas of the discourse (Brink & Metze, 2006).

Analysing discourses and whether they meet the condition of institutionalisation can be done using a discursive-institutional approach. This approach has a couple of beliefs regarding the relationship between actors and institutions: current institutions form a constraining context in which actors think, speak and act. However, this context can be changed by the same actors' thoughts, words and actions, framing a new discourse and being translated into new institutions (Schmidt, 2008). It is a way of reflecting on abrupt institutional change and crisis, by looking at how institutional practices are influenced by policy storylines and associated signposts for action, derived from policy discourses (Arts & Buizer, 2009; Hajer, 1997). Scholars using this approach believe that institutional dynamics originate from the emergence of new ideas, concepts and narratives in society. These are institutionalised in social practices, which enables them to affect social outcomes (Arts & Buizer, 2009). It is a new way of looking at institutions, shedding new light on the functioning, power structures and changes of institutional arrangements (Hajer, 1997).

Discursive institutionalism is an umbrella concept for a range of approaches to the study of institutions. The approaches vary in their theoretical and methodological understanding of the relations between ideas, discourses and institutions.

Policy instrument selection

An often answered question in policy research is on what basis the selection of policy instruments is made: whether they are selected by actors according to the discourse they support, making it a subjective and socially constructed practice, or if the more traditional goal-means-rationality approach is used, making it neutral and apolitical (Lauber & Schenner, 2011). Traditionally, policy instruments were perceived as neutral or apolitical; multiple authors, including Droste et al. (2017) and Wamsler et al. (2017), describe the choice of policy instruments based on the goals that need to be met – like the need for information or overarching integration into decision-making (Droste et al., 2017). In this way, understanding instrument selection is done by combining problem and solution in a causal way. This is a rationalist approach based on goal-means-rationality, making it neutral and apolitical (Lauber & Schenner, 2011). Using this approach, success of an instrument is based on the effectiveness of the instrument on the ground (Arts & Buizer, 2009).

With the rise of the discursive institutionalist theory, new beliefs have evolved, including that policy instruments have other structuring effects differing from the actual goals of the instruments (Halpern, 2010), and that their selection is influenced by political and ideological characteristics. In other words, that they are selected by actors by following the line of thought of the discourse that

they support, making the selection of instruments a subjective, socially constructed practice (Lauber & Schenner, 2011).

According to multiple authors, including Burby (2013); Halpern (2010); Lascoumes & Le Gales (2007); Lauber & Schenner (2011), discursive institutionalism is currently the most accurate way to explain policy instrument selection. Lascoumes & Le Gales (2007) state that policy instruments have an effect of their own, allowing to explain policy change by looking at its instrumentation. Frantzeskaki, Borgström, Gorissen, Egermann, & Ehnert (2017) support this with an example, stating that the transition from the passive experience "of nature", to an active experience of "with nature" has resulted in local nature-based initiatives and the creation of new narratives and understandings of nature-based solutions. In this study, that would mean that not (only) potential challenges in management, politics, etcetera, are of influence in the selection of policy instruments, but also the way in which nature-based solutions are perceived. These perceptions are translated into storylines, which are one of the subjects of analysis in this study.

In short, literature is not unanimous about what approach is most relevant for explaining policy instrument selection. This study will aim to combine both the rationalist approach and discursive institutionalism to explain policy instrument selection, and to (partly) answer the question which approach is important in explaining this process.

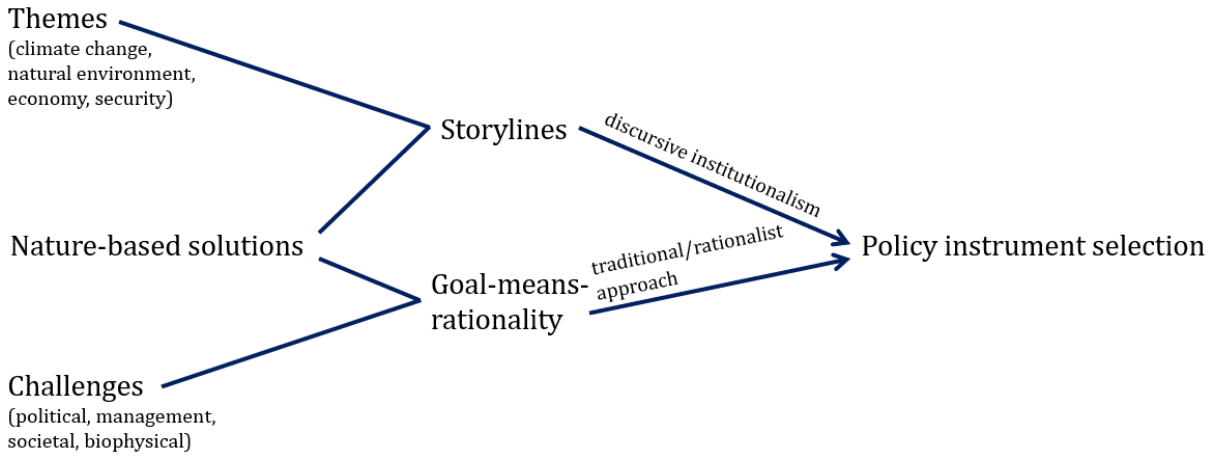

Figure 1 Visual representation of the theoretical framework, showing the two approaches to explain policy instrument selection used in this study.

Methodology

As the study aims to explore reasons behind the lack of implementation of nature-based solutions in cities by doing discourse analysis, using a qualitative approach – describing trends or patterns by using words (Hancock & Algozzine, 2006) – is considered most suitable. The research is done in two parts: a literature research and a review of two distinct studies. The study is designed using the guidelines as described by Hancock & Algozzine (2006), in their book *Doing Case Study Research*. They distinguish nine stages in doing a study: setting the stage (1), determining what we know (2), selecting a design (3), gathering information from interviews (4), observations (5; however, this stage is not used in this study), and documents (6), summarising and interpreting the information (7), reporting findings (8), and confirming case study findings (9). The methodology of this study will be explained using these guidelines.

Setting the stage

The research investigates whether cities have implemented nature-based solutions or not, how this (lack of) implementation relates to issues regarding security, economic situation, climate change and the natural environment, and to describe and explain instrument selection to increase implementation. To do this, two studies are conducted: one in-depth case-study of Rotterdam, in the Netherlands, and an international study. The case-study is done to provide detailed information, allowing to interview multiple actors within one city. The findings from this case study are supplemented by the findings of the international study, providing information of how nature-based solutions are perceived from a more holistic level, by interviewing actors working in different parts of the world. By using this approach, information from multiple countries, including for example both developed countries and developing countries, can be combined into one research.

For the case-study, the Dutch city Rotterdam is selected. To compare a well-developed city with cities in countries with other countries, where priorities related to climate change, the natural environment, the economy, and security may differ, the international study is conducted. A city is a complicated research unit, with a lot of different processes and actors that have influence on how the city functions. Exclusively using a holistic approach, only examining the global nature of the city, would lead to a vision that is too abstract, as this approach does not allow for examination of specific phenomena in an operational detail (Yin, 2003). In other words, the holistic approach of the international study compliments the more city-specific results of Rotterdam with more general assumptions about nature-based solutions.

Determining what we know: the literature research

To provide a broader, theoretical background for the research and the conceptual foundation for the study, a literature research is conducted. This is done by reading scientific articles and books,

which are obtained from the sources Google Scholar and the Wageningen UR library. The literature research is done for a variety of reasons.

First, the literature research provided the background information that is needed to do a well-informed, in-depth study. It provided information on the possibilities and advantages of nature-based solutions, and on how they are implemented in practice. Additionally, the policy issues reviewed in this study – regarding climate change, the natural environment, the economy, and security – are further studied. Second, the study aims to explore possible challenges in implementing NbS. It is useful to explore what information already exists on this topic, as this will provide a basis for later stages in the thesis. Third, a basis for the second and third research question is provided by literature. This is done in order to be able to select relevant actors to interview, and to provide sufficient background information to make interviews as efficient and informative as possible.

Selecting a design: the case study design

In this section the case study is further characterised, based on case study literature. The study is sociological: it focuses on society, institutions and social relationship to examine the structure development, interaction and (collective) behaviour of an organised group of individuals (Hancock & Algozzine, 2006). Secondly, the study is explanatory: it aims to explain causal links in real-life situations (Baxter & Jack, 2008). In this case, the explained link is the effect of both policy issues and challenges on the implementation of nature-based solutions in cities. The objective of the study is to compare the different explanations and to indicate how these may apply to other situations as well (e.g. in other cities) (Yin, 2003). Thirdly, the study is instrumental: the primary goal is to better understand a theoretical problem and a practical issue (in this case, the lack of implementation of nature-based solutions in cities). The study is conducted to gain a greater insight of the theoretical explanation that underpins this problem; the understanding of the situation in specific cities that are studied is of secondary importance (Hancock & Algozzine, 2006).

To answer the research questions, a twist to a multi-case study is done, using one detailed case and a more holistic study. This study method is qualitative and focuses on a specific topic, bounded by space and time (Hancock & Algozzine, 2006). The choice for one case-study and an international study is made by using an information-oriented approach, maximising the utility of information from the study by choosing subjects on basis of expectations about their information content (Flyvbjerg, 2006).

As the study consists of two studies, it has similar characteristics as a multiple-case study. A multi-case study facilitates exploration of the phenomenon, within its context, by using multiple data sources (Baxter & Jack, 2008; Yin, 2003). This is done to explore the subject of study through a variety of lenses, showing multiple facets of the phenomenon (Baxter & Jack, 2008). The main reason for a researcher to do a case study is to cover contextual conditions, with the belief that the

context is highly influencing to the phenomenon of study (Yin, 2003). This type of study enables the exploration of differences and similarities within and between cases (Baxter & Jack, 2008).

Gathering information from interviews: primary data collection

To gather information to address the research questions, interviews were used as a data collection method. This method allows for attaining personalised information, including personal (or collective, when shared with a discourse coalition) point-of-views, attitudes and experiences. This kind of information is highly relevant when doing a discourse analysis. It is therefore relevant to not only consider what is said by actors, but also how they phrased their opinions, which elements they included and which they left out, what the context is, etcetera.

Suitable actor interviewees

Discourse coalitions can consist of a variety of different types of actors; the greater the variety of actors is that can be interviewed for the study, the more complete the analysis is. For this research, interviewees included policy makers, NGOs, nature conservation organisations, think tanks, scientists, and involved city residents. The selection of interviewees was done first by using expert sampling, allowing the researcher to select participants based on their ability to provide relevant information. To some extent, snowball sampling was also used. This allowed the use of already existing networks, asking interviewees to identify other possible participants; however, this method was only used to some extent as it was important to find participants that adhere other discourses, providing other storylines, to be able to make the analysis as complete and diverse as possible. Based on these requirements, the following actors are interviewed:

Table 1 List of interviewees of the Rotterdam-case and the international study, in alphabetical order based on the abbreviations.

Interviewees of the Rotterdam-case	
Initials	*Full name and profession at time of interview*
AW	Astrid de Wit, program-manager, Provincie Zuid-Holland
KO	Kees van Oorschot, city development, Gemeente Rotterdam
PH	Patrick Heuvelman, advisor ecology, Gemeente Rotterdam
RA	Remko Andeweg, city botanist, Bureau Stadsnatuur
SK	Susanne Kuijpers, director spatial planning, nature and landscape, Natuur- en Milieufederatie Zuid-Holland
WB	Wouter Bauman, advisor nature & space, Rotterdams Milieucentrum
Interviewees of the international study	
Initials	*Full name and profession*
CH	Chantal van Ham, EU programme manager nature-based solutions, IUCN
JM	Jeet Mistry, programme manager/expert, One Planet Cities, WWF Sweden
MN	Merten Nefs, programme manager, Vereniging Deltametropool
PM	Pascal Mittermaier, global managing director, cities, The Nature Conservancy
RH	Roland Hunter, technical project manager and climate change expert, African Climate & Development Initiative

The nature of the interviews

The interviews were semi-structured. This has as an advantage that it allows for predetermined but flexibly worded questions. It also allows for follow-up questions, designed to get a better and deeper understanding of the issues of interest of the interviewee, as it allows interviewees to express themselves openly and freely (Hancock & Algozzine, 2006). The questions were open-ended and inspired and supported by information attained from scientific literature. The length of the interviews varied between 45 minutes and 2,5 hours, depending on the time availability of the interviewee, the length of their answers to the open-ended questions, and their overall enthusiasm to contribute to the research.

The setting varied among the case studies, as some interviewees worked within travelling distance and others did not. As a result, most interviews are done face-to-face, and others are conducted via Skype or Zoom. All interviews are recorded, the interviewees were asked for their permission before the conversation is recorded. Additionally, hand-written or typed notes are made by the researcher.

Legal and ethical requirements

All interviewees provided consent for their participation in the research. All interviewees are identified, provided that the person gave their consent for public identification. All interviewees had the right to end the interview, and the right to withdraw from participation in the research at any time before handing in the thesis. All interviewees are protected from any form of mental, physical, or emotional injury.

Gathering information from documents

To gather more information related to the research questions, approximately 35 written sources, both printed and online, are reviewed, including reports from planning practices, documents of nature conservation organisations, private and public records, websites, and governmental reports. The documents are searched on the internet using the search engine Google and are asked for from relevant actors. All documents are analysed to make sure they are valid, appropriate, timely and accurate. Additionally, documents about the city's policy and institutions are used to provide background information on the city, in order to get a better understanding of the case.

Summarising and interpreting the information: data analysis

To analyse the data, the interviews were transcribed and coded. When transcribing, only the spoken sentences are written down. This means that additional conversation elements like hesitations, mispronunciations, unfinished sentences, etcetera, are not considered relevant for this study. The coding is done manually and by using Microsoft Word. The coding is done for both studies separately (for the results, the separate studies were treated as freestanding studies; these results are combined in the discussion and conclusion) and in twofold, meaning that all interviews are coded twice. The first coding is done based on the themes of the research, being climate change, the

natural environment, economy, and security. The second coding is based on challenges and policy instruments, distinguishing political, management, societal, and biophysical challenges. To properly analyse the data, all quotes were provided with the abbreviation of the relevant interviewee, and subsequently reorganised in Word first based on their coding (for example, all quotes of all interviewees of the Rotterdam-case about political challenges were put together in the document). Next, all quotes within one code are analysed to look for patterns and overlap; based on these findings, the quotes are coded again (see Figure 1 for an example of this coding).

Table 2 An example of the system of coding as used in the study. The Rotterdam-case and the international study are coded separately; coding 1 is based on literature; coding 2 is based on patterns and similarities found within one code.

Study	Coding 1	Coding 2
Rotterdam	Management challenges	Limited budget Lacking knowledge Departmentalisation …
	Societal challenges	… …
	…	

Data analysis is based on analytic generalisation. This means that a previously developed theory (in this case, theory and information about storylines and challenges as found in literature) is used as a template to compare the empirical results of the studies (Yin, 2003). Documents are used to verify the findings from the interviews, and to add new information to those findings. For the discussion, scientific literature is used to review the results, to compare the findings with literature, and to find knowledge gaps, additions, and contradictions with the existing literature base.

Reporting findings

All information, results, and conclusions are written down in this report, structured as a research report. Additionally, the research is presented during a thesis colloquium at the 6th of June 2019, organised by the chair group Forest and Nature Policy (FNP) from the Wageningen University and Research, in Wageningen, the Netherlands. This study is a graduation research, which is a part of the master Forest and Nature Conservation at the Wageningen UR.

Confirming case study findings: the quality of the research

To make the research more valid and reliable, the method of triangulation is used (findings based on multiple sources; Hancock & Algozzine, 2006). During the research period, the work was read and reviewed multiple times by the supervisor from the university, dr. J.H. Behagel. Parts of the research are offered to participants in the research, to check whether the information they provided was interpreted and described correctly. The report is also read by fellow students – among others during peer-review sessions, as provided by the university – and other people that are active in the same or a related area of study or work.

Results I: Rotterdam, storylines and themes

The results are split into four parts. The first two are devoted to the case-study about the city of Rotterdam. For more information about Rotterdam, see Appendix A. Of these two parts, the first one discusses storylines and the relation between storylines and the themes of climate change, natural environment, economy, and security. The second part is about challenges and the policy instruments that are used in practice to overcome these challenges. The third and fourth part of the results are devoted to the international study and have the same subdivision as the parts about the Rotterdam-case.

Two major storylines have been found during the interviews for the case study of Rotterdam. Both storylines were mentioned by all or almost all interviewees, interpreted and expressed via their personal background and work experience. The first storyline discusses the distinction of two types of natural elements in the city: the elements that interviewees call “natural areas”, with actual natural value for the ecosystem and biodiversity, and elements that are often referred to as “green”, with fewer values for nature and biodiversity but with other values related to the city and its inhabitants. The second storyline discusses a shift in people’s thinking about nature, of all parties involved in the city (including inhabitants and the municipality), and how this shift is projected in management of and interactions with nature

These storylines will be discussed in further detail in this chapter. This will be done by looking at how the storylines relate to the major themes of the research: climate change, the economy, security, and biodiversity.

1. Nature versus green: the different types of green within urban nature

A storyline that appeared in almost all interviews was one that made a distinction in urban green areas: the distinction between “nature” and “green”. The storyline states that urban nature includes both these nature types and that these types have their own specific functions regarding the natural environment and the city and its inhabitants. It connects urban green spaces with the natural environment (including aspects like biodiversity and creating and preserving ecosystems), with climate change, and with social aspects including recreation and aesthetic values of the city and its surroundings.

The first category includes all green areas with actual ecological value; these areas contribute to the quality of local ecosystems, providing habitat for a variety of animal species and growing places for plants and trees. Additional to being functional for ecological aspects and biodiversity, this type of nature contributes to solving problems related to climate change, like heat waves and flooding (PH), and it offers the opportunity for people to go to a green environment and to relax, destress and walk around (SK). The municipality designated some areas to nature values in the city of Rotterdam; for example, there is a running project on riverbanks, focussing on the natural values of the river system. Additionally, the municipality owns multiple natural areas on the outer edges

of the city, designated for biodiversity and recreation (KO). Some of these areas are managed by a third party, such as Natuurmonumenten and Staatsbosbeheer (e.g. nature reserves with a Natura2000 status) in order to guarantee high quality and consequent management (PH). Lastly, the city contains a large variety of city parks (PH).

The second category includes all green areas that are contributing little to the natural environment and biodiversity but have other values to inhabitants and visitors of the city (WB). This type of green is given a variety of names by the interviewees; these names include neutral names, without any kind of negative judgement, like cosmetic green (WB) and aesthetic green (KO), but also names with a negative sound, like "shame green" and uniform green (HB). The main goal of this type of green is to give a city a green, more pleasant look (SK). Examples of this type of green are short lawns, highly maintained trees (there are about 700.000 registered trees in Rotterdam, with a tree passport (PH)) and bushes, green roofs and green facades. It provides a clean, sleek view, desired in densely built-up areas – more rough nature, like high grass, is not fitting for those areas (KO). Therefore, according to the municipality (KO), this type of green is mostly used in the inner city, where expectations of the surroundings are different than in other parts of the city; here, aesthetic values of nature are more important to maximising natural values (KO). However, also for these areas in the city, ecological value is considered: blossoming trees are preferred, attracting bees and other insects, and green facades are used, which are for example attracting bird species (KO).

Additionally, nature can cause some nuisance (e.g. bird droppings and falling leaves), which may be not desired by certain people in certain areas of the city. This type of green is used in for example the neighbourhood of the street Weena, where a variety of headquarters of large companies is located, and the area surrounding the central train station (KO). This type of green often gains more public support than green of the first type, as it looks appealing and green (RA); urban green like green roofs and green facades are "in vogue" at the moment (KO; RA). However, even the smallest green element has some ecological value, even if it is only providing habitat for soil animals or a food source for bird species (HB; PH).

Most of the interviewees agree that urban green spaces include both the first and the second type of nature, without one excluding the other (PH, WB, KO). As one of the interviewees (RA) said: "nature is everywhere (…) and nature qualities are also everywhere; one area is not automatically more valuable than another – there can only be a more valuable development (ecologically speaking, red.). A nature reserve has a type of nature, a city park has a type of nature, and the spaces between the streets have a type of nature. You should not compare apples with pears; neither should you compare the city with a forest, or a forest with a dune." This is supported by among others interviewee PH, additionally stating that the presence of green – any type of green – is important; however, creating sufficient green with actual natural value in order to achieve nature management goals is crucial.

However, some interviewees are convinced that the second type of green areas is mainly created due to a lack of financing (HB) or ecological knowledge (PH; HB). According to one of the interviewees, there is a lack of knowledge among people working with green in city design, resulting in ecologically ineffective green (PH). An example of this is the way the idea of using green roofs to adapt to climate change is used in the city of Rotterdam: the roofs that are created mainly contain of sedum plants, which have little ecological value (PH; RA; KO; WB). Secondly, city trees used to be mainly planted in monocultures, with long lanes of the same tree species. This resulted in problems related to this type of management, including the fast spreading of species-specific diseases (e.g. mortality of branches of common ash (*Fraxinus excelsior*)) (PH). Recently however, the municipality changed the policy on tree lanes, avoiding monocultures from now on in order to avoid the massive death of trees (PH). By increasing the knowledge of urban planners, the ecological value of the mostly used type green can be increased. This will be further discussed in the challenges found in the Rotterdam case.

Climate change

Both the first and the second type of green can help address problems regarding climate change mitigation and adaptation. In cities, the second type is mostly used to address climate change problems; examples include green roofs and green facades. However, important natural values are unexploited when this type of nature is used; green roofs for example are often made of sedum plants, which have very little ecological value (RA, PH, WB). Increasing the thickness of the soil layer on roofs allows for higher quality ecological values to develop (RA) and sowing these soils with a mix of native herbs that improve the living conditions of multiple bee and butterfly species (WB). Additionally, public grass fields are created to increase water inflow, but often on poor, sandy soil (RA, PH). Improving the soil would not only increase the water holding capacity of the ground, it would also improve habitat quality for plant and animal species. Additionally, it would lead to healthier, larger trees, which results in a bigger crown – and therefore a larger effect on the urban heat island effect by providing shade (PH). The reasons why type 2 nature is still used in cities to mitigate and adapt to the effects of climate change will be discussed in the section Challenges.

There are multiple additional merits for climate change mitigation and adaptation when green elements of type 1 are used; for example, forests are a standing CO2-stock and act as a sort of natural climate buffer (SK). Additionally, the project about nature-friendly riversides (as further discussed in the section Challenges and policy instruments – Biophysical challenges – City on islands) increases the water drainage capacity of the rivers, which decreases risks of flooding (SK; PH; KO). It also results in an improved quality of the water and allows children (and ducks and swans) to easily enter and exit the river (linking it back to the theme regarding security and improving the recreational opportunities of the riversides) (PH). Making a combination between nature and climate change allows the creation of public and political support for nature management plans, especially when the benefits are regarding water safety (SK).

Another (small) link between urban nature and climate change is one in the other direction: how the measures for climate change mitigation and adaptation affect the natural environment. KO and RA stress that the green surroundings of Rotterdam are not always suitable for mitigation measures; e.g. in areas where certain type of meadow birds are established, solar panels are not favourable (KO). Windmills result in a significant number of birds being chopped down every year (RA). Additionally, people tend to have problems with the creation of solar panel fields and windmills when they are located in a city's surroundings, as they affect the aesthetics of the rural landscape (KO).

Natural environment

When it comes to the natural environment, there is a large difference between the values of type 1 and type 2 urban green. Type 2 is used in neighbourhoods where the more natural type 1 is not desirable, due to its – in the opinion of some, e.g. large companies with offices at the Weena – wild and unclean look, and of the nuisance that it can cause (KO). In this type of areas, low-maintenance tree species like the plane tree are used; this tree species can grow in a wide range of soils and standing places, is easily replanted and maintained, and has some value to certain bird species like pigeons and magpies (PH). Unfortunately, it does not flower in such a way that it attracts insects, and the leaves have little organic matter (PH). However, the municipality tries in most neighbourhoods to maximise the natural values of this type of green in other ways; this is for instance done by planting flowering plant species, which have benefits for bee, butterfly and other insect populations (KO).

Type 1 nature in Rotterdam does have a lot of potential when it comes to ecological value. The river landscape is within the freshwater tidal area, which is a biotope of importance on a European scale (RA). The project about the riverbanks allows the creation of a unique, natural type of landscape. Additionally, natural areas in the surroundings of the city (both in management of the municipality and of third parties) are often managed in a way that favours recreation and ecology; within these areas, zoning is applied that makes a clear distinction between areas suitable for recreation, areas that supports both recreation and ecological values, and areas where recreation is partly or completely forbidden (e.g. in areas with meadow bird species; HB) in order to maximise the natural values (KO). Within the city some type 1 nature is also present, mainly in city parks; however, these parks are mainly designed for recreation (KO), therefore natural values are sometimes undermined (PH). Both type 1 nature in and in the surroundings of the city are worth preserving, as all biotopes include other plant and animal species that are not or less often found in the other biotopes (SK). Moreover, according to interviewee SK, type 1 green in the city has great potential to generate public support for natural areas in the city surroundings, to function as a green connection zone to nearby natural areas. The nature outside the city can maintain species populations that have stricter requirements to their habitat and have the potential to help fulfil international goals and agreements regarding the protection of certain species (Bird and Habitat Directive).

Economy

Green elements positively influence the quality of the living environment, which results in an improved environment for business and settlement (as concluded in the study Blind Spot[1] by Vereniging Deltametropool; HB); the economic value of houses and other buildings increases with 7-11% when in a green neighbourhood (HB). Comparing Rotterdam with other cities in the Netherlands like Amsterdam and Utrecht, Rotterdam lacks pleasant living environments; this decreases the attraction of the city for e.g. people that want to work in Rotterdam, as they are not able to find a house in a nice neighbourhood. In the harbour, this results in unfilled high positions due to a lack of applications (HB). Adding green to existing neighbourhoods increases the liveability and attracts people with above-average incomes, which influences the economy.

This does not only apply to neighbourhoods with residential houses; greening the areas around office buildings is also beneficial for the city's economic situation (KO). A current problem is the high vacancy of office buildings in Rotterdam, due to both the economic crisis and the fact that companies have become more efficient in using workspace and the number of employees necessary to keep the business running. To increase the chances of renting out an office building, landlords should invest in making the office "hip and modern"; currently, this means green and sustainable. The municipality believes that making buildings green and sustainable improves the overall quality of the city. The municipality stimulates this movement by creating certain conditions whenever a piece of land is assigned to a project developer, for example about the usage of green roofs and green facades. This does not directly benefit the municipality financially, but it decreases the vacancy in the city (KO). To achieve this benefit of urban green, mainly the aesthetic green is used; especially in neighbourhoods with office buildings, like Rotterdam Central District, priority is given to green spaces that fit the clean and sleek aesthetic of the area, while providing some ecological value (KO).

But that is not all benefit gained from improving the living environment: nature has a positive effect on health, for a variety of reasons. This leads to a decrease in healthcare costs in a city and to a decrease in sickness in companies and organisations (SK; HB). This directly and indirectly benefits the city's economy. Additionally, natural areas provide ecosystem services which can generate income for public and private entrepreneurs and organisations. However, it is important that natural values are not overshadowed by economic benefit (SK).

According to one of the interviewees (SK), there is a direct relation between the economic situation and the city's landscape and surroundings. If the economic situation is good, this results in an increase in expenses to infrastructure and construction work due to an increase in employment opportunities and general wealth. This increases the pressure on the environment, contradicting

[1] Blind Spot; metropolitan landscape in the global battle for talent, 2016, Vereniging Deltametropool, https://www.dropbox.com/s/kbowvmke9va71qt/20160419_Blind-Spot_metropolitan-landscape_deltametropolis.pdf?dl=0%20

the general right-winged political statement, stating that a good economy results in more budget for environmental protection and development.

Security

Security and safety are priority subjects on the Rotterdam political agenda, with Leefbaar Rotterdam as the largest party (since 2014). This argument is used by city management to increase the amount of urban green in the city, as both types of urban green have a positive effect on the (feeling of) safety in a city. Scientific research has proven that more natural elements result in lower crime rates (WB). In a lot of city neighbourhoods, there is a lot of space that HB calls "non-space": places where not a lot of people come (for example the plinth of flats, which are often not inhabited, and courtyards, which are often not very accessible) and where criminal activities tend to take place. Making these non-spaces more open and liveable by adding green elements, e.g. urban agriculture or neighbourhood gardens, attracts people and increases the social control in these areas (HB).

Moreover, adding green elements to a city creates a social meeting place, which also contributes to the liveability of a city (HB). PH adds that green surroundings contribute to the mental health of inhabitants, making people more relaxed and positive (PH; WB): "a green city is a pleasant city, which results in less hassle" (PH). For this purpose, both natural green and aesthetic green can be used. It is a political ambition in Rotterdam to increase safety, and urban green causes an increase in liveability and therefore an increase in safety (PH). Additional to that, specific projects in Rotterdam contribute to safety in a more detailed way; the project about nature-friendly riverbanks does not only affect the natural quality of the river ecosystem, it also allows children to easily enter and exit the water (PH). In this project, natural green and ecological values are directly connected to the safety of inhabitants.

However, there are also negative associations about the link between urban green and safety and security; this mainly concerns the more natural green, as this type is often denser and "uncontrolled" than the aesthetic green. This results in a decrease in the overview of parks and streets, which contributes to the feeling of being unsafe and offers opportunities to hide (WB; KO). Children's safety decreases when they play in dense groves, where they make a mess, do dangerous things with pallets and construction materials, light fires, etcetera (PH)[2]. In the past, this has been a reason for the municipality to decrease the denseness of the vegetation in parks by cutting and pruning bushes and trees, e.g. in the Zuiderpark. This had a negative impact on the natural values of the parks, as some biotopes were destroyed. However, these measures were highly supported by the public, resulting in people using the parks more often (according to the municipality of Rotterdam; KO).

[2] Other parties, like Staatsbosbeheer, promote the relationship of children with nature, as this benefits children's development, even though this may cause some nuisance from time to time (HB).

Additionally, natural green and safety in traffic are seen as a bad combination: certain animal species that are related to more natural areas, like the beaver, can get hit, affecting also human's safety in traffic (RA). This also applied to air traffic, as nature surrounding an airport supposedly leads to bird-airplane encounters (SK). Secondly, dense vegetation at e.g. crossroads affect the overview, which may result in accidents (PH; KO). Trees could pose a threat to safety when they are managed badly, for example when branches break off during a storm. However, according to PH the policy on trees is very strict and well-managed, diminishing this threat.

Lastly, there is a less supported theory about the efforts of city management to increase safety, for example in city parks, on the well-being of the ecosystem and its animal and plant species. In Rotterdam, parks and bicycle lanes are very well lit to decrease the risks of criminal activities such as robberies. However, these street lanterns affect the living environment of certain animal species, like bats. Solutions to this problem include combining lights with movement sensors (RA) or replacing light bulbs with white or yellow light with ones with green light (HB). Measures like the before mentioned cutting and pruning of trees, to give parks a better overview and an enlarged feeling of safety, also affect the ecosystem; some biotopes may be damaged or even destroyed, displeasing ecologists in the city. However, in these circumstances the municipality prioritises the wishes and the safety of the public over maintaining ecological value (KO).

2. A new way of looking at nature

One storyline that was mentioned during multiple interviews is about the changing perspective of people on nature, and how that affects nature management. This new perspective has multiple sides: it includes a new way of looking at nature in terms of recreational use, a renewed awareness among people (both among the public as among managers) of the necessity of nature and an associated responsibility to manage and maintain natural elements in and outside the city.

The first one is about how people have found new ways of using nature and recreating in natural areas. In previous times, people used to go to a natural area to spend a long period of time for leisure, e.g. to swim, sunbathe or play. In recent times, activities like running, hiking, and biking are gaining popularity, causing the natural areas in and around cities to become more popular for exercising, and the ways people use these areas to change (HB). This asks for a new approach of nature management, as recreation expands beyond the borders of the traditional recreational areas (HB). The natural areas outside of the city are under responsibility of the municipality but are managed by nature management organisations like Staatsbosbeheer and Natuurmonumenten (an example is the Akkerdijkseplas on the north side of Rotterdam, managed by Natuurmonumenten; KO). As one of these organisations, Staatsbosbeheer has launched a project about the green metropole, aiming to connect all urban nature, both within and outside city boundaries to create a green-blue network. This network aims to enable and encourage recreation, both small range recreation like walking the dog or relaxing in the park, and large range recreation, like running and biking. It also brings nature closer to the people, to make spontaneous encounters between people

and nature more likely by literally decreasing the distance between them, and to inspire people to further enlarge the network (HB). A network like this provides additional services: it contributes to people's health, their social life (possibilities for social encounters in nature), it increases the real estate value, the network can also be used by migratory species, like bats, butterflies, bees and birds, and the natural elements can contribute to the use of nature-based solutions to climate change in the city (HB). The network in its ideal form should be a common utility, like electricity and the sewage system, including the most trivial form of nature – e.g. a green roof – and nature in a more classic form, like a nature reserve (HB).

Within city boundaries, other new forms of recreation ask for a new approach of management. Events like festivals and night runs gain popularity, which is also noticeable for the municipality of Rotterdam, as it asks for a new way of using the natural areas in the city. The municipality tries to support these kinds of events: they want to advert Rotterdam as an eventful city, as these events attract people and are good for the economy. However, they also increase the pressure on the parks and have the potency to disturb the natural values that are present. This asks for zoning within the parks (certain parts that cannot be accessed during the events and other parts that are compatible for it), and strict regulations and agreements during and after the events (PH).

Additional to these new uses of nature, a new way of looking at nature has emerged in recent times. This is caused by a variety of factors. During the First Rutte Cabinet (from October 2010 to November 2012), the State Secretary for Economic Affairs, Agriculture and Innovation implemented some changes in finances for nature conservation and management, seriously affecting nature management efforts. This resulted in a shift in nature management, where stakeholders started to connect nature management with other sectors (HB). Additionally, the climate has been changing faster than was expected; the weather is becoming warmer and wetter, with additional longer periods of heat and drought, sea levels are rising, and soil subsidence (AW). This results in an increased pressure on the natural environment, caused by changes in land, agriculture and climate change (HB). The effects of climate change can already be felt by inhabitants of Dutch cities like Rotterdam; for example, during heavy rain, basements tend to flood (WB). Not acting right now will likely result in significant damage in the future (AW).

Because people are directly confronted by the effects of climate change, they become more aware of the necessity of acting. This results in bottom-up initiatives, initiated by inhabitants or NGOs (WB). These actions include creating green facades, green roofs and neighbourhood gardens (RA; KO). The municipality tries to use this public support for urban green by actively involving inhabitants in management, on a neighbourhood scale. For example, inhabitants are granted permission to take over the management of the green areas in streets or neighbourhoods (KO). Other initiatives include the Dutch Operatie Steenbreek (roughly translated into Operation Stone Break) and Tegeltje eruit, groen erin (tile out, green in). These initiatives are becoming more popular in Dutch cities like The Hague (WB).

Climate change

As previously mentioned, one of the main reasons why the new way of looking at nature has emerged is because of the increased severity of the problems regarding climate change, already to be felt in cities and by its inhabitants. There are some main threats, including flooding and the heat island effect, that will become more pressing in the near future (AW; SK). On hot days, it is already noticeable that the heat island effect results in higher temperatures within the city than in the city's surroundings; when the contrast between surroundings and centre enlarge, e.g. by decreasing the amount of urban green in the city, this effect will only increase (SK). Both the municipality and the province are well-aware of the benefits that urban green can have in addressing these climate-related issues (KO; AW).

Natural environment

With the new view on nature, some effects on the natural environment come along. The public support for nature increases and people become more aware of the necessity of nature management. This also creates support for measures of the municipality to maintain certain natural values; for example, an increasing number of inhabitants is accepting the hanging of nest boxes for bird or bat species, aiming to maintain habitat quality during construction work elsewhere (PH). Moreover, the bottom-up initiatives resulting from this shift in view on nature are perceived as positive by some of the interviewees when looking at the natural environment: increasing of awareness is good, as people become more involved with nature and problems related to the natural environment (PH). According to Bureau Stadsnatuur, it is important to involve people with nature, as they should understand how nature works and that it is also part of the urban system (RA). Also, the municipality and other governmental organisations tend to do more with nature and urban green when this awareness of necessity of action increases among the public; this results in the creation of environmental zones against pollution, water buffering and storage, and using urban green to decrease the urban heat island effect (KO). Staatsbosbeheer hopes that existing (urban) nature inspires people to further enlarge the green-blue network, in order to increase natural values and to contribute to mitigation and adaptation of climate change problems on a local scale (HB).

However, this new way of nature can also have negative effects to the natural environment in the city. For example, the bottom-up initiatives resulting from new public awareness and support may be designed to improve the natural surroundings, but both the ecologist of the municipality and of Bureau Stadsnatuur stress that a lack of knowledge of the public may result in urban green with little to no ecological value (PH; RA). The urban green that becomes "in", like green facades and neighbourhood gardens, often contribute little to the ecological quality of the city (RA), and neighbourhood nature management tends to result in grassy lawns (PH). Stronger still, these initiatives can have a negative effect when qualitative land, like fallow or half-fallow terrain, is taken into use to create neighbourhood gardens. This is what RA calls a "cigar from your own box": creating some ecological value in an area that already contained (more) value. But these problems

can be (partly) solved by making substantiated agreements with inhabitants, using a thought-through plan (PH).

Economy

One of the reasons why the shift in view on nature has taken place, is the ending of the economic crisis. During a period of crisis, budget for nature management are likely to be cut, as plans related to urban green and climate change are relatively expensive (WB); finances are more likely to be spent on other matters that are seen as more urgent. When it is going well with the economy, more money becomes available which can be invested in e.g. roads, the energy transition and housing; therefore, this is the moment to start taking nature and climate change into account (AW). Also, when the public expresses that nature and climate change mitigation and adaptation are deemed important, management reacts to this by investing more money (WB; AW). An additional reason is that when the economy is flourishing, the tourism industry increases; in order to make a city attractive to tourists, green elements are used (WB).

Security

This storyline makes a connection between urban green and both climate change and safety. Urban green contributes to mitigating of and adapting to climate change, decreasing the threats that climate change may pose to the city. In the case of Rotterdam, these risks mainly include flooding – both from the rivers and sea level rise – and the urban heat island effect (AW; WB). These risks are more severe in urban areas, due to the urban heat island effect and the hardening of the ground surface (AW). Moreover, climate change adaptation measures already in place can lose effectiveness due to an increase in climate change – dikes can shrink and become weaker due to drought and soil subsidence (AW). Lastly, climate change affects the safety of people in a direct way by influencing their health; heat has a large impact on the wellbeing of multiple population groups, including children and elderly. It can lead to heat-related and sunburn-related diseases; heat waves in Europe already claimed thousands extra deaths in the past years (AW).

Luckily, the city becomes more resilient to climate change when the amount of urban green areas increases. Trees provide shade and capture particulate matter (WB); green roofs are often used to increase the water capture capacity of the city in order to decrease the risk of flooding (WB; PH; KO). In Rotterdam there is a currently running project on riverbanks, which aims to enlarge the water surface, decreasing the risk of overflooding while also contributing to natural values of the river (PH). In short, the threats that climate change poses to the safety of Rotterdam and its inhabitants can be decreased by using urban green elements.

Summarising tables

Table 3 Summarising table of the storyline Nature versus green, from the Rotterdam-case. The links between nature-based solutions and the themes climate change, natural environment, economy, and security are briefly described.

Nature versus green	Type 1 nature: high ecological value, e.g. city parks, nature reserves near the city.	Type 2 nature: high aesthetic/cosmetic value, low-maintenance, e.g. individual trees, grassy lawns, etc.
Climate change	Used for both climate mitigation (e.g. using forests as CO2-stock) and adaptation (using nature-friendly riversides to increase water drainage capacity).	Often used for climate change adaptation purposes, e.g. green roofs and grassy lawns for water buffering; however, often executed without ecological knowledge, therefore ecological value is not maximised.
Natural environment	Lot of potential: river allows for unique ecosystems, nature areas outside the city are ecologically valuable, zoning is used to preserve natural values. In city parks, natural values compete with safety and aesthetics.	Some ecological value, but mainly used due to little maintenance, clean look, and relatively low costs. Possibilities for ecological value: flowering plant and tree species, trees and grass on better soil.
Economy	Nature positively influences the quality of the living environment, resulting in improved environment for business and settlement. People want to live in a green environment, e.g. for sportive and leisure activities. Nature has a positive effect on overall health, decreasing health care expenses.	Used in neighbourhoods with businesses, as green elements increase the attractiveness of an area (green elements like green roofs and green facades are "in vogue"), but it should not cause nuisance or damage to buildings and roads.
Security	The presence of natural elements increases the feeling of safety; can be used to make areas more accessible and used, e.g. by creating neighbourhood gardens. Less overview in parks and streets, decreasing the feeling of safety. In traffic, animals can get hit; dense vegetation affects the overview, which may result in accidents.	Used to improve the liveability of a city as well, contributing to social cohesion and safety. Creating meeting places (type 1 and type 2 can contribute to this), contributing to the liveability of the city and people's mental health.

Table 4 Summarising table of the storyline A new way of looking at nature, from the Rotterdam-case. The links between nature-based solutions and the themes climate change, natural environment, economy, and security are briefly described.

A new way of looking at nature	**A new way of looking at nature in recreational use, and renewed awareness among people of the necessity of nature and the associated responsibility to it.**
Climate change	Severity of climate change and the effects of climate change (e.g. flooding and droughts) result in more awareness of and support for climate mitigation and adaptation actions.
Natural environment	New support for measures of the municipality to maintain certain natural values; people becoming more involved with nature and problems related to the natural environment, resulting in the rise of bottom-up initiatives – however, they are not always benefitting the natural environment. Support and awareness of problems among the public makes environmental problems more important for governments to act upon.
Economy	The end of the economic crisis resulted in the new view on nature – money becomes available for investment in (nature-inclusive) urban development and nature management. And a good economic situation results in more tourists, which can be attracted to a city by using nature and green elements.
Security	Risks from climate change (e.g. flooding and urban heat island effect) are better known among people and can (partly) be solved by using green and natural elements in the city.

Results II: Rotterdam, challenges and policy instruments

This part of the results discusses the challenges in implementation of urban green elements in Rotterdam. The challenges are divided in four categories: political challenges, challenges related to management, to public involvement, and to the biophysical characteristics of the city. These challenges are discussed by looking at how they result in the choice and implementation of certain policy instruments (including motions, projects, conservation plans, etc.).

Political challenges

Local politics

One of the main political factors influencing the implementation of urban green in cities are the local politics, including the ruling local council, the aldermen and the local new and old policies that are made. During last municipal elections in Rotterdam, the local party Leefbaar Rotterdam has become the largest party, with 11 seats (WB); this party is a right-winged party, with a main focus on safety and liveability of the city, but not necessarily related to nature. This makes the forming of a green-minded coalition difficult. In the past years, Rotterdam never had a green council; this results in the exclusion of certain parties in decision-making within the municipality, including Milieucentrum Rotterdam (WB) and Natuur- en Milieucentrum Zuid-Holland (SK).

A first link between the storyline of the new way of looking at nature can be found in local politics, and how this is influenced by the way people perceive nature and environmental problems. One example is to what extent these problems influence the voting of people during municipality elections. Environmental problems, like climate change, gain importance among the public (AW), resulting in local politics to pay more attention to them as well; to decrease the threat of competition and to gain voters from more left-winged or centred voters, more right-winged parties (like VVD (KO) and Leefbaar Rotterdam (PH)) include nature and the climate in their election program (PH). During last elections, most parties were perceived as “green”, because they all advocated to create more nature in the city centre and near the river (KO).

Decisions in politics are not only made because the public adopted a new view on nature; also within parties, even the most right-winged ones like Leefbaar Rotterdam, include council members with, as one of the interviewees call it, a “green heart”; this can be independent of the principles and goals of his or her party, and may have influence on the decisions taken on nature in the city (RA). Or other subjects on the political agenda of a party can be connected to urban nature; Leefbaar Rotterdam for example has animal welfare as an important topic on their agenda; this creates opportunities for other stakeholders to lobby in favour of nature by specifically taking into account animal welfare and the benefits improved urban nature has for animals (WB).

In recent years, Leefbaar Rotterdam has been the largest party in Rotterdam, but this has not resulted in no nature development; au contraire, multiple projects regarding the greening of the

city centre and alongside the rivers were launched (KO). The awareness of the importance of nature (related to multiple aspects, including climate change) has increased among politicians, whether it is for their own benefit (to ensure voters during next elections) or the actual benefit of nature (PH). This allows for making larger developments, both in creating more awareness and in making actual changes in favour of nature (PH).

A motion as a policy instrument: nature-inclusive building

In November 2017, the motion of nature-inclusive building is implemented, as initiated by GroenLinks and Partij voor de Dieren (PvdD) (two of the most leftist parties) (PH). This means that urban nature is taken into account when renovating existing buildings or building new ones, from the earlier phases in the process onwards, by looking at possibilities to preserve habitat, minimize disruption to habitat, and to create new habitat (Gemeente Rotterdam, 2014b). Before 2017, this approach was already encouraged by the municipality: in the Natuurkaart (2014)[3] it is mentioned in a sentence saying that "in a lot of developments it is possible to make designs in a nature-inclusive manner". However, from the beginning of 2018 on it is an obligation rather than a suggestion to implement this type of planning (PH). Yet if looking at recent documents published by the municipality, e.g. "Vuistregels bouwen in de stadswijken" (2018)[4], nature-inclusiveness is not mentioned, whilst building sustainably is one of the key attention points in the document (subdivided in energy, climate adaptation (briefly mentioning roof gardens), circularity, and health).

This motion makes room for the ecologists of the ecological engineers of the municipality to steer policy in a more environmentally friendly direction, and it makes the removal of natural values more difficult (for a lot of projects, an application of a waiver is necessary) (PH). The ecologists of the municipality connect nature-inclusive building with the neighbourhood typologies of the Rotterdamse Stijl[5], which includes a design for public spaces in the city. This mainly works in (new) neighbourhoods (rather than in the city centre), e.g. by promoting the use of hedges instead of fences and walls, and using roof tiles usable for house sparrows for nesting; using nature-inclusive building to create space for nature and offer it opportunities to develop (PH). Additionally, it enhances the awareness of the corporate social responsibility of project developers to include sustainability and nature in their everyday work (PH).

National politics

Another influence on urban green policies is the political colour and developments at national level, and the ruling parties in both the past and the present. An example of how national politics have

[3] Uitvoeringsprogramma Natuurkaart Rotterdam, december 2014, Gemeente Rotterdam, https://www.rotterdam.nl/wonen-leven/natuurkaart/Uitvoeringsprogramma_Natuurkaart_dec2014.pdf
[4] Vuistregels Bouwen in Stadswijken, januari 2018, Gemeente Rotterdam, https://www.rotterdam.nl/wonen-leven/vuistregels-bouwen-stadswijken/Vuistregels-bouwen-in-de-stadswijken.pdf
[5] Handboek Openbare Ruimte Rotterdamse Stijl (2010), Gemeente Rotterdam, https://www.rotterdam.nl/wonen-leven/rotterdamse-stijl/Handboek-RS-Compleet.pdf

influenced local circumstances is when states secretary Henk Bleker, from the first Rutte cabinet in 2011, implemented serious budget cuts in nature conservation, including the removal of a government contribution for urban nature (HB) and for the creation of new nature reserves from agricultural land, near the city (KO). Some budget cuts were temporarily replaced by finances from the province, but over some time it was decided to halt the creation of new nature reserves and recreational areas (KO).

Additionally, the protection of nature has changed (Flora en Fauna-wet was replaced by the Wet Natuurbeheer, implemented in January 2017). Due to this change, the list of legally protected species in the Netherlands has shrunk significantly (RA). This results in other nature management measures both within and outside city boundaries. A large part of responsibility for protection of these species is allocated to the province. Natuur- en Milieufederatie Zuid-Holland uses the new vision of the Rijke Groen-blauwe Leefomgeving[6] (as further discussed in *Management challenges – A shared vision*) to encourage the province of Zuid-Holland to continue the protection of species that were protected under the Flora- en Faunawet on a national level, but lost protection with the new protection law (SK) – especially multiple orchid species need extra protection, e.g. by changing mowing practices (SK; RA). By creating a list of iconic species in the province that require specific measures, other species that are not on the list but have similar habitat requirements are protected at the same time (SK). In this way, habitat protection is achieved additional to the species protection induced by the new law.

In Rotterdam, the measures of the first Rutte cabinet resulted in increased attention for nature within the city's boundaries, making greening more popular not only among inhabitants, but also among local politicians (KO). Additionally, it was a wake-up call for Dutch nature protection and management, as the old situation, which always had been quite consistent over the years, radically changed. Finances for nature became less guaranteed, resulting in the realisation among nature organisations that more public support needed to be created, in order for nature protection to be maintained over the years (HB). In other words, the new view on nature needed to be promoted among the public in order to increase (or at least not decrease) public support for nature conservation and protection.

The changes by Bleker also caused a change in appreciation for varying landscapes; instead of creating more artificial recreational areas with trees and bushes, more support from the public arose for the preservation of old agricultural lands (e.g. open meadows and fields). In Rotterdam, this resulted in a discussion which type of landscape was more valuable and desirable (KO). This can be connected to the challenge of the large agricultural lobby, as the support for agricultural land increased, while the support for new natural/recreational areas decreased. These farmers, and

[6] Ontwerp Visie Rijke Groen-Blauwe Leefomgeving, May 2018, Provincie Zuid-Holland, https://www.zuid-holland.nl/publish/pages/19111/ontwerp_visie_rijke_groenblauwe_leefomgeving.pdf

other relevant stakeholders, will have to be included in the new vision on nature in order for it to be fully understood and implemented, benefitting the natural environment (HB).

Political processes

Overall, it takes a long time for a decision to be taken or a change to be made in (local) politics – especially when the subject is somewhat controversial, like limiting economic development to favour nature or solving environmental problems. This is due to two important factors in politics: money and re-elections (RA). Politicians rather not act when it either costs a lot of money, or when it may influence their chances of being re-elected during next elections; because of these factors, these kind of decisions and actions are often postponed or ignored. Additionally, in Rotterdam, the subject of the natural environment, both inside city boundaries and the province, seems to be of less urgency than for example overall sustainability and CO2 emissions (SK).

The combination of these factors results in a very laid-back approach when it comes to addressing issues related to the natural environment; when a problem emerges, it is often only addressed when the municipality is obligated to do so (RA). And when new rules or policy are made, it takes some time before it is implemented. This is partly to the democratic decision-making processes within a municipality, especially when there is conflict with other stakes or interests (like economic or transportation interests) (AW). Additionally, not only politicians but especially the civil service is resistant towards change; the implementation of decisions is often postponed, until a new municipal administration is installed. Then, the subject is taken off the agenda, including the changes that still needed to be implemented (RA). Due to these factors, few actual changes are made.

There is a clear difference between the municipality of Rotterdam and the management of the harbour when it comes to decision-making processes. If a problem emerges in the harbour, also when it is related to nature and the environment, not the question of whether addressing it is obligatory or not is asked, but whether it will negatively influence development in the harbour area. If this is the case, the problem will be solved as soon as possible (RA). This business approach differs from the approach of the municipality.

Suggestions to the municipality

To gain support for urban nature and green in the city of Rotterdam, multiple parties have created documents for the city council members. Natuur- en milieufederatie Zuid-Holland sent all party leaders during the municipal elections a document of guidelines, including suggestions of what to improve and develop in cities in the province of Zuid-Holland (SK), for example. Additionally, Natuurcentrum Rotterdam in cooperation with Rotterdams Parkenoverleg has created the

document Groene 18 voor 2018[7], including recommendations for the new city council based on a green, sustainable vision with benefits related to climate mitigation and adaptation (WB).

Management challenges

A shared vision

To successfully implement nature-based solutions on a city scale, the idea should be adopted by multiple stakeholders. Looking at green roofs for example, 40% of buildings in Rotterdam is owned by the government – the rest is owned by private companies and organisations. However, there are no policy instruments that obligate private actors to make their buildings' roofs green; therefore, creation of the majority of potential green roofs – as well as other green solutions – is dependent on the intrinsic responsibility and willingness of these actors (AW; PH). Using nature has a lot of potential, e.g. in reducing problems related to flooding and heat stress. However, multiple actors must implement this strategy in order for it to bring actual advantage to the city as a whole (HB).

This also becomes an issue when talking about a green infrastructure network, connecting the city with its green surroundings using green elements throughout the city. This does not only cross boundaries between public and private property, but also borders of projects, the city, or municipalities (HB). This cross-border thinking is often new for actors, which are often only acting and thinking within their designated border.

Designing a vision

To create a shared vision that's crossing borders, the province is introducing a vision called the Rijke Groen-Blauwe Leefomgeving[8] (roughly translated in the rich green-blue living environment), in cooperation with multiple stakeholders including Staatsbosbeheer, environmental federations, entrepreneurs and employers organisation LTO, and multiple cities in the province (AW). The vision includes green and blue infrastructures both in the cities and the cities' surroundings, looking at policies and management from a perspective of, among others, safety, health, climate adaptation, and biodiversity (AW). It aims to provide a healthy, attractive, and climate resilient living and working environment, with direct access to high-quality blue and green (Provincie Zuid-Holland, 2018). This is achieved by multiple measures, including: encouraging and supporting green initiatives, which also increases social cohesion; connecting green and blue infrastructure stimulating both ecological and recreational values; and making agricultural practices more sustainable and restoring the balance between nature, landscape and agricultural use (Provincie Zuid-Holland, 2018).

[7] De Groene 18 voor 2018 (2018), Het Rotterdams Parkenoverleg, Rotterdams Milieucentrum, Bureau Stadsnatuur Rotterdam, http://www.milieucentrum.rotterdam.nl/site/wp-content/uploads/2018/04/Groene18.RMC_.def_.pdf

[8] Ontwerp Visie Rijke Groenblauwe Leefomgeving, 14 mei 2018, Provincie Zuid-Holland, https://www.zuid-holland.nl/publish/pages/19111/ontwerp_visie_rijke_groenblauwe_leefomgeving.pdf

This vision crosses the boundaries between nature in cities (responsibility of the municipality) and nature outside cities (responsibility of the province, among others). This vision connects these scales, involving parties from these different scales in all work areas (AW). In the cities, the focus is on recreation and aesthetic value of nature, connected these to the cultural-historical value of the area; a dense recreational network, composed of e.g. multiple green-blue elements, including roofs, shopping areas, business terrains, and parks, connecting the entity of the city to the surrounding landscape, including the rivers (Provincie Zuid-Holland, 2018).

Starting a conversation and creating a network

Staatsbosbeheer is trying to start a conversation involving all these actors and crossing these boundaries. In practice, there often arises a common agenda during these conversations, as actors are increasingly enthusiastic about the ideas of a green infrastructure network (HB). However, it still seems to be difficult to actually implement these ideas into the real world, as the consensus of a great variety of actors is necessary. Private organisations, for example, often have a small reach – only the areas where their own projects are executed. To connect these fragmented project areas, the consensus of the municipality is needed as well; however, municipalities of cities like Rotterdam are large organisations with compartmented departments. All these compartments have to be united as well – the difficulties of this are discussed in the next paragraph –, together with the other actors involved (HB).

A way to involve all actors and to create a consistent green infrastructure network, is to create it in segments. When one project turns out to be successful, other actors may be more easily convinced by this vision (HB). This slowly generates more supporters, finishing the entire network over time – both the green infrastructure network as well as the network of actors sharing the same vision.

Common practices

A city is a dynamic system, always changing and in development. This creates opportunities for the creation of new green/natural elements; nature can become an integral part of building new houses, and when roads are altered due to sewage maintenance work, natural elements can be used to make the roads part of the city's green infrastructure (HB). However, when there is a construction plan that needs to be implemented, developers and building agencies often use the common practices used for a long time – they are well-known, allowing for the work to be done quickly and cheap. These common practices often win from ambitious plans involving natural elements, as for some parties the time schedule is more important than potential benefits from a greener environment (AW).

Rotterdam is a civil engineering organisation, with a focus on the quick and safe functioning of infrastructures in the city like cabling, pipelines, the sewage systems, roads and bridges. In this picture, green infrastructure is often seen as an issue of secondary importance and will often be neglected when it becomes expensive or complicated to create and maintain (PH). This type of

tunnel vision, where the own agenda and finances are most important, sometimes leads to inefficient situations, for example when construction or destruction of built-up areas requires action towards the existing natural values. An example within Rotterdam is bats in an old school building, being demolished in favour of development of a neighbourhood. The project developer did not take these bats into consideration when starting the project, due to unwanted expenses for alternative nesting possibilities; this resulted in a delay of more than half a year before demolition work could start (PH). In this case, taking the ecological values into consideration early on in the project would have saved more money what would have been spent on the ecological measures beforehand (PH).

Changing mindsets

It is of great importance to adopt the mindset of nature-based solutions and green infrastructure when developing the city, whether it is about the (re)construction of roads, buildings, or existing green areas, in order for it to actually be used in practice, and to include problems related to climate change, biodiversity, and health (HB). An example of changing the common practices related to the existing infrastructures in a city in favour of ecological value, is the use of eco-culverts instead of normal culverts, used to connect waterways underground; an eco-culvert can be used by small terrestrial animals, in addition to aquatic animals, as a part of these culverts is above water level. This reduces fragmentation of territories of animals within the cities and allows for migration of animals (PH). However, these eco-culverts are more expensive, resulting in problems related to budget (see also paragraph Budget for nature).

In some cities, like Eindhoven, they completely changed their vision: rather than slightly altering the old practices, they now work with the idea of making everything more green, except when it really needs to be paved (e.g. when it is a road or a parking lot) (HB). When this is combined with looking at places where new natural elements can be created, the green infrastructure network of the city is enlarged and strengthened. Mentioned programs, like the province's vision of Rijke Groen-blauwe Ruimte (AW) and Staatsbosbeheer's Groene Metropool[9], can help implement a green-centred vision like discussed.

Certification and subsidies

Changing the common practices is also achieved by the introduction of new energy labels and certificates for sustainability (KO). Concerning these labels, it is required to meet certain standards before the place can be rented: having an energy label of at least C will be obligated for owners of office buildings from 2021 onwards, creating a need for renovations and investments to comply with the new requirements. An example of a certificate are the BREEAM certificates[10], for area

[9] Groene Metropool, n.d., Staatsbosbeheer, https://www.staatsbosbeheer.nl/-/media/08-dossiers/groene-metropool/brochure-groene-metropool.pdf?la=nl-nl&hash=8B860FD02C00A180163D9F3919B59D53B4EFFF4C

[10] https://www.breeam.nl/

development, construction and renovation of buildings, in-use (sustainability of an existing building), and demolition work (BREEAM-NL, n.d.). A certificate like this attracts both investors and users (KO), and improves the sustainability image and the financial value of the area or building (BREEAM-NL, n.d.). Even when the owner of a building or area is not green-minded, the economic benefits of a certificate or label result in the use of nature-inclusive building and/or nature-based solutions, as they often include some sort of nature-inclusive measure, like creating green roofs or putting up nesting boxes for bird or bat species (KO).

Another way to stimulate the use of nature-based solutions is by granting subsidies to stakeholders (organisations, businesses, inhabitants, etc.) that do, by the province. However, there is no such subsidy yet, although it could be an option for the future (AW). By using subsidies (and other stimulating policy instruments), the province tries to have their vision influence the green infrastructure and the city's design (AW). The municipality does grant subsidies for green roofs, when at least a specific amount of water (in millimetres) is buffered by the roof. This promotes the creation of more ecologically valuable green roofs, as these can hold more water (KO).

Knowledge and data

There is a knowledge gap among people working with urban green in Rotterdam, like urban designers and policy makers, especially related to the ecological value of green infrastructure elements (PH). Lack of ecological knowledge in early planning phases results in missed opportunities for ecological value in multiple parts of the city; for example, for the construction of roads, bridges, height differences, and waterways, construction sand is used, with a layer of nutrient rich soil on top for grass – not suitable for a species rich natural vegetation (RA). This lack of knowledge can even be reflected in the realisation of environmentally beneficial technical projects, like the creation of a wadi (a solution to let water naturally infiltrate in the soil and to reduce the pressure on the sewage system). These can be ecologically valuable, but when ecological knowledge is lacking during the execution phase, the opportunities for nature development are not maximised (RA).

When designing green elements or environmental-technical elements, like the beforementioned wadi, the designer designs often from a technical or architectural perspective rather than from an ecological perspective. For example, architects often look at the city and decide where nature development is desirable rather than where it is ecologically viable; this results in ecologically ineffective elements in less optimal places and missed opportunities in areas with a lot of ecological potential (RA). Additionally, in urban planning predictability is often desired – how the area will develop in the near future. This while nature is often unpredictable and needs room to grow (RA). The complexity of ecology is often difficult to explain to civil-technical people (PH), and knowledge is often momentary due to continuous changes of positions in the official world (RA).

Obligatory inclusion of natural values

In construction and development projects, it is obligated by law to look at natural values before starting – the values that are existing and should be preserved, e.g. protected animal and plant species (PH; RA). These laws are efficient when it comes to saving existing values, however it does not state anything about creating new nature; from time to time a project developer is willing to spend money on this, but that does not happen often (RA). One way to tackle the challenge of knowledge gaps is to bring ecologists to the planning and design table. This happens to a certain extent, but often too late in the process – often when the conservation is discussed, rather than the design and realisation; involving ecological knowledge may result in completely different designs, more ecologically valuable and resilient to the dynamic environment (RA).

Providing information to policy makers, designers, and planners

Another way is to increase the knowledge in planning and design by providing the information in an understandable and easily accessible way. The ecologists of the municipality of Rotterdam provide the minimal ecological knowledge needed to successfully include certain animal species, like bat and bird species, in construction and development in urban areas by using the documents of BIJ12[11] (PH). These documents are created following the implementation of the new Wet Natuurbescherming (law for nature protection) at the beginning of 2018, specifically protecting plant and animal species that are naturally present in the Netherlands (BIJ12, n.d., p. 12). These documents do not only provide the needed information, it also increases the understanding between the municipality's ecologists and project managers; this results in more willingness to take nature into account (PH).

Something similar is done by the Dutch Vlinderstichting (butterfly foundation); they provide lists with plant species suitable for butterflies and other insect species, to prevent the well-meant but ineffective planting of unsuitable vegetation (HB). Also Bureau Stadsnatuur in Rotterdam has developed a small course on biodiversity, designed to provide non-ecological officials with basic ecological knowledge – enough to know in what phases of design, planning and implementation an ecologist should be involved (RA).

To sustain this level of knowledge and to create more awareness about the necessity of enhancing the biodiversity in the city, research is necessary to gather more data on the current state of biodiversity. Data like this are often lacking, resulting in a missing view on the progress or decline of animal and plant species in Rotterdam, which influences the effectiveness and monitoring of policies targeting these species (PH). Research is mainly done based on nature protection laws, focussing on the list of protected species. This research is conducted by other parties (PH), like Bureau Stadsnatuur (RA). However, the municipality tries to also look at other species to create a better overview of biodiversity in the city (PH). Additionally, more data allows to better evaluate

[11] For all documents by BIJ12: https://www.bij12.nl/onderwerpen/natuur-en-landschap/kennisdocumenten-soorten-ontheffingen-wet-natuurbescherming/

permit requests for construction activities, as a complete dataset allows for more accurate predictions of ecological values that may be threatened when construction activities are executed (PH).

Budget for nature

As discussed in previous chapters, green surroundings have multiple benefits for inhabitants in cities. Among these benefits there are some that can be converted to a financial value, e.g. when the presence of natural elements directly decreases expenses that otherwise would have to be made; for example, the overall health of inhabitants tends to improve in green surroundings, decreasing health care costs (AW; HB). This can be a reason to act upon: the municipality of Rotterdam is an economically stimulated organisation, and measures that cost money are preferred to also generate financial income (PH). However, nature offers multiple services to humans that cannot be easily valued in an economic manner (SK). This is a major discussion in the world of natural sciences: how can you (or even: can you?) express other, immaterial values economically? Or, as one of the interviewees phrased it: what is the value of an encounter with a butterfly? (HB). In decision-making, values that generate financial income often win from values that are immaterial (SK).

Because there is not always an economic incentive to do so, the creation of new natural elements in a city is often lacking. Little budget is reserved for this type of developments; urban development is often influenced by money – how much money is available, how much something costs, or what earnings it will generate in the future. Looking at urban development and the choices a city planner has, creating or maintaining natural areas often has to compete with the creation of new buildings, suitable for living or business premises – development that will directly generate income in a near future, while natural areas will mainly cost money for maintenance (SK; HB). Additionally, cuts seem to be made relatively often and easy in budgets for maintenance and creation of natural/green areas in the city; this results in little green areas, using vegetation with low maintenance cost – like grass instead of bushes (WB). Because of small budgets and budget cuts, green areas in cities are often uniform, with small value when it comes to ecology and recreational use (HB). In other words, it results in type 2 natural elements, which are green elements with little value for ecology. But for recreational values it is a meagre investment as well: you can sit on the grassy lawns and look at the individual trees, but it does not offer possibilities for other forms of recreation. This effect is even greater when ecological knowledge is lacking as well (HB).

Another issue related to budgets within a municipality is compartmentalisation – when civil servants only work within their own department and only with their own knowledge, and how this affects said budgets and on what measures money is spent (AW). As said before, the creation and presence of natural elements in a city is beneficial for multiple aspects of the city's system, including health benefits, climate change mitigation and adaptation, etc. However, these side effects are often not considered financially when looking at budgets for multiple facilities in the city (AW; HB). For example, the creation of green and nature increases the water storage capacity of the city,

decreasing the pressure on the sewage system (AW). The potential savings resulting from this can often not be invested in more nature and green in a city, regardless of the beneficial (and often generally acknowledged) connection between these urban facilities (AW).

Even when the values of nature are recognised within the municipality's departments, there is still a problem related to budgets and compartmentalisation. Because, since nature benefits multiple sectors at once, who is going to pay for it? Departments making the construction plans have to present these to the town council and executive board, including a statement of account. All departments make these separated from other departments – the department of health or elderly care, for example, are (most often) not included in making any of those plans and can therefore not join negotiations or contribute to the financing of projects (HB). Financing nature without taking into account the health and other immaterial benefits – and therefore the potential profit from these sectors – can lead to holes in statements of account – nature being too expensive for the small financial profit it generates – and natural elements being replaced for the creation of more buildings (HB).

In the private sector investments in nature are scarcely made due to the diffuse benefits of nature in the city. When one organisation pays for more natural elements in a city, multiple stakeholders reap from these individual investments (SK). It would be an option for health insurance companies to invest in nature, due to the proven health benefits. However, not only their own customers will benefit – also the customers of competitors, resulting in other health insurance companies to make profit on the expense of other companies (SK). A solution for this problem would be to involve the government, e.g. they could make it obligatory for insurance companies to make an investment in nature – however, these solutions remain controversial.

Budget for nature or for green

Within the municipality, there is quite some budget urban green, including subsidies for green initiatives and management by third parties, like inhabitants. However, as discussed in the part Storylines – a new view on nature – natural environment, green initiatives do not necessarily have a positive effect on the ecological values of the area (PH; RA). In other words, this does often not result in nature type 1, but rather in nature type 2. Therefore, the budget for these initiatives and nature management is mainly for green rather than for nature. There is some budget and manpower for the checking and assisting of these initiatives by governmental employees, which helps, but ecological values are not maximised (PH). Furthermore, there is budget for maintenance of registered trees – nature type 2 –, to make sure they are healthy and safe for their surroundings.

There is budget for nature for compensation; rules from the Bird and Habitat Directive state that when nature is transformed for urban or industrial development, it should be compensated elsewhere. For example, when the second Maasvlakte was made – a extension of the Rotterdam harbour – a part (about 2.000 hectares) of the protected nature reserve Voordelta was used. These losses in natural value need to be compensated elsewhere. However, often the valuable nature areas

are replaced by nature of a lesser ecological value, like agricultural nature or meadow bird habitat (PH). Still landscapes in the first nature type, but ecological values are lost nonetheless.

Dividing expenses by joint funding

Ideally, the overall advantages of nature should be designed and financed by all the parties that generate profit from them – both the direct as well as the indirect profit. Within the province of Zuid-Holland, there are municipalities that reduce the strict division of departments and their budgets, allowing for shared payment of the maintenance and creation of natural elements (AW); however, this is very unusual, both at local, provincial, and national level (AW; HB). One solution would be to make regulations that make budgets less compartmented. But, as discussed in the previous paragraph, making decisions within a government or municipality often takes a long time.

Staatsbosbeheer (SBB) tries to realise joint funding for urban nature by bringing together stakeholders that may benefit from more green surroundings (HB). As it is very unusual for nature to be funded from governmental sources other than the ones specifically funding nature (HB), SBB starts the conversation with not only local stakeholders, like the public and entrepreneurs, but also governments (Staatsbosbeheer, n.d.). By talking to e.g. the ministry of public health, SBB tries to find support for the positive health effects of the presence of a green infrastructure, in terms of allowing for sportive and leisure activities in the close-by surroundings by creating an enjoyable and safe green environment (HB). When ministries and the cabinet acknowledge these positive effects, this may influence decision-making about the financing of nature and urban green, and the design of urban areas (HB).

This is part of the SBB Groene Metropool (Green Metropole) project, which aims to create a green network connecting the city with its natural surroundings by creating more urban green elements. An example of the work within this project is the Diemerscheg, which is a green zone crisscrossing and connecting multiple neighbourhoods from the East of Amsterdam to Diemen, a town East of Amsterdam. However, multiple railroads, highways, and waterways fragment the area (Staatsbosbeheer, n.d.). In cooperation with organisations from the city and the municipalities, SBB continues to restore this connection by creating recreational areas (HB). A project like this, where the municipality cooperates with both nature management organisations, local entrepreneurs, the public, and other stakeholders, could benefit the creation and maintenance of urban nature in Rotterdam as well.

Societal challenges

Strong agricultural lobby

One of the factors often influencing nature conservation and management in the Netherlands is the existence of a strong agricultural lobby (HB), supported by two of the largest political parties, the VVD and the CDA (SK). Because of the pressure on the space in the province of Zuid-Holland,

development of nature is often at the expense of agricultural land, as the use of e.g. old business parks is more expensive; however, a decision like this is often heavily disputed by farmers and right-winged stakeholders (SK). As a result, decisions concerning nature are often not taken, or it takes a long time to come to a compromise. With local stakeholders, there is a need for a common agenda and a shared vision as well, which can be achieved in a process with (elements of) participatory decision-making and with the inclusion of farmers (HB).

Good intentions but lack of execution

Even though environmental problems are becoming more well-known and people know they should act upon them, and they sometimes even say that they are (willing to) act, there is still a lack of actual action being taken. This is especially the case when the more sustainable or environmentally friendly options are more expensive (e.g. milk from environmentally friendly cow farms; SK), when they take more time and effort (e.g. people choosing for artificial grass instead of normal grass, and tub plants instead of bushes, even though the second options are more valuable for certain bird species; PH), or when the natural options bring inconveniences (like bees, wasps and other insects; PH).

Public participation

One way of encouraging people to adopt more environmentally friendly behaviour is by making them enjoy the positive effects of their behaviour in a more direct way (e.g. when their behaviour results in nice direct surroundings; SK). Examples could be neighbourhood gardens or creating more pleasurable agricultural areas using agricultural nature conservation. Green surroundings contribute to the quality of the living environment and of life itself, supporting social interaction and cohesion; Bureau Stadsnatuur, Rotterdam Milieucentrum and Parkenoverleg therefore recommend in their advisory document “De Groene 18 voor 2018” to develop a program that supports green initiatives of inhabitants – e.g. for jointly taking care of park maintenance – both financially and organisationally. An example of a green initiative is the Dakakker on the Schiekade, as initiated by Milieucentrum Rotterdam (WB; KO); here, volunteers work together in a vegetable garden on top of a building, providing for both the café on the same roof as well as some restaurants in the neighbourhood (WB). Additionally, they provide education programs for children, e.g. the program Dakkennie, focused on biodiversity and ecosystems (also in cities) (WB).

Another way is by conducting more research in the (near) areas where the people live that do or do not change their behaviour (e.g. regarding their gardens). An example is the areas Park Zestienhoven in Rotterdam, where populations of breeding birds decreased by 65% due to lack of food, safety and shelter (PH). Ecological knowledge and facts can both increase awareness among the municipality, but they can also be used to stimulate inhabitants to do something to help solve these problems. Support for environmentally friendly solutions among inhabitants can increase when sufficient information is provided.

Negative effects of recreation

These days, people have more appreciation for nature, and want to experience it in new ways. In the Netherlands, one the most important value of natural areas and reserves is related to recreational activities; most of the time, nature is only created and maintained if people are allowed to enjoy it (PH). In addition, people tend to want to benefit from their investments – e.g. when someone invests in nature (by supporting a nature management organisation, for example, he/she often wants to benefit from this investment, by recreating in the natural areas that are protected (PH). This is beneficial according to some parties: Staatsbosbeheer highly supports recreation, as it increases public support for nature, contributes to the overall development of children, and is often healthy (HB). However, this demand for possibilities for recreation results in damage to natural values as well, due the creation of multiple paths and tracks (for hiking, biking, etc.), which increases the fragmentation of nature, and noise disturbance and littering caused by recreants (PH).

The new view of nature includes more appreciation for nature and support for protection of nature, but it lacks actual ecological knowledge or incentives to act in an ecologically benefitting way. This not only applies to recreants themselves, also the people that benefit from these recreants financially – event managers, for example.

Zoning and regulations

Policy instruments that help diminish this challenge include stricter regulations (e.g. zoning) on the use of parks. Every park in Rotterdam has a profile and a risk matrix, taking into account natural factors like breeding seasons; during organised events, these instruments help minimise disturbance by providing specific guidelines for the placement of e.g. lights, fences, entrances, etcetera (PH). Additionally, as some effects are not yet known, more research is conducted by the municipality on recreational disturbances on nature. Until the effects are known and clear, preventive measures must be taken to minimise disturbance, in order for an event to take place; taking these measures is the responsibility of the event manager (PH).

Decreasing the negative effects of events is also included in the advisory documents “De groene 18 voor 2018” of Rotterdams Milieucentrum, Bureau Stadsnatuur and the Parkenoverleg; they recommend making events more sustainable by creating goals for damage prevention to nature and by the commission of an environmental event coordinator. Additionally, water and energy use, and the processing of waste more sustainable is recommended.

Biophysical challenges

Pressure on space

The city of Rotterdam is a crowded, heavily built-up city: it gives space to a large amount of buildings, both residential as well as for businesses and industry (SK), to infrastructure and other

utilities (PH). Because this high demand for space, nature has made way in the past to give room for these uses, and it is still difficult to maintain green spaces in the city centre. Most of the green spaces are transferred to the outer edges of the city (PH). Additionally, the large number of cables and pipes necessary to provide all buildings of water, electricity, and gas have a prioritised position when it comes to the use of space; the municipality does not allow the planting of trees on these pipeline routes, as they may damage these utilities with their root systems (KO; PH).

The pressure on space affects plans for creating natural areas as well: in multiple cities in the Netherlands, including The Hague and Utrecht, old water bodies that have been removed in the past to make way for other uses, are reintroduced in the city (e.g. project Herstel Singels in Utrecht[12], restoring the Catharijnesingel and the Weerdsingel). There is potential to restore water structures in Rotterdam as well, e.g. when looking at the Coolsingel and the Schiekade (WB). These could both increase recreational and natural values, while also improving the city's resilience climate change. However, these streets are two of the main roads of the city and with current population and resulting demands on cities, it is priority to preserve these roads (WB).

A plan for trees

However, the municipality has created a plan for trees in the city centre, allowing some trees to be planted even in very densely built-up areas. The plan is called Bomenstructuurvisie[13], expressing a vision on the wanted tree structure on city level (especially regarding trees on main roads, along watercourses, in city parks, and on city squares). This plan aims to provide the city with a connected tree structure that aims to give the city more unity and quality. In this vision, there is a distinction of three sizes and types of trees: trees of the 1st size, or monumental trees – allowed to stand somewhere for 50-60 years, sometimes longer, growing up to 50 meters in height –, trees of the 2nd size – with an age up to 40 years and a height of 15-25 meter –, and trees of the third size, which are called "throw-away trees" (weggooiboompjes). These trees require locations of lower quality and live only 10 to 15 years, which makes them more flexible in city planning than the trees of the other sizes. They can be combined with utilities below-ground due to their smaller root systems; they can easily be cut down or replanted elsewhere (the municipality has a tree depot, from where trees are relocated after removal due to e.g. road work). However, they are most interesting when it comes to ecological value, as they are often trees that blossom (PH). With this system, the municipality allows for the presence of more city trees in an everchanging city centre.

Natural areas near the city

In the surrounding areas of the cities the pressure on space is significant: a large portion is used for agricultural practices, including arable and dairy farms. Of what remains, about 7% of the area is appointed as protected nature area, and an additional 5% for recreational purposes; the ratio of

[12] https://www.utrecht.nl/wonen-en-leven/bouwen/bouwprojecten/herstel-singels/
[13] Rotterdamse Stijl Bomenstructuurvisie, 2008, Gemeente Rotterdam, https://www.rotterdam.nl/wonen-leven/monumentale-bomen/Bomenstructuurvisie.pdf

nature and recreational green per inhabitant in the province of Zuid-Holland is the smallest of all Dutch provinces, due to this pressure on space and the resulting high ground prices (SK). However, the population of Rotterdam has increased, which results in a larger demand for recreational areas. As a solution, the municipality of Rotterdam owns a number of natural areas in the near surroundings of the city; examples are the nature areas North of Rotterdam, like Vlinderdistrict, Schieveen, and Schiezone. These are project nature areas, designed by the municipality (KO) and managed by nature organisations like Natuurmonumenten (KO) and Staatsbosbeheer (HB). Additionally, there are multiple nature areas, including near the river Rotte, that are partly financed by the municipality (KO), but in management of the Recreatieschap (HB; KO), with management being executed by Staatsbosbeheer (HB). To connect the natural areas in the city and the reserves in the city surroundings, the Natuurkaart[14] is designed; this document includes an overview of existing natural areas, where these areas are already connected, and where more areas or connection zones are desirable, based on the local circumstances and natural values (Gemeente Rotterdam, 2014a). This document is used as a starting point for projects, guiding the municipality's policies (KO).

In these areas, recreation is one of the prime management goals, together with more space for nature to develop. The focus differs between areas: some are more strictly managed for nature and increasing biodiversity, whereas others include playing opportunities for children like play areas and petting zoos (KO). Overall, management mixes recreation and nature in varying ratios. To improve recreational values, areas – like Kralingsebos – contain multiple catering and recreational facilities (KO); this contributes to employment opportunities for local residents.

Soil

Another biophysical issue in the city of Rotterdam that decreases the potential for the use of effective urban green is the way soils are used in the city (PH; RA). Sand is often used in construction work, e.g. when roads, water works, bridges, or height differences are being built (RA). As cables and pipelines often need to be maintained or changed, sand is used in these areas as well (PH). Because a city is very dynamic and this kind of adjustments are often made, sand is an easy material to work with – the use is strongly embedded in common practices in the city (RA; PH). Sandy soils have potential for ecological value, as they are suitable for the development of a species rich vegetation. However, this soil is often covered with a layer of highly productive vegetable mould (or humus); this may work when planting grass, but a natural and mixed vegetation cannot flourish in these conditions (RA). Also, life in these soils (e.g. worms and other insects) is little, removing an important food source for bird species (PH).

[14] Natuurkaart Rotterdam, Gemeente Rotterdam, 2014, https://www.rotterdam.nl/wonen-leven/natuurkaart/Natuurkaart_Rotterdam_2014.pdf

However, sandy soils have low water-retaining capacity, which causes rainwater to end up in the sewage system; this while part of the reason why urban green is used in Rotterdam is to disburden this system during heavy rainfall (PH).

Guidelines and quality requirements

To improve the conditions of the soil in Rotterdam, Patrick Heuvelman of the municipality of Rotterdam has written a document with guidelines and quality requirements for the variety of types of soils that are used in the city[15]. This document includes special soil types for trees, planters and (grassy) verges, contributing to a more effective green management, but also soils that can be used for embankment (Gemeente Rotterdam, 2015). This enables the municipality to select a suitable type of soil in specific situations and circumstances, by providing a clear overview of all available types (Gemeente Rotterdam, 2015). In the last years, this system has been implemented in all services of the municipality, and especially in city management and city development; all soils that are processed in the city are conform the quality and composition norms as described in the report (PH). Additionally, the use of soil is circular in the city, as used soils are upgraded to the quality standards, and reused elsewhere (PH). With these systems, environmental conditions can easily be improved, resulting in higher biodiversity, healthier trees and plants, and a better buffer for the effects of climate change. Because good quality soil does not only result in better drainage but can also contribute to decreasing the heat island effect when the percentage of rocks (and therefore sand) in the soil is minimised (PH).

Pavement

In Rotterdam, most of the surface is paved (RA; WB), with bricks, asphalt, or cement. It is a cheap, clean way to design a city, as the creation and maintenance costs are low (WB). However, it also happens in places where it is not necessary, which unnecessarily decreases the water infiltration capacity of the city, making the system less resilient to climate change (WB). Luckily, the idea of de-paving ("ontharding") – opening-up paved surfaces and replacing pavement with open ground, open vegetation, trees, and bushes (KO) – is gaining popularity, both among municipal employees (KO) as well as among inhabitants (WB).

Ground-breaking initiatives

Two Dutch initiatives that use this concept are "Gewildgroei"[16] (roughly translated to "wanted growth"), and "Operatie Steenbreek"[17]. The former promotes the use of their nature friendly "Living Pavement", which are tiles with holes allowing plants to grow. The latter promotes making gardens and neighbourhoods greener, aiming for a "climate resistant, healthy, and overall green society" (operatiesteenbreek.nl, 2018). The municipality also encourages making gardens less paved and

[15] Gronden en substraten in Rotterdam; Voedingsbodem voor goede kwaliteit groen in een stedelijke omgeving, juli 2015, Gemeente Rotterdam
[16] http://gewildgroei.nl/
[17] https://www.operatiesteenbreek.nl/

greener, using the slogan "tegel eruit, groen erin"[18] (tile out, green in) (WB), in order to work together towards an attractive and climate-resistant city (Rotterdam, n.d.).

City on islands

Another biophysical challenge is the fact that Rotterdam is a city that is built on islands, surrounded by water, and that these islands are all densely built-up as there is not enough room for very spacious developments (HB). In this aspect, the city differs from e.g. Breda, which is a city built on sand, surrounded by forests. This takes away some opportunities for Rotterdam, but it also creates chances to realise nature types that cannot flourish in other parts of the Netherlands – nature types related to dunes, tides, and rivers for example. It is important to look at the local characteristics of the environment, and to execute projects specifically designed for those circumstances (HB). Examples of projects focusing on the natural values of the river are the "Rivier als getijdenpark"[19] project (HB; PH), and the programme "Rivieroevers"[20] (KO).

Nature development focussing on rivers

The first is a regional programme consisting of multiple local projects, in Rotterdam and its surroundings, aiming to improve existing tidal areas and to create new, vital and attractive ones. These areas are beneficial to the economy – they attract entrepreneurs and people –, to nature, and to water safety. The projects also aim to bring the city and nature closer together by making the river more approachable (Gemeente Rotterdam, 2016b). With these projects, some rugged nature is created in the middle of the city, bringing together biodiversity, recreation and an improved quality of life (HB). For this programme, the municipality works together with multiple other organisations, like the WWF (Gemeente Rotterdam, 2016b).

The second programme is local, focussing on the rivers Nieuwe Maas, the Schie, and the Rotte, and commissioned by the college of Mayor and Aldermen of the municipality. It is in cooperation with a wide range of parties, including the inhabitants, the harbour, Rijkswaterstaat, the province of Zuid-Holland, the water boards, and WWF, as it both includes project of own initiative of the municipality, but also tries to connect with existing projects and supports initiatives of other parties (including the Rivier als Getijdenpark programme). It aims to make the rivers more lively, attractive, natural, and characteristic, contributing to a more attractive, economically stronger and future-oriented Rotterdam (Gemeente Rotterdam, 2016a). Certain benefits of urban nature are mentioned, including a more attractive environment suitable for recreation and other activities (benefitting the economy), and improved resilience towards climate change.

[18] https://www.rotterdam.nl/wonen-leven/tuintips/
[19] Rivier als Getijdenpark Groeidocument 2018, Gemeente Rotterdam, https://www.rotterdam.nl/wonen-leven/getijdenpark/Getijdenpark.pdf
[20] Rotterdamse Rivieren: levendiger, aantrekkelijker, natuurlijker, maart 2016, Gemeente Rotterdam, https://www.rotterdam.nl/wonen-leven/rivieren/Programma_Rivieroevers.pdf

Summarising table

Table 5 Summarising table of the challenges found in the Rotterdam-case, divided into political challenges, management challenges, societal challenges, and biophysical challenges. A short description of potential policy instruments to help tackle the specific challenges is added, as discussed in the interviews.

Political challenges	
Local politics	Nature-inclusive building: including ecological values and the implementation of green/natural elements during the planning and execution of urban development plans. Used in order to achieve some nature development, even when local politics are mainly right winged.
National politics	The new vision the Rijke Groen-Blauwe Leefomgeving, introduced by the province of Zuid-Holland, to keep protecting animal and tree species, including their habitat and related ecosystems after the change of nature protection law in 2018.
Political processes	To encourage decision-making and taking action in a nature-favouring way by the laid-back municipality (due to issues related to finances and re-elections), multiple parties send documents to all city council members including suggestions for green, sustainable development.
Management challenges	
A shared vision	Rijke Groen-Blauwe Leefomgeving allows the cooperation with multiple actors, looking at nature from a perspective of safety, health, climate adaptation and biodiversity. It supports green initiatives and the renewed connection of blue and green infrastructures, among others. Groene Metropool by Staatsbosbeheer invites stakeholders from varying scales to think about the natural environment in a border-crossing way, creating a likeminded people to create a physical network of green infrastructure throughout the city and to the natural city's surroundings.
Common practices	Changing common practices by changing the mindset: always using green/natural elements except when physically impossible, instead of only using them when it is obligated by e.g. law. Certifications and subsidies can be used to change common practices from nature-exclusive to more nature-inclusive (e.g. more ecologically valuable green roofs).
Knowledge and data	Laws that obligate the inclusion of nature when conducting construction and development projects (conserve existing values, like the presence of certain animal or plant species), and to include ecologists when creating the projects. Ecological information is provided to policy makers, designers, and planners, e.g. by the municipality (using the documents of BIJ12), for them to be able to take little ecological knowledge into account during all project phases.
Budget for nature	To generate more budget for the creation and maintenance of natural elements in and surrounding the city, joint funding can be used; this can be achieved both between departments within one organisation (e.g. the municipality), but also between organisations. De Groene Metropool (SBB) encourages joint funding by bringing together stakeholders that may benefit from the same green infrastructures.

Societal challenges	
Strong agricultural lobby	-
Good intentions but lack of execution	To encourage people to adopt environmentally-friendly behaviour, involve them more to enjoy the positive effects – e.g. creating neighbourhood gardens. Supporting green initiatives, like the Dakakker on the Schiekade (Milieucentrum Rotterdam).
Negative effects of recreation	Minimising the negative effects of recreation by the use of zoning, strict guidelines, and preventive measures.
Biophysical challenges	
Pressure on space	Bomenstructuurvisie: a plan from the municipality to allow for some ecological value in very densely built-up areas of the city, by categorising trees based on their size and habitat requirements. Natural areas near the city: to allow for inhabitants to enjoy nature, multiple natural areas surround the city; some of them owned by the municipality but managed by external parties, others owned by the Recreatieschap. Varying ratios of recreation versus nature development are applied in these areas.
Soil	Guidelines by the ecologists of the municipality are made, including requirements for the quality of different types of soil used in the city; this is done in order to maximise the ecological value of the soil, while still allowing for other infrastructures and used in the city.
Pavement	Bottom-up green initiatives exist to decrease the amount of paved surface in the city; these include “Gewildgroei” and “Operatie Steenbreek”
City on islands	To benefit from the geographical characteristics of Rotterdam, multiple projects focus on maximising natural value of the rivers near the city. Examples are the regional programme “River als getijdenpark” and the local programme “Rivieroevers”. Both programmes consist of multiple projects aiming to improve ecological value of the rivers, while making them more appealing for recreational activities and enhancing resilience to climate change.

Results III: International study, storylines

In this part of the results, the storylines found in the international study, with their relation to the four themes of climate change, the natural environment, the economy, and security, are discussed. During interviews conducted for the international case study, three major storylines were discussed. The first discusses the current attention to nature-based solutions on the international level, and how the degree to which this relatively new approach is implemented on a national and local level differs between countries. The second storyline also touches upon the subject of whether NbS are implemented or not, looking at other national and local priorities at hand that are of influence. The third discusses only the countries and cities that use nature-based solutions, looking at how local characteristics are key to how and why natural areas are being developed in order to address issues related to the environment. All three storylines are discussed using only the themes that were clearly discussed by the interviewees (the themes being natural environment, climate change, economy, and security).

1. Varying attention for nature-based solutions due to due to lack of willingness and differences in political structures

Over the last years, increased attention has been given to nature-based solutions on the international level (CH; JM). This is partly due to increased severity of problems related to climate change (CH; PM) and biodiversity loss (JM). The effects of climate change are increasingly affecting life on earth (CH). Biodiversity levels are continuously dropping, both due to climate change and the overall increase of humanity's ecological footprint since the industrialisation in the 1960s and 1970s (JM). Additionally, global urbanisation results in an increased demand for resources and services, making cities hotspots of both production and consumption (JM), which increases the demand for energy and resources and, consequently, the pressure on nature (CH). In fact, the uncontrolled sprawl of cities worldwide is responsible for roughly 15 percent of all species extinction (PM); in the future, this leads to the potential loss of up to 480.000 km^2 of natural habitat worldwide, according to the Nature in the Urban Century report[21]. As one of the interviewees stated: "If you want to save nature, you also need to go to the cities, where the people are" (PM).

In short, the interviewees made it clear that pressing environmental problems lead to attention to and implementation of various approaches to nature-based solutions in cities, like green infrastructure and ecosystem-based approaches. These concepts were first institutionalised in the global initiative Countdown 2010[22] (CH) and the United Nations Conference on Sustainable Development in 2012 (also known as Rio 2012 or Earth Summit 12) (RH). The concept of NbS has

[21]https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_NatureintheUrbanCentury_FullReport.pdf

[22] A programme aiming to reach biodiversity goals by 2010 (CH); https://www.iucn.org/content/countdown-2010

been picked up by a large number of international organisations, including the World Wide Fund (WWF; JM), the International Union for Conservation of Nature (IUCN; CH), the Global Environment Facility (RH), and the Nature Conservancy (PM). Additionally, multiple programs have emerged that (partially) focus on nature in cities, such as the Horizon 2020 programme[23] of the European Commission (CH) and the One Planet Cities Challenge[24] (JM). These kinds of programmes create context, opportunities, and sometimes budget for cities to start working on NbS (CH; RH). The popularity of NbS in projects like these can be explained by the way it manages to tackle both climate change mitigation and adaptation issues while remaining practical for implementation, as well as relatively easily understandable and relatable to the public (RH).

Willingness to contribute

All interviews discussed the differences between countries (and subsequently a country's cities) in whether they implement nature-based solutions, and for what reasons. For example, some cities promote NbS as a new solution to climate change related issues, while others continue to use traditional solutions (CH). During the interviews, the potential benefits for the environment were thoroughly discussed; however, it was also mentioned that nature cannot solve every environmental problem everywhere (PM). Multiple differences between cities and countries were discussed, and how these affect NbS implementation. One factor that influences the implementation of NbS is whether a country is willing to work on issues related to climate change or biodiversity (CH; JM; RH). This willingness can be influenced by the degree to which a government feels responsible for climate change (RH). The feeling of responsibility may be low when a country has contributed relatively little to climate change, and/or when there are other pressing development challenges related to the economic situation and access to energy and resources (RH). Another factor is consensus on the existence of man-made climate change, which is lacking in, for example, the current US government (PM).

The interviewees remained positive about countries contributing to climate change measures: apart from some unwilling countries, most countries, both developed and developing, acknowledge the importance of climate change adaptation and mitigation due to the impacts of climate change (JM; PM; RH). They are often willing to work on nature-based solutions because of the resilience and adaptation benefits to reduce impacts like flooding and the urban heat island effect (JM). This awareness for adaptation and resilience measures can be induced by a crisis: an example is the city of Cape Town, where increased attention is given to nature as a way to enlarge freshwater resources is since extreme droughts have been affecting the city (PM). Crises like these create urgency to start looking at innovative, (CH) cost-effective and efficient ways to tackle the problems at hand (PM) – which can be nature-based solutions (JM; PM). The problems in Cape Town are for example

[23] https://ec.europa.eu/programmes/horizon2020/en/
[24] https://wwf.panda.org/our_work/projects/one_planet_cities/

addressed by the installation of the Cape Town Water Fund (PM), which will be further discussed in the Challenges-section of this chapter.

Willingness of a city or country to invest in NbS can also be influenced by the attitude of the local leader, like the mayor or the city council, and how the priorities and personal beliefs of this leadership are manifested into a city's policy and management (CH; RH). In some cases, choices regarding sustainability are made based on these personal beliefs, rather than on there being a clear financial case or quantifiable benefits for it. For example, this pro-active mindset (among other factors) resulted in African countries like Uganda, Kenia, and Ruanda to be ahead of the pack (compared to other African countries) in terms of managing their environment (RH). Another example of local leaders manifesting their beliefs in policy is taking place in the US, where local policy makers (e.g. mayors of cities in the C40 network[25], and governors as part of the U.S. Climate Alliance[26]) have pledged to continue working on climate change goals, regardless of the beliefs of the national government (PM).

Political structures

Another factor influencing the involvement in NbS is the political structure of the local or national governments (JM; RH). One aspect that was mentioned by most interviewees is how the political hierarchy is structured: who to look for when it comes to power (CH; JM) or responsibility for a particular subject (RH). Within a government, responsibilities for a wide variety of themes are divided among ministries, including conservation and environment, but also water, agriculture, forestry, etc. (this compartmentalisation will be further discussed in *Challenges)*. The way these ministries are framed, which responsibilities are assigned, and what the budgets are for varying ministries, often reflects the priorities of the government (RH). Whether the responsibility for climate change is allocated to the ministry of energy or the ministry of agriculture, for example, reflects how a country frames an environmental problem like that (RH).

The amount of resources available for environmental issues varies significantly between different countries. This influences the degree to which the respective ministries can contribute to solving these problems (e.g. whether they are able to participate in international conferences, or how large the delegation is that is sent to top negotiations; RH). The amount of available resources be linked to the economic situation in a country, as priorities of a government are often defined by the economic situation and how this situation is perceived. Examples can be found in multiple African countries, facing and prioritising issues regarding poverty and land distribution to the poor (RH). Governmental priorities are further discussed in the next subchapter and in *Results international case: challenges and policy instruments – Political challenges – Priorities and responsibilities of the government*.

[25] https://www.c40.org/press_releases/american-mayors-pledge-climate-leadership-in-response-to-united-states-presidential-election
[26] https://www.usclimatealliance.org/

2. Prioritisation of other pressing issues

By most interviewees the existence of pressing issues and the way this influences the (successful) implementation of nature-based solutions was discussed. Mainly the difference between developing countries and more developed countries was mentioned: whereas some cities have enough budget and capacity to invest in the natural surroundings and green urban areas, others are more likely to spend most resources on tackling challenges related to the economic situation or security. In this subchapter, this storyline will be discussed looking at the themes *economy* and *security*. These themes showed up most clearly; no clear link was found for the themes *natural environment* and *climate change*.

Nature development versus urban development

Multiple interviewees discussed the effect of economic development issues on the implementation of nature-based solutions. Often the mentioned effect is negative: challenges related to the economy and economic development lead to a decrease in implementation. For example, in India, China, and multiple African countries, there are large goals set for urban development due to increasing urbanisation, mainly when it comes to infrastructure and housing. This will have significant impact on ecosystems in and surrounding the countries' cities (CH). However, one of the interviewees (MN) was involved in the execution of a large research (the earlier mentioned study Blind Spot[27]), which explores the positive link between economy and landscape (including nature), and describes nature as an increasingly important condition for a valuable business climate for companies and organisations.

The study makes a distinction between cities in terms of the level of development, and the priorities that exist when it comes to investments in the urban landscape. It distinguishes three layers of conditions for investment in a metropolitan landscape, shaped into a pyramid: basic resources and services for liveability on the base of the pyramid, experience and access of the landscape in the middle, and image and identity at the top (see also Figure 1). This shows that for some cities investing in the attractiveness of the landscape may be of second priority, as some of the primary conditions are not fulfilled. Cities may face economic problems like lack of employment opportunities or poverty, making investing in nature seem irrelevant (CH; RH). Other cities have invested enough in the base of the pyramid and on access to the landscape, creating opportunities for investing in nature and the city's identity. In fact, some cities in the Netherlands (like Eindhoven) currently face a problem of highly skilled people leaving the cities due to a lack of amenities and attractive landscapes (MN).

Most interviewees emphasised the notion that when cities address the challenges that are prioritised, the solution should go hand-in-hand with the preservation (or even creation) of the

[27] https://www.dropbox.com/s/kbowvmke9va71qt/20160419_Blind-Spot_metropolitan-landscape_deltametropolis.pdf?dl=0+

metropolitan landscape (CH; MN; RH). In this way, the natural landscape can contribute to the economic attractiveness of the city (Vereniging Deltametropool, 2016), while avoiding a decrease in biodiversity and natural values (CH; PM). For cities in the developing world, nature-based solutions can in theory be of great value due to their potential of generating a large variety of benefits (JM). Additionally, using nature as a solution is relatively cheap, as it can often be implemented using local resources and without expensive maintenance (RH). However, successful implementation does require political priority and capacity in terms of budget and implementation skills of actors, which are factors that are often lacking (CH). All interviewees encouraged a pro-active attitude towards nature-based solutions by all countries, emphasising the potential opportunities and benefits.

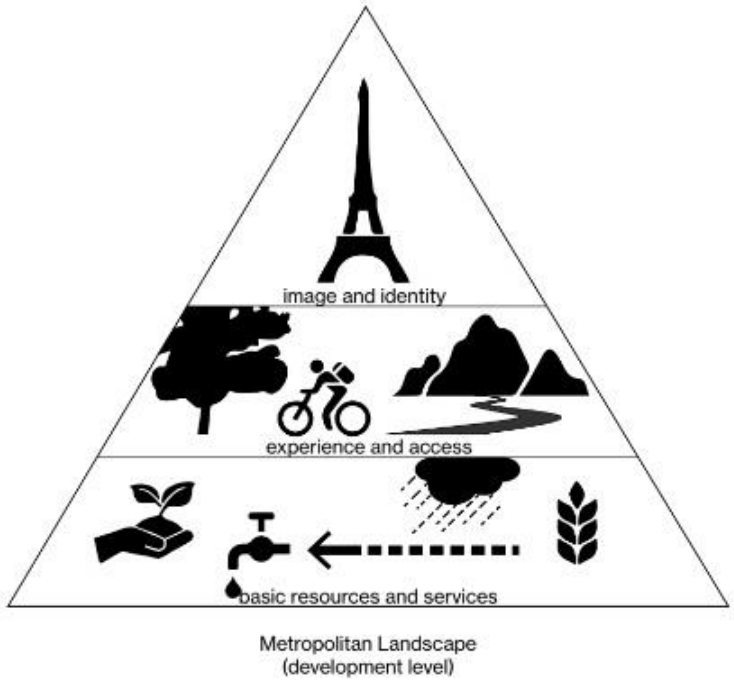

Figure 2 Pyramid of development of the metropolitan landscape, conducted from the study Blind Spot by Verenging Deltametropool (2016). The first condition is the availability of basic resources, also described as "supporting services for a reasonable quality of life", including clean air, drinking water, and storm water capacity. The second layer consists of attractive features and accessibility to the metropolitan landscape. The third layer is the existence of a unique metropolitan landscape identity, contributing to the regional and corporate strength in the global competition.

Nature development in a war zone

One of the interviewees mentioned the assumption that in countries and cities where security is an issue due to war or the threat of terrorism, investing in nature is often not seen as a priority (RH). Spending money for nature is believed to be unsustainable in a war-zone environment as it is often ineffective and monitoring whether resources are efficiently spent, or even diverted to other causes, is difficult (RH). Additionally, governmental spending on topics related to the environment may seem irrelevant to the public (RH). Ideally, initiative would be taken from a bottom-up approach

rather than from top-down, as a result of awareness among inhabitants about the importance of nature and a healthy environment (RH).

According to the same interviewee, nature should be one of the first things to invest in in a (post-conflict) world, due to the numerous benefits and side-benefits of a natural environment (RH). In countries that face challenges related to security – South-Asian countries like Afghanistan or Pakistan, for example – people are often dependent on nature for their food, water, and livelihood security (JM). People migrating from rural areas to cities are expecting a lot in terms of economic development, as often promised by the government (JM). When such promises fall short, people tend to fall back on what they know best, which, for example, can be urban farming and other ways of exploiting nature for a (more) stable livelihood (JM). Sensible and sustainable management of those natural resources will therefore result in improved living conditions for inhabitants (RH).

3. Implementation and environmental conditions of a city or country

Throughout the interviews it became clear that there are differences among countries and cities when it comes to the type of nature-based solutions are used, and for what reasons and to what extent they are implemented. As interviewees stated, there is not a single approach or solution that is applicable to all cities (CH; PM). In other words, a project that works well in one situation, can have completely different outcomes in another (RH). There are two themes that have a strong connection with this statement, both related to the environmental conditions of a city or country: *natural environment* and *climate change*. Combined they create the storyline that makes environmental conditions decisive for the choice and implementation of nature-based solutions.

Landscape characteristics

One of the factors influencing differences in nature-based solutions that was often mentioned in the interviews, is what kind of landscape can be found in and surrounding cities (MN). An important factor is whether the city is coastal or situated near a river, which makes flooding an important threat to the city due to sea level rise and storm water (CH; PM). Conversely, if a city is located in a dry or desert-like area, lack of water or the heat island effect are more severe threats, leading to other uses of nature to help tackle these problems (CH). For all these threats, both nature-based solutions and more traditional infrastructure solutions can be of help (CH). The extent to which NbS will be used (at all, or in a combination with hard infrastructure) is dependent on the local circumstances (CH). Popular solutions for storm water are for example restoration of wetlands (CH) or mangroves (PM; RH), often in combination with building dykes (CH).

Another factor that influences the use of NbS is the existing quality and quantity of existing natural areas. To explain this, look at two examples with different management approaches. The first is Rio de Janeiro, with multiple nature reserves within city boundaries, including one of the largest urban tropical rainforests worldwide (Tijuca Park; MN). The second is the city of Vitoria-Gasteiz in Basque country Spain, situated near the wetland reserve Salburua (CH). In Vitoria-Gasteiz, a green

belt is created around the city, connecting the city parks with the surrounding natural areas. Due to high natural values, parts of this belt are protected under Natura2000 (CH); the city was named the European Green Capital of 2012[28]. This connection improves the access to the nature reserve, both for recreation and biodiversity.

In Rio de Janeiro, on the other hand, natural values were already present in the city, creating opportunities for improved livelihood and recreational activities within the city's boundaries (MN). However, due to these protected nature reserves, the city faces a challenge regarding demand for residential and business areas, which increases due to urbanisation (MN). Many of the worker-class inhabitants in Rio de Janeiro do not have easy access to the natural areas, since these are located near rich neighbourhoods. At the same time, informal urban sprawl (slums) threatens natural areas; these consequences should be understood, considered, and minimalised when sustainably developing the city (MN; PM).

Some cities (like Milan and multiple Dutch cities) are situated in highly cultivated landscapes. Here, other approaches of nature-based solutions and green infrastructure can be used to provide for the demand for natural values and recreational activities: either by creating value in an originally less valuable landscape (MN), or by putting more emphasis on the creation of nature in cities, for example by creating urban parks (PM).

An important notion from the interviews is that cities, regardless of the landscapes they are situated in, should aim to maximise natural values or urban nature (MN) and to use the natural resources and benefits in a sustainable way (CH). A first step is to make the existing landscapes accessible and to further develop the cultural-historical or ecological values present (MN). Another step is to enhance the values of the present iconic places in and surrounding the cities, for example by restoring and beautifying waterways and water bodies (RH). This will not only result in improved ecological and recreational values, it also has potential to contribute to solving issues related to climate change (CH) and to boost the local economy (MN), for instance by promoting ecotourism (JM).

Climate change

The problem of climate change was highly emphasised in the study: the continuously changing climate increasingly challenges societies all over the world (RH). The effects of climate change differ between cities, which results in other approaches of decreasing these impacts (PM). First and foremost, this is dependent on the location of a city, as discussed in the previous paragraph. The severity of the effects influences the approaches as well. Cities in countries that are heavily affected (e.g. coastal cities in the Philippines, Indonesia, and India) often place emphasis on *adaptation* and resilience, as the impacts in terms of flooding may be quite extensive (JM). Also, when a city faces large issues related to air pollution, like the Chinese city of Beijing, nature may be a part of the

[28] http://ec.europa.eu/environment/europeangreencapital/winning-cities/2012-vitoria-gasteiz/

solution to diminish these problems (PM). In countries less visibly threatened by climate change, like Sweden or France, solutions for climate change *mitigation* are often more present on the agenda (JM). However, the context of these issues should be understood, in order to evaluate the potential benefits of NbS in a specific situation; when the problems are too severe, other solutions may be a better first go-to for policy makers; PM).

Summarising tables

Table 6 Summarising table of the storyline *Varying attention for nature-based solutions due to lack of willingness and differences in political structures*, as discussed in the international study. The links between nature-based solutions and the themes climate change, natural environment, economy, and security are briefly described.

Varying attention for nature-based solutions due to lack of willingness and differences in political structures	
Pressing environmental problems lead to attention for nature-based solutions in cities on the international agenda. This leads to more implementation; however, some countries and cities express less or no willingness to do so, due to either the feeling of not being responsible for current climate change problems, or lack of local leadership. Additionally, the political structure of a country or city can be of influence when it comes to whether NbS are implemented or not, starting at the allocation of the responsibility to do so.	
Climate change	Climate change is the most important environmental problem that is mentioned by interviewees and that can be addressed by the implementation of nature-based solutions. Knowledge and awareness of climate change is continually increasing, making it an important topic on the international agenda. Not all countries/cities feel responsible for climate change, as it is mainly caused by countries in the developed world.
Economy	The economic situation of a country or city is an important factor in the level of attention to climate change. First is the difference mentioned under Climate change, between developing and developed countries. Second, the economic situation of a country often dictates whether climate change is a priority, and how much budget is allocated to adaptation and mitigation.

Table 7 Summarising table of the storyline *Prioritisation of other pressing issues*, as discussed in the international study. The links between nature-based solutions and the themes climate change, natural environment, economy, and security are briefly described.

Prioritisation of other pressing issues	
Economy	Priorities regarding economic development are visualised using the study Blind Spot (2016), distinguishing three levels of conditions for the development of the metropolitan landscape. According to this study, a healthy, green environment becomes a priority when a city has sufficient provision of basic resources and services. However, for cities especially in developing countries, these basic conditions are not met, which makes investing in the natural environment of secondary importance.
Security	When a country or city faces serious threats regarding the livelihood of inhabitants, for example due to war or terrorism, investing in nature is of secondary priority, even though livelihood security could improve when the natural environment remains healthy.

Table 8 Summarising table of the storyline Prioritisation of other pressing issues, as discussed in the international study. The links between nature-based solutions and the themes climate change, natural environment, economy, and security are briefly described.

Implementation and environmental conditions of a city or country	
Natural environment	The geographic location of a city (e.g. whether it is coastal/near a river, or situated in a desert-like landscape defines which effects of climate change must be dealt with) and the natural values of the existing surrounding landscape are important factors that determine the type of NbS that can be used in a specific city.
Climate change	The severity of the effects of climate change define whether a city focusses more on climate change adaptation or on climate change mitigation.

Results IV: International study, challenges and policy instruments

This part of the results discusses the challenges in implementation of urban green elements as discussed in the international study. Again, the challenges are divided in four categories: political challenges, challenges related to management, to public involvement, and to the biophysical characteristics of the city. These challenges are discussed by looking at how they result in the choice and implementation of certain policy instruments (including motions, projects, conservation plans, etc.).

Political challenges

Priorities and responsibilities of the government

As discussed in the first storyline, many countries and cities express a lack of interest in environmental problems due to other, more pressing concerns (JM; RH). As a result, the implementation of nature-based solutions may not come up as a priority, or as a solution to these concerns (JM). Nevertheless, issues like air pollution, water security, and drought are becoming more pressing by the day (JM; RH), affecting people's livelihood and safety in ways that cannot remain ignored (PM). In some cases, this leads to more attention for NbS, especially when tackling problems related to air pollution and water quantity and quality (JM). However, this mix of problems can also result in a nation creating contradicting target. For example, the country of South-Africa aims for economic growth in the next couple of years, with an increase in exportable commodities and job availability. Meanwhile, the country targets to decrease overall greenhouse gas emissions (RH). A lack of capacity and resources leads to tackling these problems in an ineffective, even hazardous way, rather than by the implementation of efficient, sustainable solutions. As a result, these contradictions are not solved, and deadlines related to climate change mitigation and adaptation targets have to be postponed (RH).

The governmental organisation of a city or country can influence whether and how the city works on issues related to the environment: in terms of leadership (CH) and the structure of the municipality in terms of departments and, respectively, the assigned responsibilities (JM; RH). (Political) leadership can be vital when it comes to the implementation of nature-based solutions (CH). When national leadership in this area is lacking, the work by both municipal organisations and other organisations is affected (PM). Departmentalisation, as discussed in the paragraph *Political structures* of the previous subchapter, can become a problem when new responsibilities occur within a municipality, which are to be assigned to an existing department (JM; RH). Departments are often not eager to adopt new responsibilities; translating a new concept into existing work can be a technical challenge (RH), especially when there is a lack of capacity within the department and/or cooperation among departments (JM).

There are multiple possible ways to overcome these political challenges, either by trying to convince governmental actors to act, or by shifting action to other (local) stakeholders. For the latter, the earlier discussed example of the United States is relevant: the national government expresses no urgency to tackle climate change, therefore local leaders like mayors and governors take responsibility to act instead (PM). As one of the interviewees stated, it is more effective to work with people that are acceptive and care about the problems, rather than to try to convince people that are not likely to change their minds (PM). This can be governmental stakeholders, but sometimes the private sector and the public can play a role as well and carry responsibilities: these actors are not restricted by the short time-span in which governments often have to work, especially when looking at the conservation of areas on the long-term (RH).

H2020

An important source of projects that activate municipalities, civil society actors and the private sector to work on goals related to climate change and biodiversity by using nature-based solutions, are projects that are financed under the Horizon 2020 (H2020) programme of the European Commission (CH). This programme is a five year financial instrument aiming to secure Europe's global competitiveness and to tackle societal challenges, supporting cooperation between the public and private sectors in launching projects that result in smart, sustainable, and inclusive growth (European Commission, n.d.). This programme has led to several initiatives focussing on nature-based solutions in cities, like the GrowGreen project, which is a partnership for greener cities in order to increase liveability, sustainability, and business opportunities[29]. The inclusion of a city is dependent on the willingness of a city's municipality, but involves multiple other stakeholders in decision-making, implementation, and knowledge-sharing (CH).

The value of nature

A large challenge in finding support for varying approaches of using nature-based solutions is making (governmental) actors see and understand the resulting benefits and advantages of such an approach (JM; RH). This is due to a couple of characteristics of these benefits. Firstly, benefits related to green or natural surroundings are not always clearly and/or immediately visible (JM; RH), like benefits related to health and pollution reduction (JM). Secondly, the benefits are not always quantifiable (CH; RH), while actors often look at and calculate what is generated from investments before making them (CH), and prefer solutions that gain immediate, clear profit (RH). Thirdly, investment in nature often generates benefits on a long-term (CH; RH). This is especially the case for, for example, ecosystem-based approaches of NbS, when (parts of) ecosystems (and, consequently, the benefits) must be completely restored (RH). Lastly, benefits related to health and environmental problems are diffuse, not only benefitting the investor but also other actors – they are public goods (CH) (as also discussed in the Rotterdam case).

[29] http://growgreenproject.eu/

Because the benefits of nature are as invisible, not-quantifiable, long-term, and diffuse as they are, investors often see investments in nature as risky, which makes it harder to involve them in the implementation of nature-based solutions (CH; RH). However, during the interviews multiple policy instruments and solutions came up. The two most discussed solutions will be further explained in the following paragraphs.

Providing research

Research on the benefits of nature can be helpful in convincing actors to start investing in nature-based solutions (RH). One example is the previously discussed study Blind Spot, looking closely at the benefits of natural surroundings to the (knowledge) economy of a city (MN). Another study is the Green Heart Project[30], conducted in the city of Louisville, Kentucky, in the United States (PM), by a large partnership including the Nature Conservancy, the Louisville University, the U.S. Forest Service, and the Hyphae Design Laboratory (The Nature Conservancy, n.d.-a). The city has air quality that is among the worst in the US, due to its geography and the fact that it is an important harbour for UPS (PM). The Green Heart Project is a five-year urban laboratory investigation, measuring the power of greenery as a public health strategy in Louisville neighbourhoods (The Nature Conservancy, n.d.-a). For this, approximately 8,000 trees, plants and shrubs are planted throughout certain neighbourhoods, which will be compared to adjacent neighbourhoods that have not been greened up using a set of parameters, related to both physical and mental health (PM). This study is the first ever clinical trial in this size where nature is the pharmaceutical, and it is already been copied in other cities (PM). Studies like the Green Heart Project and Blind Spot highlight the benefits of NbS in a scientific way.

Involving and connecting actors

One reason why implementation of nature-based solutions can be lacking, is the lack of (successful) examples of nature-based solutions (CH; RH). Good examples can be a strong way of convincing other actors to act in a similar way, creating a dialogue between different cities and actors and a common understanding of the values of nature and nature-based solutions (CH). City networks can play an important role in increasing the understanding and knowledge of innovative concepts like nature-based solutions among cities worldwide, by pro-active sharing of information, working together, and sharing experiences (JM). Some examples include the ICLEI[31] network, mentioning nature-based development as one of their five pathways. Another example is C40 cities[32] provides a City Solution Platform, in order to find innovative best-practice solutions for megacities (however, NbS are not specifically named), by encouraging for collaboration between cities and creating a shared understanding of the problems faced by cities (C40, 2019). The Rockefeller 100 Resilient

[30] https://www.nature.org/en-us/about-us/where-we-work/united-states/kentucky/stories-in-kentucky/green-heart-project/
[31] https://www.iclei.org/
[32] https://www.c40.org/

Cities Network[33] partners with cities as they hire a Chief Resilience Officer and develop and implement their resilience strategy (100 Resilient Cities, 2019). The main effect of these networks is the creation a global movement by sharing solutions, challenges, and benefits regarding climate change adaptation and mitigation (JM).

Other initiatives to bring together actors are also mentioned in interviews, including a conference organised by the GrowGreen project[34], in cooperation with IUCN. The aim is to convince investors of the benefits and the potentials for a business case of NbS, by showing examples and encouraging a dialogue between parties (CH). Another initiative that was mentioned, mainly focussing on the private sector, is the Natural Capital Coalition[35]. This international collaboration uses the natural capital approach, which supports the understanding that natural, social, and economic systems interact, impact, and depend upon one another, leading to better informed decisions with co-benefits for all systems (The Natural Capital Coalition, 2019). WWF is also doing work on city collaboration for nature-based solutions, including One Planet Cities[36]. This program broadly focuses on getting cities to work on climate emission reductions, city resilience, and adaptation-related issues, also encouraging the use of NbS to tackle these issues (JM).

Management challenges

Lack of resources and time

A problem in some countries is the allocation of insufficient resources for successful implementation of nature-based solutions and the execution of nature-related projects (RH; PM). In the case of projects, limited budget and time may result in rushed jobs, not allowing for the in-depth research and community consultation that would be desire (RH). When it comes to nature-based solutions in cities, the available budget is depending whether or not, to what extent, and in what way green spaces are created, managed, and maintained (PM). Some city municipalities have reserved no specific budget allocated to urban green, resulting in a decline of green due to lack of maintenance, upcoming diseases, or urban development (PM).

External aid

There are multiple ways for a country to receive finances for nature development when the national budget is limited. The first one, mentioned by one of the interviewees (RH), is the receiving of external aid, of which some countries are heavily dependent for their national operating budgets. Countries often offer aid for development spending, in order to contribute to solving environmental problems beyond the own national borders. Ecosystem-based approaches, for example, have been, as the interviewee described, sort of the "darling" of the UNFCCC and the post-Paris declaration, resulting in a rush of different agencies to get a flagship EBA project in a country that is expressing

[33] http://www.100resilientcities.org/
[34] http://growgreenproject.eu/
[35] https://naturalcapitalcoalition.org/
[36] https://wwf.panda.org/our_work/projects/one_planet_cities/

interest in participating in and hosting that project (RH). Even though this allows for the development of projects including NbS, the interviewee also mentioned some downsides of this type of financing. Specific funding might lead to disproportionally large amounts of attention to one area, while development in other areas remains lacking. Additionally, it often happens that countries accept funding even though the concept may have better viability elsewhere, or the country may have other priorities. In this way, a country's agenda is heavily influenced by these aids. To avoid this, multilateral agencies like the UN try to spend according to each country's needs and identified priorities (RH).

Shared financing models

As discussed previously, natural areas can have multiple benefits to society, including the improvement of air and water quality (JM; PM). As these benefits are diffuse, benefitting a large range of actors, one way to ensure the preserved benefits is by financing nature development with actor's contributions. An example where such a shared financing model is used, is the creation of Water Funds[37] in different part of the world (CH; PM), including Latin America (CH), and South Africa (PM). Water Funds, as operationalised by the Nature Conservancy, are organisations that design and enhance financial and governance mechanisms, uniting public, private, and civil society stakeholders (The Nature Conservancy, n.d.-b). These organisations aim to protect nature areas upstream of rivers through NbS, to preserve the water-cleaning ability of natural habitat, increasing water quality and quantity, and reducing the cost of water treatment (PM). Through the work of these organisations, NbS projects are financed by private and public donors (The Nature Conservancy, n.d.-b), and for a large potion by companies heavily dependent on clean drinking water, like Coca Cola and Heineken (PM). In this way, nature areas are preserved and improved, various costs are reduced, and a vital service to a city's inhabitants is ensured (CH).

Regional financing and subsidies

One interviewee mentioned a financing system for nature in cities, consisting of financing from a regional fund. This system is used in parts of Europe, including Germany (CH). For this fund, national or regional priorities are determined; municipalities and other actors can admit a proposal, for which a budget becomes available through this regional funding (CH). Another finance model, from an international organisation (such as the UN) or national government to private and civil society stakeholders, is via the allocation of subsidies (CH; JM). These can, for example, be used to convince private actors to invest in nature, making up for the decreased direct profits from nature-based solutions, compared to traditional solutions (CH). A pitfall in this system is the necessity of monitoring, to ensure proper use of the subsidies (CH). Nevertheless, subsidies have shown to be a good financing model for sustainable solutions in the past (JM), and already for the inclusion of nature in the construction sector (CH).

[37] https://waterfundstoolbox.org/

Societal challenges

Lack of public support

A challenge that came up is the lack of public support for nature development. Two reasons for this were mentioned during the interviews: other prioritised issues (CH; RH), and the lost connection with nature that can be seen in cities (CH; PM). Prioritisation of other issues by the public can mainly be found among inhabitants of either relatively poor neighbourhoods or in developing countries. There is a strong correlation between poor communities and lack of nature in a neighbourhood (PM), as a result of a lack of investments in the quality of those neighbourhoods (MN) due to other development priorities, like housing and infrastructure (CH; MN). Additionally, greening neighbourhoods has shown to have a downside, as property values in neighbourhoods tend to increase when more green spaces are added, causing gentrification (CH; PM; MN). Even though this is beneficial for the economy of the city (CH; MN), it often victimises original inhabitants that have to move due to insufficient finances (CH; PM). In developing countries, like in parts of Africa, people are more concerned with issues related to education, food, and fuel than with issues related to the environment and nature development (RH). Short-term, fast, and traditional solutions are therefore often preferred over NbS, from which benefits can be generated after multiple years (RH).

Another factor that influences public support for nature development is the connection between humans and nature. Mainly in cities with highly developed economies (like in Europe and the United States, but also in other parts of the world; CH), support for nature decreases due to a lack of this connection, fuelled by daily interactions and encounters (CH; PM). It becomes increasingly important for nature organisations and policy makers to focus on reconnecting inhabitants with their surroundings, by bringing nature back to the people (PM).

Encouraging public involvement

During multiple interviews, programs and initiatives of organisations were mentioned that try to reconnect citizens to nature and to encourage public involvement in nature management. The Nature Conservancy tries to achieve this by executing projects (like rain gardens) in cooperation with for example local schools (PM). The IUCN provides information and education for stakeholders and the public, by proper communication and training programs (CH). The WWF works on projects aiming to make local communities understand the values of nature as well, and in what ways they rely on the proper functioning of the natural environment. One example is the We Love Cities-project[38], with the goal to excite and engage inhabitants with their cities and the urban green spaces that the cities provide (JM).

[38] http://welovecities.org/

Summarising table

Table 9 Summarising table of the challenges found in the Rotterdam-case, divided into political challenges, management challenges, societal challenges, and biophysical challenges. A short description of potential policy instruments to help tackle the specific challenges is added, as discussed during the interviews.

Political challenges	
Priorities and responsibilities of the government	A large number of initiatives aim to convince governmental actors to start with addressing environmental problems in general, or specifically with the implementation of nature-based solutions. Often, this concerns actors on a local level, like city municipalities or the local private sector. Policy instruments include the Horizon 2020 financing programme of the European Commission.
The value of nature	To convince governmental actors of the importance and value of nature-based solutions, new research is conducted (including the Blind Spot study and the Green Heart Project). Additionally, city networks and other initiatives are an important factor in encouraging dialogue between cities and creating a global movement towards nature-based solutions in cities.
Management challenges	
Lack of resources and time	There are multiple other sources of money for the implementation of nature-based solutions when the local government has insufficient budget or other priorities. These include external aid (specifically for developing countries), shared financing models like Water Funds, and regional financing and subsidies (mainly from governments to local actors).
Societal challenges	
Lack of public support	Lack of public support caused by other priorities (mostly in developing countries) or by a disconnection between people and the natural environment (in the developed world) is affecting the implementation of nature-based solutions. Especially external nature organisations, like the Nature Conservancy and WWF, target this issue by projects that actively involve inhabitants with the city.

Discussion

The study aims to understand the unsuccessful and lacking implementation of nature-based solutions in cities. This is done by doing three analyses: the first one aims to understand how actors perceive nature-based solutions, and how they relate to both environmental issues and societal issues. This is achieved by analysing how nature-based solutions are related to the themes climate change, the natural environment, the economy, and security. Secondly, the study provides an overview of the most important challenges in implementation of NbS, trying to understand what hinders the implementation in practice. Lastly, a categorisation is provided of policy instruments that are used to encourage or obligate the implementation of nature-based solutions by actors in the city. Instrument selection is analysed to get a better understanding of which factors influence this process.

Storylines and their relation to the themes

The first sub-research question that is answered in the results is *what storylines shape perceptions of nature-based solutions in cities from varying actors, and how do these storylines connect nature-based solutions to the themes of climate change, the natural environment, the economy, and security?* A total of five storylines was found in the study, which all had varying connections to the themes. To better understand the context in which nature-based solutions are used in cities, the themes will be discussed using the storylines; these results will be compared to other academic studies discussing the same or similar topics.

Climate change

Quite some links were found between nature-based solutions and climate change; this is not surprising, as climate change is often mentioned when defining or introducing nature-based solutions (e.g. Kabisch, 2015; Potschin et al., 2015; Wamsler, Pauleit, Zölch, Schetke, & Mascarenhas, 2017). Nature-based solutions can contribute to both climate change mitigation and adaptation (Demuzere et al., 2014); both strategies are important, as cities tend to be more vulnerable to the threats of climate change, and the contribution of cities to climate change is relatively high due to high densities of business, industry, and residents (Hunt & Watkiss, 2011). Looking at the storylines found in the Rotterdam-case and the international study, links between nature-based solutions and both climate change mitigation and adaptation are indeed found: the need for adaptation is discussed in both studies, also concerning the specific biophysical characteristics of a city and how adaptation strategies are tailored to them. Mitigation is reflected in both studies (in *A new way of looking at nature* from the Rotterdam-case and the storyline *Varying attention for nature-based solutions…* in the international study), stating that feasible effects of climate change lead to increased awareness of the necessity of climate change mitigation.

Looking at the examples of nature-based solutions that were discussed during the interviews (specifically in the Rotterdam-case, but also in the international study), most attention is given to climate change adaptation. In other words, most solutions aim to tackle problems related to the heat-island effect or flooding, rather than to decrease emission of greenhouse gasses (with the exception of green roofs, which contribute to both adaptation and mitigation; Oberndorfer et al., 2007). This focus on adaptation in cities is researched by Hamin & Gurran (2009), concluding that little availability of space is often a reason for cities to prioritise adaptation over mitigation. They state that adaptation strategies often require more land left open in space than mitigation strategies. In case of nature-based solutions, the opposite seems true, as nature-based solutions designed for adaptation, like green facades, are often used in the city centre, while nature-based solutions for mitigation are in the city surroundings (like planting forests for CO_2 storage). Nevertheless, lack of space might be a factor influencing the choice of adaptation over mitigation strategies in Rotterdam.

Another factor that may explain why adaptation is often favoured over mitigation is the nature of both strategies: adaptation strategies benefit a specific city while mitigation strategies benefit the entire world (Hasson, Löfgren, & Visser, 2010). This is also discussed in the storyline *Prioritisation of other pressing issues*. This storyline explains why cities in developing countries often focus on adaptation rather than on mitigation. This is confirmed by Ayers & Dodman (2010), describing climate change adaptation as a "developing countries issue" due to high climate impacts but little resources. However, it does not explain why highly developed city like Rotterdam would do the same. In fact, both the storyline and Ayers & Dodman (2010) state that developed countries with relatively little felt consequences of climate change will (also) invest in climate change mitigation. This creates a knowledge gap, which leaves the question why implementation of nature-based solutions for climate change mitigation remains lacking in developed countries unanswered. This creates an opportunity for further research.

Natural environment

The storylines that were discussed in the study show that the natural environment has multiple links with the implementation of nature-based solutions in cities. The first link describes the creation of healthy and functioning ecosystems as an objective of nature-based solutions, mainly discussed by the storyline *Nature versus green*. This link is also found in literature (including Faivre, Fritz, Freitas, de Boissezon, & Vandewoestijne, 2017; Pauleit, Zölch, Hansen, Randrup, & Konijnendijk van den Bosch, 2017), describing sustainably managing the natural environment as one of the key features of successful implementation of nature-based solutions. However, the storyline describes that ecological values of nature-based solutions are often not maximised due to lack of resources, knowledge, or attention. Andersson, Borgström, & McPhearson (2017) confirm the importance of understanding the ecosystem, stating that ecosystems and their own dynamics and characteristics should be fully understood for us to understand how they mitigate climate

change. This shows that knowledge and attention might be even more important to successful implementation of nature-based solutions than was shown in this study, as not only ecological values are compromised by unsuccessful management.

The second link between nature-based solutions and the natural environment describes a healthy ecosystem as a prerequisite, rather than as an objective, for successful nature-based solutions. This relation is found in the storyline *Implementation and environmental conditions of a city or country* from the international study. The necessity of a healthy ecosystem in order to provide a basis for nature-based solutions and to deliver ecosystem services is also discussed in literature, for example in Potschin et al. (2016) and Faivre et al., (2017). Andersson et al. (2017) make a distinction in external and internal insurance: the first being the capability of nature to protect urban systems from impact of disturbances in weather and climate, and the latter being the resistance and resilience of ecosystems themselves. In order to give cities external insurance, internal insurance needs to be guaranteed. An approach that is based on this idea is the ecosystem-based approach (as discussed in the international study): this approach is based on the capacity of nature and its sustainable delivery of ecosystem services to help protect communities against the impacts of climate change (Munang et al., 2013). The same storyline adds that existing ecosystems and natural elements are defining in which nature-based solutions are suitable for a specific location or city. As Nesshöver et al. (2017) state, nature-based solutions should be designed according to the incentive, but based on current local circumstances.

Economy

Multiple links between the economy and the use of nature-based solutions are discussed in the study. In the Rotterdam-case, the storyline *A new way of looking at nature* explained that nature development on the local level becomes more important when the economic situation improves. Additionally, nature in cities proves to be beneficial for the economic situation, increasing the value and attractiveness of the city for entrepreneurs, inhabitants, and tourists. This value of nature-based solutions for the economic situation is supported by literature: (Maes & Jacobs, 2017) state that the double goal of economic growth and sustainability can be achieved by investing in nature-based solutions. This is relevant for both developing and developed countries, as any region's economic competitiveness and security is dependent on sustainable use of natural resources (Maes & Jacobs, 2017). Also the wider social and environmental competitiveness, including resilience and adaptation to various challenges, is dependent on this sustainable use (Potschin et al., 2015).

Another link in the international study shows a more restraining factor of economic situations: multiple interviewees discussed how limited resources, in combination with problems related to hunger and poverty, result in the prioritisation of other issues in developing countries. According to the storyline *Prioritisation of other pressing issues*, developing countries should in fact first invest in achieving a sufficient, sustainable level of basic resources and services before investing in the natural environment and in solving problems that are caused by developed countries. These

inequalities are acknowledged in literature (e.g. Ayers & Dodman, 2010), but not all studies agree with this long-term approach. Climate change has the most severe effects on lower-income populations, putting climate change adaptation high on national agendas (Ahmed, Diffenbaugh, & Hertel, 2009; Ayers & Dodman, 2010). Ayers & Dodman (2010) state that adaptation should always go hand in hand with economic development, for example by reducing poverty, providing health benefits, improving living conditions, etcetera. Not only will this help fight climate change in the present, improving these conditions will lead to increased capacity to help tackle climate change in the future (Ayers & Dodman, 2010). Nature-based solutions have the potential to help meeting multiple needs at once, which are dependent on both the city's biophysical conditions and socioeconomic factors (Andersson et al., 2017).

Security

The theme of security can be interpreted in multiple ways in relation to nature and nature-based solutions, according to the findings in the study. Firstly, the benefits of nature (and therefore also nature-based solutions) for various aspects of security are acknowledged, including livelihood security (mainly found in the international case), climate security (found in both cases, also connecting security with the theme of climate change), and health and safety (acknowledged by most interviewees in both cases). Most of these connections are confirmed by literature, describing the benefits of nature-based solutions in strengthening and securing human well-being by contributing to food security, risk reduction of climate change, sustainable urbanisation, and reducing pollution in water, soil, and air (Potschin et al., 2015).

Security was often interpreted as safety, resulting in another way of linking nature-based solutions with this theme. Multiple interviewees described the existence of natural areas as something affecting the safety and the feeling of being safe in urban areas. This has two sides: first, natural areas both decrease safety in traffic and the feeling of safety in relation to criminality in parks. Second, nature increase safety by creating meeting points, encouraging the use of city parks (both sides are discussed by the storyline *Nature versus green*). This second aspect of nature in cities is also found in literature, stating that nature in inner-city neighbourhoods may decrease levels of graffiti, vandalism, and even more severe criminal acts, due to the fact that greening increases the use of previously barren spaces (Kuo, Bacaicoa, & Sullivan, 1998). However, the same article states that a sense of safety in the neighbourhood should be established before developing nature areas, because people that do not feel safe in the first place are unlikely to use these new spaces (Kuo et al., 1998). As the study shows, the feeling of safety is influenced by the presence of green spaces, and proper maintenance is key in defining whether the influence is positive of negative (as discussed in storyline *Nature versus green*).

A third link between security and nature-based solutions was found when looking at priorities of governmental actors, specifically in developing countries with security issues related to war or terrorism. A growing literature base links climate change and acts of violence (Barnett & Adger,

2007; Scheffran et al., 2012), resulting from livelihood problems related to water resources and agricultural productivity (Stewart, 2002). As nature-based solutions address problems related to climate change, including water resource management and possibly food production, NbS has potential to improve the state of security in cities and countries where these issues are pressing. This potential value of nature was discussed in the study (mainly in storyline *Prioritisation of other pressing issues* from the international study), but investing in nature-based solutions (or in nature development in general) is often seen as of secondary priority by both governments and residents, and as a waste of resources in times of conflict and insecurity. It is rather seen as something to invest in, if possible, as soon as the situation improves. Not all literature agrees with this finding, as nature-based solutions can help establishing food and water security, improving livelihoods in developing countries (Potschin et al., 2015).

Summarising table

Table 10 Summarising table of the links between nature-based solutions and the four themes used in this study (climate change, natural environment, economy, security).

Theme	Links to nature-based solutions
Climate change	Often used in the definition of nature-based solutions;
	Used for both climate change mitigation and adaptation;
	More attention for adaptation due to the local benefits of adaptation, and the diffuse benefits of mitigation.
Natural environment	The creation of healthy and functioning ecosystems as an objective of nature-based solutions;
	A healthy ecosystem as a prerequisite and a basis for successful nature-based solutions.
Economy	Nature development becomes more important when the economic situation improves;
	Nature is beneficial for the economy: increases value and attractiveness for entrepreneurs, inhabitants, and tourists;
	Developing economies need to prioritise other developments first, including the provision of basic resources and services;
	Climate change adaptation and economic development can go hand in hand, also by using nature-based solutions.
Security	Nature development can help improve livelihood security, climate security, and health;
	Nature can both increase and decrease the (feeling of) safety in urban areas, depending on how it is used and managed;
	Nature-based solutions often not prioritised in countries with problems related to security, regardless of potential for security and economy.

Challenges in implementation of nature-based solutions

In this part of the discussion, the first part of the second sub-research question will be answered: *which challenges in implementing nature-based solutions can be identified*? The most important challenges (being the ones mentioned by most interviewees, preferably in both the Rotterdam-case and the international study) in implementation will be analysed by looking at academic literature. The second part of the question, *which policy instruments are used to tackle the challenges*, will be answered in the third part of the discussion.

Political challenges

Political challenges were found in both studies, and most reflected a lack of action from various governmental levels due to political unwillingness, other priorities, and slow and indecisive political processes. In the Rotterdam-case, the challenges varied between national and local (municipal) politics, while the international case reflected how national and international politics affected implementation of nature-based solutions on a local scale. The lack of political will for sustainable choices is endorsed by literature: Maes & Jacobs (2017) claim that one of the reasons why development of nature-based solutions is lacking is the lack of political interest for a shift from fossil fuel consumption to the use of renewable energy sources. This connection was not found in the study, but it does show that political will is an important factor in implementation of innovative, sustainable solutions.

Another reason for lack of implementation is the disconnect between short and long-term political goals due to the short political cycles in which municipalities often work, as found in the Rotterdam-case. This is confirmed by literature (e.g. Kabisch et al., 2016; Maes & Jacobs, 2017), also describing an additional discontinuity between short-term actions and long-term plans and goals. Projects often exist for a short period of time, while only projects that run for a longer term can contribute to gaining experience and knowledge about maintenance and effects, also after funding ends (Kabisch et al., 2016). This correlates with a finding in the international study describing a lack of good practical examples of nature-based solutions to show policy makers the long-term benefits of nature development in cities. Case studies of place-based examples of nature-based solutions have the opportunity to highlight how NbS can be applied to a variety of situations, truly clarifying what the concept entails and has to offer (Potschin et al., 2015).

A challenge that is related to this lack of examples is the fact that value of nature is difficult to determine. This topic came up as a political challenge in the international case and as a management challenge in the Rotterdam-case; the difference is that in Rotterdam, the question is who should pay for nature due to its diffuse effects, while in the international case the issue is that support for nature in some countries is low due to insufficient knowledge on the (non-financial) values of nature. The diffuse valuation of nature is acknowledged in literature, as ecosystems and the values that they provide are poorly understood (Daily, 2000). Existing ways to valuate nature(-

based solutions) are in terms of avoided costs in for example climate change mitigation and adaptation and health care (Potschin et al., 2015). Maes et al. (2017) make a connection between the discussed long-term goals/short-term actions and this valuation of nature, as investors and practitioners may not choose for nature-based solutions when long-term net benefits for society do not concur with the short-term interests of businesses. This was also found in the study, especially related to businesses in health care.

Management challenges

A management challenge that was discussed in both cases is related to the availability of money and resources: limited budget results in a lack of nature-related projects on the national or local scale. Additionally, unsuccessful long-term maintenance of natural areas due to high maintenance costs or budget cuts can be a result of limited financial resources, resulting in green areas with low ecological value, as discussed in the storyline *Nature versus green*. Departmentalisation is a challenge that is related to budget for nature: due to the existence of multiple departments, it becomes unclear which department (and their allocated budgets) is responsible for nature(-based solutions). This finding is supported by literature, explaining that traditional structures of city departments, with their own knowledge, language, and fields of responsibilities, are a major barrier for nature-based action (Kabisch et al., 2016). Droste, Schröter-Schlaack, Hansjürgens, & Zimmermann, (2017) add to this that municipalities often work via the principle of public finance, where those benefitting from a service should also bear the costs of providing the service. As a result, nature-based solutions can only be financed by the department gaining the most direct benefit (e.g. for water management). This restrictive management structure was not found in the Rotterdam-case, but departments showing lack of *willingness* (rather than *ability*) to contribute to the funding of nature-based solutions has the same result.

Research shows that nature-based solutions have the potential to increase social innovation in a city, accelerating the transition to more sustainable urban planning and governance, plus more sustainable models for business, institutions, and society (Faivre et al., 2017). In other words, better understanding and implementation of nature-based solutions may lead to the creation of a better understood, shared vision and an innovative mindset. For this better understanding a sharp definition of the concept is necessary, including knowledge on ecosystem services and the overall value of nature for societies (Maes & Jacobs, 2017). This corresponds with a set of challenges found in both the Rotterdam-case and the international study, explaining how lack of ecological knowledge, shared vision, and innovative mindset of project-executing actors influence (successful) implementation of nature-based solutions. A main challenge discussed in the Rotterdam-case is how lacking knowledge leads to ineffective implementation of nature-based solutions; this concern is shared by Kabisch et al. (2016), describing technical knowledge gaps on the local executive level and how they result in suboptimal designs and integration of NbS with existing grey infrastructures. Lack of knowledge may lead to path dependency and the continued use of traditional, grey

infrastructure to rely on for protection of hazard prone areas (Depietri & McPhearson, 2017), as also shown in the Rotterdam-case.

Societal challenges

In both cases, challenges related to public support were found. Public support is an important topic in literature, not only regarding to acceptance of planning decisions, but also to building trust, strengthening people's awareness of their local landscapes, and encouraging people to treat their surroundings responsibly (HöPpner, Frick, & Buchecker, 2008). Support for urban nature shows widespread regional and national variations, possibly related to socio-demographic differences between and within countries (Faivre et al., 2017). In this study, a difference in public support between inhabitants of cities in developed and developing countries is found – or, more specifically, a difference in why public support is lacking in those cities. In developed countries, the reason for this seems to be a disconnect between citizens and their surroundings. The attachment of people to their surroundings, including the feeling of belonging to and relationship with their living environment, and the overall interest in landscapes and their development, are important factors in whether they want to participate in projects related to nature-based solutions (HöPpner et al., 2008). Also in literature reconnecting citizens with nature is seen as a point of attention, and to empower and involve them in urban nature development (Faivre et al., 2017).

In developing countries, prioritisation of other issues is an explanation of lacking public support for nature-based solutions (as found in the international study). A finding of the research is that in some cases nature development is seen as a waste of resources rather than as an investment in the future. Eggermont et al. (2015) describes a new approach to NbS, where humans and integration of societal factors such as human well-being, poverty, and socio-economic development are the focus of nature-based solutions; benefits for the environment are of secondary importance in this approach, but the focus is on the benefits for people. Reframing nature-based solutions like this has potential to increase the relevance when discussing societal issues.

Another societal issue is related to (environmental) equity. A finding in the research shows that urban nature development often takes place in the richer neighbourhoods, creating a gap in access to nature between population groups. This finding is supported by multiple studies, showing evidence for environmental injustice (the distribution of and access to urban green space) for low-income people and racial and ethical minorities (Wolch et al., 2014). The importance of addressing this is stressed in literature: people living in less-developed neighbourhoods are more prone to medical conditions, making access to healthy natural environments especially important for these more vulnerable populations (Faivre et al., 2017). In other words, increasing the availability of nature can decrease not only environmental inequality (Emilsson & Ode Sang, 2017), but also socioeconomic and health inequality (Faivre et al., 2017). This while, as shown in the previous paragraph, people with limited resources tend to show little support for urban nature development. It is therefore especially important to look at the strategic level when allocating resources for

nature-based solutions from the local or national level, taking into account not only biophysical characteristics of a city, but also information on populations (Emilsson & Ode Sang, 2017).

A side note to this is the existence of the green space paradox, where greening of low-income neighbourhoods increases the housing prices, making them too expensive for the population to live. This is a finding in both this research and literature (like Wolch et al., 2014).

Biophysical challenges

Biophysical challenges are only found in the Rotterdam-case, as this was a more detailed study focussing on one city rather than on the general international context that is applicable to multiple cities worldwide. Some challenges from Rotterdam show similarities with the international storyline *Implementation and environmental conditions of a city or* country, showing that implementation of nature-based solutions and nature development in general is highly dependent on the local circumstances, both looking at political, social, and biophysical factors. This finding is supported by literature, stating that the purposes of nature-based solutions should be determined by looking at both the biophysical and the socioeconomic situation of a city (Andersson et al., 2017).

Scott et al. (2016) describe a city as a social-ecological system with multiple spatial and temporal scales that are largely determined by natural processes but calibrated by society. They call this approach the "re-naturing" of cities, aiming to work with nature to reshape urban areas to provide current needs and facilitate adaptation to future challenges (Scott et al., 2016). This approach was not mentioned in this study, but it shows similarities with the ecosystem-based approach as described in the international case, using existing ecosystems as the baseline for further creation of nature-based solutions. Approaches like this may be of great importance for cities worldwide, as proper design of nature-based solutions results in maximised benefits for communities (Connop et al., 2016). This includes protection of natural values, safeguarding the provision of ecosystem services and with that the physical and economic well-being of communities (Connop et al., 2016).

Biophysical challenges in the Rotterdam-case either describe problems related to the lack of available space for nature development (due to the crowded, heavily built-up nature of the city, and the fact that the city is surrounded and limited by the existing rivers), or lacking quality of existing (green) spaces. Scott et al. (2016) claim that due to the built-up nature of cities, cities often rely on traditional forms of grey infrastructure to maintain good living conditions of inhabitants. However, this decreases the ability of cities to adapt to changing biophysical conditions (Scott et al., 2016), which corresponds with the challenge of lack of space as found in the Rotterdam-case.

However, it is not just the limited open space available that affects the creation of green spaces: it is also the competition of green spaces with other types of urban development, including space for housing, industry, and businesses. This is confirmed by Haaland & van den Bosch (2015), explaining that green spaces tend to decrease due to redevelopment of urban areas for housing, industrial areas, and grey infrastructure without new green measures to compensate for related

losses. They claim this development is rooted in a lack of interest or economic incentive for developers to preserve green space, and a lack of regulations to prevent their removal (Haaland & van den Bosch, 2015).This lack of interest and economic incentive was previously discussed in both the Rotterdam-case and the international study, but is mainly related to the creation of new green spaces and not in relation to the removal of existing green. The statement about lack of regulations is incorrect for the Rotterdam-case, as urban development plans including the removal of existing green must be reviewed and approved before they can be executed.

Summarising table

Table 11 Summarising table of the most important challenges in implementation of nature-based solutions, found in both the Rotterdam-case and the international study.

Category	Challenge
Political challenges	Lack of action due to political unwillingness, other priorities, and slow and indecisive political processes;
	Disconnect between short-term actions and long-term goals due to lack of good examples of NbS;
	Value of nature diffuse and difficult to determine.
Management challenges	Limited resources and (allocated) budget;
	Departmentalisation results in a lack of shared vision and innovative mindset among different departments/actors.
	Limited understanding and definition of nature-based solutions;
	Lack of ecological knowledge among policymakers and actors working in urban development;
Societal challenges	Lacking public support due to other priorities (in developing countries);
	Lacking public support due to a disconnect between humans and their natural surroundings (in developed countries);
	Environmental inequality makes the use of nature-based solutions important in less-developed cities and neighbourhoods, with taking the social circumstances into consideration.
Biophysical challenges	Implementation of nature-based solutions is highly dependent on local biophysical circumstances, which should therefore be considered (in additional to social circumstances);
	Heavily built-up spaces often rely on traditional solutions to climate change due to lack of space, and competition with housing, business, and infrastructure;
	Little quality of existing spaces makes implementation of NbS difficult.

Policy instrument selection

The results show the large variety of policy instruments that were discussed during the Rotterdam-case or the international study. A question that still needs answering is how and why policy instruments are selected in order to successfully implement nature-based solutions in cities. Lascoumes & Le Gales (2007) open the debate on the issue of instrument selection. The question is whether instrumentation is merely a neutral and rational issue, based on the properties of the instruments and applicability in the policy context, or if it is based on the policy makers' understanding of the problem, reflecting the perceived relationships between actors. The first approach reflects a traditional, rational approach, while the second approach corresponds with discursive institutionalism, describing how dominant discourses can be translated into institutions (Brink & Metze, 2006). To address this issue, the research question *how do storylines on urban planning and policy lead to the choice of certain policy instruments?* will be answered, and compared to the results of the research question *Which challenges in implementing nature-based solutions can be identified, and which policy instruments are used to tackle these challenges?* To gain better understanding of the variety of policy instruments, they are categorised based on actor relationships.

Categorisation of policy instruments

The connection between storylines, being simplified interpretations of more complex discourses (Smith & Kern, 2009), and policy instruments can be used to better understand how discursive institutionalism may shape policy instrument selection. Looking at how the existence of certain challenges lead to the choice of policy instruments reflects the traditional/rational approach to policy instrumentation, choosing a solution (the policy instruments) to reach a certain goal (overcoming the challenge). In short, combining and interpreting the results can help understand how policy is instrumentalised, adding to the existing debate. The debate will be structured by categorising policy instruments, based on relationships between actors. This results in the division of (1) intergovernmental instruments, (2) intragovernmental instruments, (3) public policy instruments, (4) third-party instruments, and (5) new governance instruments. Note that some instruments show characteristics of multiple instrument types, making them a combination of multiple approaches and strategies. As a result, some instruments are mentioned in more than one category.

Intergovernmental instruments

Intergovernmental instruments are used by governmental actors, aiming to either obligate or encourage governments on lower levels to include nature in urban planning and development. For the sake of this research, a distinction is made two types of intergovernmental instruments: national (or domestic) policy instruments and international (bilateral, multilateral, or global) policy instruments, as suggested by Stavins (1997). International environmental policy instruments

are a result of negotiated agreements among sovereign nations (Carraro & Siniscalco, 1998; Stavins, 1997). These can cover a wide range of topics, like climate change and biodiversity, showing a high degree of interdependence among countries in order to solve them (Carraro & Siniscalco, 1998). National policy instruments, on the other hand, enable individual nations to achieve specific national targets or goals (Stavins, 1997), including the delegation of targets to subnational levels.

Examples of this type of instruments, in this case used to encourage or obligate implementation of nature-base solutions, are found in both studies, and are often used in the context of lacking governmental action. The instruments from the Rotterdam-case are national policy instruments, showing the relation between the provincial or national government and the local municipality. However, the interests that shape these policies are the result of further top-down policy from an international level: in Rotterdam, this is often the EU Birds and Habitats directive. Once implemented on the national level – in case of Rotterdam previously via the Flora- en Faunawet and currently via Wet Natuurbescherming – these directives are legally-binding. This is where they differ from the instruments found in the international study, as these are more economic/fiscal rather than regulatory (as described by Lascoumes & Le Gales; 2007). These instruments are mainly used by policy-making actors to direct the behaviour of local or national governments, leaving the power of decision-making completely allocated to the governed actor. Another example of an economic instrument is intergovernmental aid, used as an encouraging instrument by developed countries as described in the international study. This corresponds with the definition by the OECD, as discussed by Kanbur (2006), describing international aid as being undertaken by the official sector of the donor country, lending and donating funds to promote economic development and welfare in the recipient country.

The necessity for intergovernmental instruments is expressed in both the Rotterdam-case and the international study, both in storylines (concern about the unwillingness of political actors is found in *Nature versus green*, a sub-storyline in the storyline *A new way of looking at nature*, *Prioritisation of other pressing issues*, and *Varying attention for nature-based solutions*) and challenges (mainly challenges discussing how (slow) local and national politics result in lacking implementation of NbS). Burby (2013) makes a distinction between coercive and cooperative intergovernmental instruments. In this distinction, coercive instruments are regulatory in a traditional way, with rules or regulations that are enforced onto lower-level governments. Cooperate instruments, on the other hand, include rules and regulations that are developed by lower-level governments, complying with the goals of high-level governments. Burby (2013) states that in recent times, coercive instruments are often replaced with cooperative instruments. This is confirmed by this research: all examples of intergovernmental policy instruments leave at least some decision-making power at the lower levels, complying with the principle of state sovereignty.

When looking at policy instrument choice, Burby (2013) claims that the choice for cooperative rather than coercive instruments is based on the interest and capability of local governments to work toward higher-level policy goals. These instruments mainly aim to shape the planning process

and increase capacity to act. This completely contradicts the findings of this research, as it shows that lacking political action due to unwillingness is one of the main reasons implementation of nature-based solutions is hindered. In fact, cooperative instruments are often used to overcome these challenges, while according to Burby (2013), coercive intergovernmental instruments would be more appropriate in this context. The use of coercive/regulatory instruments to address issues of resistance and unwillingness is supported by scholars like Halpern (2010), but adding that they can be used in addition to agreement-based instruments. However, this raises a question about whether returning to more regulatory instruments would be viable and desirable in the current (inter)national environmental policy debate, considering the international shift from "old" policy instruments, relying on command and control, to new environmental policy instruments, using agreement, incentive, and markets (e.g. Halpern, 2010; Jordan, Wurzel, & Zito, 2005; Tews, Busch, & Jorgens, 2003).

Intragovernmental policy instruments

The second category consists of policy instruments that are implemented within a governmental organisation (like a municipality), influencing decision-making and work among departments/sectors of that same organisation. A challenge from both the Rotterdam-case and the international study is departmentalisation, resulting in ineffective spending of resources, unused knowledge and expertise, and missed opportunities for cooperation and win-win solutions. Jacob & Volkery (2004) state that the need for efficiency within a government results in specialised, defined policy domains with sectoral responsibilities. However, they also state that cross-sectoral problems, like ones related to the environment, are not solved or even increased by this departmentalisation. Scholars (like Ayers & Dodman, 2010; Jacob & Volkery, 2004) present environmental policy integration as a solution to this problem: the incorporation of environmental concerns into the decision-making of non-environmental policies, like energy, transport and agricultural policies (Jacob & Volkery, 2004). Studies show that policy integration results in more rationality and effectiveness in policy-making, as a result of increased knowledge and chances of finding win-win and cost-effective solutions and opportunities (Nilsson & Persson, 2003).

Jacob and Volkery (2004) distinguish two approaches to policy integration: the horizontal approach and the vertical approach. In the horizontal approach, a single department or actor is responsible for the integration of solving environmental problems in the strategies of all departments. Examples of this found in the Rotterdam-case include the introduction of quality requirements for soil (as described in *Biophysical challenges – Soils – Guidelines and quality requirements*), created by the engineering bureau within the municipality, and the BIJ12 Kennisdocumenten, used by the municipality's engineering bureau to increase knowledge and understanding of ecological values among other departments. Policy instruments aiming for policy integration in the horizontal approach tend to have an organisational motive: they aim to involve positive and negative aspects of environmental issues at an early and anticipatory stage in policy-making, contributing to the achievement of environmental goals and increasing the number of

policy decisions made in general (Nilsson & Persson, 2003). This corresponds with the goals that were discussed during the Rotterdam interviews, related to important management challenges about lacking (ecological) knowledge, resulting in low-quality urban green spaces.

In the vertical approach every department is responsible for its own integrated strategy for the incorporation of environmental objectives. With this responsibility comes the obligation to report on activities to a higher level actor (Jacob & Volkery, 2004), like the cabinet or parliament on the national level and the city council on the local level. This approach needs clear and realistic objectives, indicators and benchmarks to allow for successful monitoring (Jacob & Volkery, 2004). An example that reflects this approach from the Rotterdam-case is the creation of the Rotterdamse Stijl. This vision, introduced by the city council, includes guidelines for all departments working on public space, promoting nature-based solutions as an alternative to common practices in city planning and urban development. It has a normative motive, aiming to make environmental objectives the overarching goal and at least as important as other objectives in decision-making and planning (Nilsson & Persson, 2003). However, the Rotterdamse Stijl does not solely aim to increase attention to environmental problems, this is merely a part of the entire plan. An overarching, strategic plan like this is recommended by Emilsson & Ode Sang (2017). They state that it has potential to strategically use nature-based solutions on city-scale, to find cost-effective solutions with high gains for not only climate change and biodiversity, but also for environmental justice of vulnerable population groups. One of the interviewees stated that this instrument enhances the awareness of corporate social responsibility to include sustainability and nature in everyday work, which corresponds with the normative motive as described by Nilsson & Persson (2003).

Intragovernmental instruments are used in Rotterdam to help solve multiple challenges, including departmentalisation, lacking knowledge, and path dependency. Regardless of this potential to solve multiple challenges – challenges also mentioned in the international study, like departmentalisation –, no examples of this type of instruments were discussed in the international study. Additionally, the occurrence of policy contradictions as a consequence of mixed goals (as discussed in *International study – challenges and policy instruments – Political challenges – Priorities and responsibilities of the government*) can be avoided by integrated policy (Nilsson & Persson, 2003). It can also help increase public support for nature development, as unavoidable trade-offs can be made more transparent (Nilsson & Persson, 2003). This finding is not surprising: multiple scholars, including Adelle & Russel (2013) and Jordan & Lenschow (2010) show that, regardless of attention on both scientific and policy level, successful and large-scale policy integration remains lacking on a national and international scale. The local scale is not mentioned in environmental policy integration literature. This reveals a knowledge gap, as this research shows that environmental policy integration does take place within urban governments.

Third-party policy instruments

The third category consists of instruments used by third parties, including NGOs and other (inter)national organisations, to encourage local governments and municipalities to implement nature-based solutions. These instruments express the relation between (local) governments and third-party actors, where the governmental actor is in charge of decision-making, and other parties try to influence this process. Bomberg (2007) stresses the importance of the influence of third parties on the adoption of new environmental policy instruments. Third-party instruments can be subdivided into three methods: (1) political learning, (2) instrumental learning; and (3) social learning (Bomberg, 2007).

The first method, political learning, focusses on capacity building by providing information and assistance, and by building transnational links (Bomberg, 2007). An example of this method found in the interviews is the creation of international city networks, facilitating mutual learning processes and the exchange of information on sustainable innovations among international governments (Kabisch et al., 2016; Keiner & Kim, 2007). Examples from the study include C40, the Rockefeller 100 Resilient Cities, and One Planet Cities by WWF. Furthermore, the programme Groene Metropool by Staatsbosbeheer has some elements of a network, as it aims to connect actors and increase understanding and capacity among those actors. This type of instruments is used to overcome multiple challenges related to political unwillingness, especially on the national level: the storyline *Varying attention for nature-based solutions…* explains that lacking implementation of national governments leads to action on a local scale. This idea is supported by Keiner & Kim (2007), describing city networks as the most effective way to strengthen cities' capacity to solve major environmental and social problems. The connection between networks and nature-based solutions, as found in this research, is supported by Kabisch et al. (2016), saying that city networks promote implementation of nature-based solutions by using current knowledge and experience, while continuing the further exploration of required actions, challenges, and issues regarding nature-based solutions worldwide. Hence, city networks not only help solving issues related to political unwillingness, but also contribute to the base of information and examples of (successful) implementation of nature-based solutions. This will be further discussed in the next paragraph.

The second method, instrumental learning, aims to increase the understanding of certain instruments among decision-makers (in this case, nature-based solutions), including related costs and benefits, strengths and weaknesses (Bomberg, 2007). Additionally, information about how to deal with conflicts of interest in urban development must be provided (Kabisch et al., 2016, also found in the international storyline *Prioritisation of other* issues). The necessity for more information and examples of successfully implemented nature-based solutions is discussed in both the Rotterdam-case and the international study; it is mentioned as an important reason why urban development and policy often sticks with common practices, resulting in path dependency and a lacking use of innovative solutions.

The creation of a base of evidence and best-practice examples is important for multiple reasons. Firstly, it helps design nature-based solutions based on the specific characteristics of a city, tackling the challenges that are most important there and making suitable trade-offs between grey and green infrastructure (Faivre et al., 2017; Potschin et al., 2015). The importance of place-based examples is supported by the international storyline *Implementation and environmental conditions of a city or country*, and the trade-offs between grey and green is related to multiple biophysical challenges of the Rotterdam-case. Secondly, the difficult valuation of nature-based solutions shows the importance of evidence and examples. Examples of case-studies have the potential to show how NbS are applied and which benefits they generate in practice (Potschin et al., 2015), especially considering the limited cost-benefit analysis done on NbS (Faivre et al., 2017). The integration of natural values and socioeconomic values can be shown (Eggermont et al., 2015; Maes & Jacobs, 2017), in comparison with traditional solutions (Kabisch et al., 2016).

Important examples of instrumental learning by third parties include the studies Blind Spot and the Green Heart Project. An example of instrumental learning from the Rotterdam-case is the provision of information booklets for decision-makers by Natuurcentrum Rotterdam (*Groene 18 voor 2018*) and Natuur- en milieufederatie Zuid-Holland. The provision of information is seen as an important way for NGOs to influence policy-making, affecting agreements by placing items on the agenda of decision-makers (Betsill & Corell, 2001).

The third method, social learning, shapes the climate in which policy decisions are made. This is done by disseminating knowledge in order to change the perceptions about policy instruments, and to reform the policy-making process by bringing together stakeholders and empowering civil society groups (Bomberg, 2007). This method aims to identify and acknowledge values and interests of all stakeholders involved, in order to reach consensus based on both scientific discourse and policy debate (Collins & Ison, 2009). The need for a decision-making climate like this is specifically discussed in management challenge *A shared vision*, from the Rotterdam-case. Additionally, it has links with challenges related to political unwillingness, as this approach mainly focuses on involving governmental actors.

There are multiple examples of instruments from the Rotterdam-case using social learning: both the Staatsbosbeheer programme Groene Metropool and the Visie Rijke Groen-Blauwe Ruimte include governmental, civil society, and private stakeholders on multiple scales. The instruments create a cooperative decision-making climate with emphasis on the inclusion of nature. The project Rivier als Getijdenpark in the region of Rotterdam includes a cooperation of governmental and non-governmental organisations, citizens, and private partners, aiming to encourage nature development in river ecosystems. An example of the international study is the GrowGreen project; particularly the European conference that was organised within this project shows the use of a social learning approach. Social learning shows similarities with new governance instruments, including public participation (Schusler, Decker, & Pfeffer, 2003), as it often not only targets

governmental actors, but also private and societal actors (like programme Groene Metropool). This will be further discussed in the paragraph *New governance*.

Public policy

The category of public policy includes policy instruments that are used by a governmental actor, like the state or the municipality, and that address civil society and private stakeholders. These are an embodiment of public policy, with the instruments defined as devices that organise specific social relations between the state and the actors the instrument is addressed to (Lascoumes & Le Gales, 2007). A difference was found between the Rotterdam-case and the international study when it comes to the aim of public policy instruments. In the Rotterdam-case, the storyline *A new way of looking at nature* describes public involvement as something that is on the rise, resulting in more awareness of the necessity of nature among people, creating a shared responsibility for nature protection and improvement. In the international study, it was shown that the opposite was of concern: the international storyline *Prioritisation of other pressing issues* is not only about unwillingness of political leaders, but also about a lack of support from local communities. The challenge *Lack of public support* also shows how the disconnection between people and their natural environment, mainly in the developed world, is affecting public involvement. The approaches of policy instruments that follow from these contradicting storylines are similar, as they all aim to involve inhabitants in decision-making and/or project execution. However, the goal is different: in Rotterdam the aim is to guide existing public support in the right, ecologically valuable direction, while in the international study the aim is to increase public support.

To further elaborate on this multi-goal aspect of public policy, the theory of Lascoumes & Le Gales (2007) is used. They divide public policy instrument into regulatory instruments, economic instruments, and new-governance instruments (for the sake of clarity of this research, this type is called communication-based). The first type consists of instruments that directly regulate the activities of firms and individuals, also known as command-and-control (Stavins, 1997). These instruments typically have three functions: a symbolic function, attributing legitimate power over the controlled actors; an axiological function, reflecting the values and interests of the governing actor; and a pragmatic function, directing behaviours of the governed actors (Lascoumes & Le Gales, 2007). In this research, policy instruments were found that target both inhabitants and private actors. Behaviour of inhabitants is controlled by, for example, regulations and zoning in city parks, as discussed in the Rotterdam-case (in *Societal challenges – Negative effects of recreation*, and as an effect of the *A new way of looking at nature*). There was also an example found where private real estate owners are obligated to build nature-inclusively, and to add green elements to their property in order to rent them out. Looking at the challenges in the study, this type of instruments seems mainly to be relevant when acknowledging and including natural values is vital, regardless of whether the targeted actor supports nature development or not. In other words, it is how governmental actors make sure nature is protected, regardless of the public opinion.

The second type consists of economic instruments, either aiming to redistribute financial resources, or to direct the behaviour of actors in an encouraging way (Lascoumes & Le Gales, 2007). Problems related to biodiversity tend to be difficult to address with economic instruments. There is no clear market for biodiversity, like there is for example for carbon, and the question of what nature is worth (as discussed in both the Rotterdam-case and the international study) becomes especially important when considering economic or market-based instrumentation (Helm, 2005). Regardless, some economic instruments were discussed during the interviews. An important example, found in both cases, is the allocation of subsidies to stakeholders that include nature-based solutions. Another example is the creation of certificates, like the BREEAM certificate found in the Rotterdam-case. Both these examples are used to direct the behaviour of actors, encouraging sustainable thinking in urban development. This type of instrument is seen as important in shifting behaviour in a more sustainable and innovative direction, especially when there is little will to do so due to short versus long-term considerations and the inclusion of multiple values (Maes et al., 2015; as also discussed in both the Rotterdam-case and the international study).

The third instrument type, communication-based, is an overarching term for instruments that have a less interventionist nature in public policy. These instruments are based on agreement, information, and consultation, rather than on command and control (Lascoumes & Le Gales, 2007). Arnstein (1969) shows that these policy instruments mainly reflect different degrees of tokenism, where stakeholders are allowed to hear and to be heard. This type of participation is deemed to increase residents' acceptance of planning decisions, building mutual trust and strengthening people's awareness of their local landscapes (HöPpner et al., 2008). An example was mentioned in the Rotterdam-case, describing meetings organised by the municipality to inform the public about nature-inclusive plans related to urban development. In these meetings, people are informed about plans, get the opportunity to express their opinions, and are able to further support the plans by small contributions (e.g. allowing for a bat nesting boxes to be placed on their property). HöPpner et al. (2008) found that the willingness of a person to attend such a meeting is slightly dependent on the social belonging to a place, and highly dependent on the person's interest in the surrounding landscape. This may explain the finding that participation of inhabitants when discussing their own property and close surroundings is relatively high, as seen in the Rotterdam-case.

In the previous example, the municipality consults other actors but remains the decision-making actor, which is the main characteristic of tokenism (Arnstein, 1969). This is different from participation based on agreement, where negotiations, decision-making, and to some extent execution of the project is in cooperation with civil society actors (Arnstein, 1969), private actors, and non-governmental organisations (Lascoumes & Le Gales, 2007). This type of inclusion of citizens aims to transform decision-making processes, discovering citizens' views, and fostering citizen influence. This method aims to adjust local government initiatives to the needs of citizens and to improve the quality of governmental services (Yetano, Royo, & Acerete, 2010). In the same

time, these instruments build a strong foundation for natural resource governance, and empower citizens by addressing their values, interests, and knowledge (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). This has the potential to solve challenges related to lack of public support and involvement, as found in both the Rotterdam-case and the international study. An example from Rotterdam is the programme Rivierenoevers, as initiated by the municipality. This programme includes multiple smaller projects, where citizens cooperate with the municipality and other stakeholders, aiming to improve the ecological values of rivers near the city. This type of policy instrument is not found in the international study. This can be explained by the scale-difference of the two studies: Rotterdam is a local case, whereas the international study has a broad, international scope. Nevertheless, this type of projects can have positive influence in cities in other countries as well. Lacking trust in the government can be an underlying cause for limited public support (Yetano et al., 2010), not only in Rotterdam, making these instruments potentially valuable for other cities as well.

New governance

According to (Faivre et al., 2017), a community multi-stakeholder platform is necessary to fully integrate nature-based solutions in urban development, aiming to promote NbS innovation and to build capacity on basis of perspectives of multi-disciplinary scientific expertise, policy, business, and society. These instruments are included in the fifth category of the policy instrument categorisation: new governance. With these instruments, governmental actors are participant or completely excluded, rather than initiator and decision-maker, while citizens and other stakeholders gain agenda-setting, advisory, and decision-making powers (Faivre et al., 2017; Harris et al., 2013). This corresponds with citizen power, as discussed by Arnstein (1969). According to Faivre et al. (2017), nature-based solutions play a critical role in the community-based transition to sustainability, affecting actors from multiple sectors, domains, and scale-levels. This relates to the storyline *A new view on nature*, describing the start of this transition in Rotterdam. However, Faivre et al. (2017) state that nature-based solutions can be the start of this kind of transition, while the study describes nature-based solutions more as a result of a transition. This either is a difference, or it shows unexplored potential of nature-based solutions in Rotterdam. This potential includes the fostering of innovative planning and governance, and the creation of new models for business, finance, institutions, and the wider society (Faivre et al., 2017).

In this research, two major new governance instruments are distinguished: partnerships and citizen initiatives. Collaboration and participation by stakeholders in decision-making, particularly by local residents, is crucial for successful plan development and project implementation (Hawkins & Wang, 2012). Challenges emerge when this is lacking, due to lack of capacity, interest, or connection to nature (as discussed in the results). To improve the local capacity to develop, implement, and manage initiatives, a support network of organisations with knowledge and expertise is crucial (Hawkins & Wang, 2012). Examples found in the Rotterdam-case of this include the Groene Metropool programme by Staatsbosbeheer and the Dakakker on the Schiekade by

Milieucentrum Rotterdam. In the international study, this idea is reflected in multiple projects including the GrowGreen project and the WWF project We Love Cities. These projects all aim to include inhabitants and are executed by third-party organisations.

A slightly different type of collaboration between public and private parties emerges when financial challenges occur, as discussed in both the international study (*Management challenges – Lack of resources and time*) and the Rotterdam-case (*Management challenges – Budget for nature*). These collaborations are called public-private partnerships: an institutional means of dealing with particular sources of market failure (in this research this often means that no budget is available for development of nature(-based solutions)), by creating a perception of equity and mutual accountability in transactions between public and private organisations, through cooperative behaviour (Pongsiri, 2002). In the international study, multiple examples were found that show similarities with these partnerships, including the Natural Capital Coalition and Water Funds. Both these examples generate funding for nature development via private and/or public actors. This idea was also discussed in the Rotterdam-case, framed as a type of joint funding: multiple stakeholders from various backgrounds and expertise that cooperate in generating funds for nature development. The importance of making a business case for investment in nature is stressed in both this research and literature, with roles for both public and private sectors to finance nature-based solutions on multiple scales (Cohen-Shacham et al., 2016).

Most types of citizen participation as described in literature include interference by either governmental actors or other organisations, as discussed in previous paragraphs. However, another type was found in the study, resulting from the storyline *A new way of looking at nature* from the Rotterdam-case: citizen initiatives. Citizen initiatives are self-organised actions by residents without the participatory mechanisms provided by local governments (Hawkins & Wang, 2012). These initiatives emerge when satisfaction with democratic practice and citizen involvement in democratic processes decrease (Yetano et al., 2010); this is described in the Rotterdam-case, as part of the *A new way of looking at nature* storyline and related challenges. Traditional democratic processes fall short due to inequalities in wealth, voice, knowledge, and access to information among citizens (Yetano et al., 2010). This is similar to the challenge regarding inequality among inhabitants, as found in the international study, causing the lack of public support for nature in cities and nature development in general. However, no instruments of this type were found in the international study. This is not surprising, as the storyline of increased public attention for nature development of Rotterdam was completely absent in the international study. Examples in Rotterdam include initiatives like Gewildgroei and Operatie Steenbreek, as discussed in *Biophysical challenges – Pavement*. A possible explanation for the lack of citizen initiatives on the international level is that during the interviews a main theme was the prioritisation of other problems by the public was discussed, which contradicts the storyline of *A new way of looking at nature*.

Summarising table

Table 12 Categorisation of policy instruments for implementation of nature-based solutions, including summarised description and sub-categories.

Categorisation of policy instruments	
• **Intergovernmental instruments:** instruments used by governmental actors, aiming to obligate or encourage governments on lower levels to include nature in urban planning and development.	
International instruments	Instruments based on negotiated agreements among sovereign nations;
National instruments	Enabling nations to achieve their national targets or goals, including delegation of targets to subnational levels.
• **Intragovernmental instruments:** instruments implemented within a governmental organisation, influencing decision-making and work among departments/sectors of that organisation.	
Horizontal approach	One responsible actor or department for environmental policy integration in all departments;
Vertical approach	Every department is responsible for its own integrated policy and is obligated to report on activities to a high-level actor.
• **Third-party policy instruments:** instruments executed by third parties, aiming to encourage local governments and municipalities to include nature-based solutions.	
Political learning	Building capacity by providing information and assistance, and facilitating mutual learning by creating transnational links among actors;
Instrumental learning	Promoting the use of nature-based solutions by increasing knowledge and understanding among decision-making actors;
Social learning	Shaping the climate in which policymakers make decisions, aiming to disseminate knowledge and to reform the policy-making process by bringing together stakeholders.
• **Public policy:** instruments executed by a governmental actor, addressing civil society or private stakeholders, determining what the relation between these actors is.	
Regulatory instruments	Regulate the activities of firms and individuals directly, via command-and-control systems, used to make sure nature is protected without considering the public opinions.
Economic instruments	Aim to either redistribute financial resources, or to direct the behaviour of actors in an encouraging way. Important in shifting behaviour in a more sustainable and innovative direction.
Communication-based instruments	Based on agreement, information and consultation rather than intervention and command-and-control. Deemed to increase actors' acceptance of planning decisions, building trust and strengthening awareness.
• **New governance:** citizens and other non-governmental stakeholders have agenda-setting, advisory, and decision-making powers, while governmental actors are excluded or participant.	
Partnerships	Used to generate funding for nature development by both non-governmental and governmental actors, making a business case for nature development;
Citizen initiatives	Self-organised actions by residents, emerging when satisfaction with democratic practice and citizen involvement in democratic processes decrease.

The need for a new categorisation of policy instruments

The five categories of policy instruments create a new categorisation for policy instruments for the development of nature(-based solutions) in cities, including all instrument types that were found in this research, from both the Rotterdam-case and the international study. Most existing categorisations in literature express a certain focus. For example, multiple articles only categorise public policy instruments (governmental actors governing other actors), including Borrás & Edquist (2013); Lascoumes & Le Gales (2007); and Mickwitz (2003). These articles make only a distinction between regulatory, economic, and information/soft/new public policy instruments (corresponding with the categorisation of carrots, sticks and sermons, by (Vedung, 2017)). However, the research has shown that other instruments affect implementation of nature-based solutions, making it crucial to include these as well to fully understand why implementation is successful or lacking.

Other than categorisations of public policy, literature knows multiple typologies describing the different instruments or approaches to governance rather than government (including Jordan et al., 2003; Bomberg, 2007). However, these typologies focus only on these instruments (or only describing top-down instruments as "old instruments"; Jordan et al., 2003), making them not completely competent when trying to understand implementation of nature development projects (including nature-based solutions). The proposed categorisation includes both top-down and bottom-up instrumentation, therefore adding to the existing literature. Additionally, no categorisation yet includes intragovernmental policy instruments, even though this research has shown that these instruments may play a significant role in successful implementation of nature-based solutions.

Policy instrument selection: a matter of rationality or discourse?

This research aimed to help answer which approach is best to explain policy instrumentation by using both the approach of discursive institutionalism and a more traditional/rational approach. Looking at the results of this research, there are policy changes discussed in the storylines which are also apparent when looking at choice of policy instruments. Halpern (2010) and Lascoumes & Le Gales (2007) say that policy instruments have structuring effects other than the aims for which they were designed. In the scope of this research, the structuring effects are mainly seen in relations between actors, and the scales on which these actors operate. For example, the storyline *A new way of looking at nature* discusses increased public support for nature-based solutions, resulting in the emergence of instruments involving citizens and other actors. An example from the international study is the storyline *Varying attention to nature-based solutions…*, where a lack of implementation of nature-based solutions from the government leads to increased action from third-party actors, citizens, and private actors.

In some cases, the connection between some policy instruments and the challenges they are designed to tackle is much stronger than between policy instruments and the storylines promoting them. The broad look at problems as described by storylines seems to be not detailed enough to explain the choice of policy instruments designed to address specific issues. Examples include the problem of lack of budget, with joint funding and partnerships as a solution, and the use of some intragovernmental instruments in order to address challenges like departmentalisation. These problems are to some extent linked to a storyline, but not to a sufficiently specific to be able to explain the choice of some instruments. Challenges give information about the actual effects and applicability of instruments rather than on transitions on an overarching level; this is supported by authors using this approach (including Droste et al., 2017; Wamsler et al.; 2017).

In short, to completely understand policy instrument selection, only using discourse or a more rational approach is not sufficient. To understand certain transitions, for example from execution on a national to more local levels or from governmental actors to third-party actors, looking at discourse is helpful and sufficiently explanatory. However, both storylines and discourse express accumulated opinions of multiple actors in different organisations and situations. Due to this, more specific reasons to choose for a certain type of instrument can only be found by looking at the problems and challenges that need solving. This multi-theory approach is supported by Ostrom (1991), describing it as a combination of using the logic of consequentiality, based on rationality and the logic of appropriateness, looking at rules, routines, and relations that define appropriate action. In this view, an actor's action is based on the logic of appropriateness, and justification on the logic of consequentiality (March & Olsen, 1989). This study agrees with these authors, promoting to use both a traditional/rational and a discourse approach when explaining policy instrumentation.

Conclusion and recommendations

Nature-based solutions have a lot of potential when it comes to increasing a city's resilience to climate change and improving the natural environment, but also regarding multiple societal issues like the local economy and security. Regardless of the potential, both in developing and developed countries the implementation of nature-based solutions remains lacking. Little research was done on what causes this lacking use, and what factors hinder successful implementation. This research answers these questions, using two approaches. First, the full potential of the concept of nature-based solutions is researched by looking at the themes mentioned above. Secondly, the study provides an overview of the most important challenges to the implementation of nature-based solutions, and an additional categorisation of policy instruments that are used in practice (and can be used by other cities) to overcome these challenges. The most important findings of the research will be summarised in this conclusion.

Storylines and themes

By analysing the storylines found in the study, a lot is learned about how people perceive nature-based solutions at this moment. NbS are seen as a way to address multiple major issues at once, but the question is to what extent this potential is reached in practice. To do this analysis, the concept of nature-based solutions is discussed in relation to the themes climate change, the natural environment, the economy, and security.

Climate change mitigation or adaptation

Climate change is the most important problem that can be addressed by using nature-based solutions, both in mitigation and adaptation strategies. As written in de discussion, developing countries tend to focus on adaptation, due to relatively small historic contributions to the cause of climate change, and the limited availability of resources. However, regardless of potential to focus on mitigation strategies due to relatively high historic responsibility and availability of resources, developed countries also tend to focus on adaptation strategies in cities. The measures aiming for mitigation to do the latter are often reserved for the city's surroundings – this while city centres are seen as hotspots for climate change action due to the large concentrations of greenhouse gas emissions.

The clear distinction between mitigation and adaptation was found in the research but was not considered when looking at the challenges in implementation. Further research would be recommended to see whether the challenges in implementation differ when it comes to mitigation or adaptation measures. For example, whether cities prefer to adapt to the local effects of climate change, while freeriding when it comes to mitigation, or whether more traditional solutions for mitigation are just more efficient than nature-based solutions.

The economic and security paradox

Looking at the economic situation of a city, two findings are considered most important. First, nature-based solutions can have positive effects on the economic and social situation in a city, supporting goals related to both economic growth and sustainability (next to the numerous other benefits that urban nature provides). However, the other finding shows that investing in nature-based solutions is often not prioritised in cities from countries with developing economies. This creates a paradox, where the potential benefits of nature-based solutions are not maximised, regardless of climate change adaptation being high on the political agenda. A similar paradox is shown looking at the theme of security: nature-based solutions can help increase livelihood, water, and food security by providing natural resources and sources of income. Still, countries and cities at war or in threat of terrorism often do not prioritise using nature-based solutions, as nature development is often perceived as a waste of resources in this kind of circumstances.

The institutionalised discourse in developing countries is that nature is of secondary priority and not as important as solving threats related to security or the economy. A shift in discourse is not likely, as challenges like limited resources, lack of knowledge of the benefits of nature, and lack of both public and governmental action strengthen this paradox. For this discourse to change, it is essential that actors gain more knowledge and understanding of the benefits of nature development in cities. As both national governments and residents tend to have other issues prioritised, either a third-party actor or another governmental organisation should act upon this.

Challenges in implementation

In the second part of the conclusion, the most important findings discussing new or especially important challenges are highlighted. These are most relevant, especially since they are not discussed in the current literature base on nature-based solutions.

Departmentalisation and its consequences

An important phenomenon that is discussed in both studies, but particularly in the Rotterdam-case, is departmentalisation. Multiple challenges, including political unwillingness, lack of finance, and ineffective management due to lack of shared vision and knowledge, are linked to ineffective structures of municipal departments. This affects the work for nature development and sustainability done in cities and their surroundings. Changing the current structures in governmental organisations, improving communication between departments, and creating a better overall understanding of projects and goals may help solve multiple management challenges at once. This makes further research into how departmentalisation affects the use of nature-based solutions crucial, for example by doing more detailed case-studies of cities and the role departmentalisation has in the implementation of nature-based solutions.

Designing nature-based solutions

The research shows that it is vital to design nature-based solutions according to both the socioeconomic and the biophysical characteristics of the specific city. In developing cities, or in relatively poor neighbourhoods of a city, nature-based solutions can have significant impact on environmental, socioeconomic, and health inequality, improving people's livelihoods by providing resources and potential jobs. However, as discussed in the section about the economy and security paradox, support for nature-based solutions is relatively low among poor populations. Designing and implementing nature-based solutions based on local circumstances and the needs of the population becomes more important when the population is relatively poor, or when large gaps between population groups exist. An opportunity for further research is to investigate how designing of NbS can contribute to improving the socioeconomic situation in a city while also meeting the needs of and gaining support from the public.

The designing of nature-based solutions based on the local circumstances is also important for the viability of the solution itself, looking at the biophysical characteristics of the built environment. The research shows that including the quality and quantity of existing urban nature, the potential for new nature, and the characteristics that determine which climate change threats should be prioritised, must be considered when effectively designing nature-based solutions. This is explained in the Rotterdam-case, discussing biophysical conditions together with the availability of space and the competition of urban development plans as important guidelines for designing NbS. A city is described as a social-ecological system, where taking into account both social and natural processes is crucial. This way of designing should be included in nature-based solutions all around the globe. This research studied one in-depth case: further research on how conditions and characteristics of both the biophysical and the social environment affect design and success of nature-based solutions is recommended.

Policy instrument selection

In the third part of the conclusion, the two most important questions on policy instrument selection when implementing nature-based solutions are answered. First, the discussion introduced a new categorisation of policy instruments. The conclusion will summarise this categorisation and discuss its innovativeness. Second, policy instrumentation is explained by discussing a rational approach and a discursive approach. This part of the conclusion will summarise why both approaches are necessary to fully understand policy instrument selection.

Categorisation of policy instruments

Based on the results of the study, a new categorisation of policy instruments is made, aiming to increase the effective implementation of nature-based solutions. This categorisation consists of five categories, all expressing different relations between actors. The categories themselves are based on the actor using the instrument, and the actor(s) affected by the instrument. Within the

categories, distinctions are made to further specify these relations, mainly based on the nature of the instrument (e.g. whether it is regulatory or more liberal) or on the scales in which actors operate. Some of these categories are well represented in scientific literature discussing nature-based solutions, including intergovernmental policy instruments, public policy, and new governance instruments. However, instruments in the categories intragovernmental instruments and third-party instruments are less clearly present in these discussions. In fact, the existing literature base on intragovernmental instruments is minimal altogether but is especially lacking when it comes to nature-based solutions. More research on the effects of this type of instruments is recommended, as the study shows that their impact on the success of NbS is significant.

Bringing these instrument types together in one instrumentation is new and relevant, as most existing categorisations focus on one type of instrument or executing actor. This new categorisation makes it easier to understand which instruments affect implementation of nature-based solutions, combining the influences of all actors involved, both top-down and bottom-up. A recommendation for further research is to look more into the effectiveness of the instrument types. This study explores which instruments are used in practice to support the use of nature-based solutions but does not look further into the actual effects of the instruments.

Explaining instrument choice

The study shows that policy instrumentation cannot be fully explained only by using a rational approach or a discursive approach, but that both approaches provide different and complementary information. Instrument selection has multiple dimensions. The first one is the goal of the instrument: what should the instrument achieve, and in which way. The study shows that this aspect of instrument selection can be understood by looking at the challenge(s) affecting successful implementation of nature-based solutions. Specifically looking at challenges gives information on the on-the-ground effects of instruments and their applicability in specific contexts. In other words, it explains rationally why an instrument would potentially be useful in certain circumstances.

Whether an instrument is actually useful is not only dependent on the goal or incentive to use it, but also on the actors that are involved. Information about relationships between relevant actors and their rolls, overall goals and the scales and levels on which they work can be obtained from looking at the discourses surrounding the topics of nature-based solutions and urban nature development. Which instrument is appropriate or desirable in given circumstances is dependent on these factors, which makes using a discursive approach crucial in understanding policy instrument selection.

In conclusion, selection of policy instruments can only be understood completely when using both discursive institutionalism and a more traditional goal-means-rationality approach. These approaches complement each other in understanding other, but strongly related dimensions of policy instrumentation. This knowledge can make instrument selection more effective, based on both the goals and the specific political and social environment.

Policy recommendations

Based on the findings of the research, two major policy recommendations are made. Firstly, in order to implement nature-based solutions it is vital for policymakers to understand all conditions of a city. This includes both the biophysical and socioeconomic characteristics, as these are all vital in defining if a nature-based solution will be effective or relevant in a specific city. Also, a large variety of challenges in implementation can be avoided by proper design of urban nature development projects.

Secondly, when promoting the implementation of nature-based solutions, or nature development in general, the selection of the instrument to do so should be based on the two dimensions of policy instrumentation. This means that the desired effects in practice should be determined first. After that, the context in which the instrument will have effect must be analysed, including the roles, goals, and powers of the actors involved, as well as the relationships between actors. This will increase the effectiveness of the policy instrument chosen.

Final remarks

The threat of climate change is becoming more visible every year, not only causing severe water shortages in non-western countries, like the recent crisis in Cape Town, but also here in the Netherlands, where temperature records are broken almost every day. Nature-based solutions have great potential for tackling climate change, while simultaneously addressing other major social and environmental problems. This makes nature-based solutions a solution for all countries to adopt, including the countries facing serious threats to their population's livelihoods and safety. With nature-based solutions getting more attention, awareness of their potential is growing and the number of actors using them is increasing. However, implementation remains lacking or unsuccessful in other cities, creating a gap between the potential benefits and the benefits actually obtained.

This research provides information to help understand the lacking implementation of nature-based solutions. The research can be used by a variety of actors to help identify the nature of the challenges that are ahead. Additionally, the research provides a categorisation of policy instruments that can be used to overcome these challenges, and to change the perspective of nature-based solutions that people have. It contributes to the existing literature base on nature-based solutions, also revealing knowledge gaps for further research.

In short, the research has the potential to make the implementation of nature-based solutions more successful and common in cities around the world. It is vital to adopt both mitigation and adaptation strategies for climate change in cities, in which nature-based solutions can play a significant role. It is time to reconnect with nature, to make the world green and more resilient to the problems that we must face.

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Appendix A: case description of Rotterdam

This appendix includes the information found about Rotterdam during the orienting literature study, conducted before the actual case study. It gives an overview of the most important characteristics of the city, and is conducted to have well-informed interviews with actors in the city.

General information

Rotterdam is a city in the Netherlands, in the province of Zuid-Holland. The city originates as a fishing village on a dam in the river Rotte. From thereon, it has grown into the second-largest city in the Netherlands (after Amsterdam), with an urban population of 994.000 in 2018 (World Population Review, 2018)[39]. Of these inhabitants, 45% is foreign born; the city has over 170 nationalities with a high population of Muslims (13% of the population) and the largest Dutch Antillean and Suriname community in the country. The current mayor of Rotterdam is Ahmed Aboutaleb. He has been mayor since 2009, and previously represented the Labour Party (PvdA) as State Secretary for the Ministry of Social Affairs and Employment in the cabinet Balkenende IV in 2007-2008 (Gemeente Rotterdam, 2018)[40]. Rotterdam is home to the Erasmus University and multiple universities of applied sciences. The city has a vibrant culture and a rich history, which makes it a top travel destination in the area (World Population Review, 2018).

Economic situation

The current economic situation of Rotterdam is good. Since the end of the economic crisis (2008-2013), Rotterdam has been experiencing an annual economic growth of more than two percent. However, the economic situation is relatively bad on a national level; compared to other major cities in the Netherlands, Rotterdam contains a smaller percentage of highly educated persons and the unemployment rate (8.5%) is twice as high as the Dutch average (World Population Review, 2018). Rotterdam is home to the largest port of Europe (Kreukels & Wever, 1996; World Population Review, 2018); because of this, large corporations – including Unilever, Eneco and Roboco – choose Rotterdam for their headquarters. The city hosted over 23.000 enterprises in 2008, of which 34,9% were in the public services and 23.3% in the financial and commercial services. Other large sectors are trade and repairs (13.1%), transport and logistics (11.3%), and tourism (5.7%) (World Brand Rotterdam, 2009). The presence of enterprises results in people coming to the city for job opportunity; this can explain the large unemployment rate in the city (World Population Review, 2018). Due to this urbanisation trend, Rotterdam is expected to grow at a slow but steady rate over the years, with an estimation of more than a million inhabitants by the end of 2020 (World Population Review, 2018).

[39] World Population Review, 2018: http://worldpopulationreview.com/world-cities/rotterdam-population/
[40] CV A. Aboutaleb, Gemeente Rotterdam, 2018: https://www.rotterdam.nl/bestuur-organisatie/burgemeester-aboutaleb/CV-Ahmed-Aboutaleb_English.pdf

The economic situation in Rotterdam is influenced by the location of the city. Rotterdam is part of the "Randstad area", which is the economic centre of the Netherlands. The city is well-connected to other large cities in the Netherlands (Amsterdam, Utrecht and The Hague) by road, railway and inland waterways (World Population Review, 2018). The largest port of Europe is located in Rotterdam (Kreukels & Wever, 1996); it has a well-equipped port infrastructure and multi-model accessibility, where large volumes of goods from all over the world are imported, processed and transported. The success of this port can be explained by the favourable geographical location within Western Europe, the good connection with the inland (Rotterdam lies in the Rhine-Meuse-Scheldt river delta, at the mouth of the Rhine River) and international waters due to the connection with the North Sea (World Population Review, 2018; Kreukels & Wever, 1996). Because of this beneficial location, Rotterdam is often referred to as the "Gateway to Europe".

Security

Dutch cities are relatively safe and secure; according to the Safe Cities Index[41] (The Economist, 2017), Amsterdam is one of the safest cities in the world (as 6th of 60 cities, with Tokyo at 1st place and Karachi as 60th). The municipality of Rotterdam conducts safety research, presented every two years in the security index (Veiligheidsindex)[42]. This is translated into multiple neighbourhood profiles, showing security and feeling of safety in multiple neighbourhoods in Rotterdam (also taking into account the social index (reflecting the quality of living, including the amount of interaction with neighbours) and the physical index (including e.g. public spaces). According to these indexes, safety and security in Rotterdam is improving.

However, there are some factors influencing the overall (feeling of) safety. In September 2017, the Dutch police published a report about the main threats that the city of Rotterdam – and therefore the local police, the municipality and the public order – faces today. This report is called "Dreigingsbeeld Rotterdam"[43] (threat assessment Rotterdam). The first threat on the list is violent jihadism, radicalisation and terrorism. Violent jihadi are the most serious threat to human security in Rotterdam today; currently it mainly concerns followers of the Islamic State (ISIS) in Iraq and al-Sham (Politie Eenheid Rotterdam, 2017). The National Coordinator of Terrorism Prevention and Security, within the Dutch Ministry of Justice and Security, makes a distinction between five levels of threat, based on periodical threat assessment (Dreigingsbeeld Terrorisme Nederland, DTN; NCTV, 2018[44]). This distinction reflects the current level of threat of terrorism in the Netherlands over a longer period of time, on a one to five scale (one meaning minimal threat with no clues of

[41] Safe Cities Index, The Economist, 2017: https://dkf1ato8y5dsg.cloudfront.net/uploads/5/82/safe-cities-index-eng-web.pdf
[42] Veiligheidsindex Rotterdam, 2018: https://wijkprofiel.rotterdam.nl/nl/2018/kaart
[43] Dreigingsbeeld Rotterdam, Politie Eenheid Rotterdam, 2017: https://www.politie.nl/binaries/content/assets/politie/nieuws/2017/07-rt/dreigingsbeeld_rotterdam_definitief_28sept2017.pdf
[44] Dreigingsbeeld Terrorisme Nederland, NCTV, 2018: https://www.nctv.nl/binaries/DTN48%2C%20samenvatting_tcm31-352621.pdf

potential terrorists, and five meaning critical threat, showing that a terroristic attack is to be expected or has already occurred).

The current level of threat in the Netherlands is level four, which means that the country is under substantial threat of becoming the target of a terrorist attack. This is because, regardless of the defeat of ISIS, there are likely still followers of the group preparing attacks in varying countries (NCTV, 2018). No terrorist attack has taken place in the Netherlands so far; however, attacks in the past show that not only countries in conflict areas are a target of ISIS, countries in Europe tend also to become target of attacks (Politie Eenheid Rotterdam, 2017). In fact, according to the AIVD (Algemene Inlichtingen- en Veiligheidsdienst, the General Intelligence and Security Service of the Netherlands), four serious terrorist attacks in Dutch cities are prevented in the past six years (Elsevier, 2018)[45]. Also in Rotterdam there have been some incidents related to terrorism in the past, with the most recent one the cancellation of a concert in Maassilo after the find of a van full of gas bottles (NOS, 2017)[46]. In the past four years, the police of Rotterdam monitored circa 100 people related to radicalisation (Politie Eenheid Rotterdam, 2017). The terrorism threat is also reflected in the foreign travel advice of the Netherlands, which is mainly positive except for the possibility of occurring terrorist attacks (gov.uk, 2018)[47].

The second threat comes from debate and agitation resulting in polarisation among different groups within the population of Rotterdam. In the past, inhabitants of Rotterdam and other parts of the Netherlands have been involved in political and cultural debates, which incidentally result in tensions and disturbance of the public order (Politie Eenheid Rotterdam, 2017). An annually returning example of such a debate is the national "Zwarte Piet-discussie" (roughly translated in Black Pete discussion), about whether (controversial) Dutch traditions should be changed or not in order to prevent racism against and discrimination of minorities. This debate has led to demonstrations in the past, including arrests of circa 200 protesters in Rotterdam in 2016 (NOS, 2016)[48]. Other debates that have potential to lead to disruptions of the order include discussions about religion, political preferences (leftists against rightists), refugees and conflict or events in other countries (e.g. the tension within the Turkish community in Rotterdam after the failed coup attempt in Turkey in the summer of 2016 (Metro, 2016)[49]).

Polarisation and radicalisation are related; polarisation leads to outrage, disbelief and fear, which may result in confrontation between different groups within a population. These confrontations can disturb the cohesion in the Dutch society, driving people with differing political, religious and/or ethical backgrounds away from each other (Ministerie van Binnenlandse Zaken en

[45] Elsevier, 2018: https://www.elsevierweekblad.nl/nederland/achtergrond/2018/01/aivd-verijdelde-4-concrete-zware-aanslagen-575354/
[46] NOS, 2017: https://nos.nl/artikel/2189465-popconcert-rotterdam-afgelast-vanwege-terreurdreiging.html
[47] Travel Advice the Netherlands, 2018: https://www.gov.uk/foreign-travel-advice/netherlands
[48] NOS, 2016: https://nos.nl/artikel/2142733-200-tegenstanders-zwarte-piet-opgepakt-in-rotterdam.html
[49] Metro Nieuws, 2016: https://www.metronieuws.nl/nieuws/rotterdam/2016/07/betoging-in-rotterdam-tegen-mislukte-coup

Koninkrijksrelaties, 2007)[50]. In Rotterdam, specific attention is addressed to Islamic radicalisation. In the past years (between 2012 and 2015), the number of cases of Islamic radicalisation has significantly increased; to prevent polarisation and radicalisation in the future, the municipality of Rotterdam has created the "Rotterdamse aanpak radicalisering 2015-2018"[51] (Rotterdam approach to radicalisation). With this plan, the municipality aimed to prevent polarisation and related tensions, and to increase the defensibility of vulnerable groups within society (Gemeente Rotterdam, 2015).

Other threats listed by the Rotterdam police are disturbances in public spaces, e.g. by football supporters, during large events, and during demonstrations. An increasing problem is the existence of so-called "confused persons"; people with a (temporal) disrupted judgement due to (mental) health problems, exhibiting behaviour that is threatening themselves or other people (Politie Eenheid Rotterdam, 2017). The number of events related to these confused people is increased by 14% in 2016, up to a total of 75.000 events on the national level. This problem is also vivid in Rotterdam; in 2017, approximately 8.000 of these events took place, including various murders (NRC, 2017)[52]. Police-chef in Rotterdam, F. Pauw, relates this increase to financial cutbacks in healthcare, however this is not significantly proven (NRC, 2017). Again, events related to confused persons are sometimes related to radicalisation; vulnerable people can be easily influenced by terrorist organisations like ISIS, resulting in them (pretending) to attack people in public spaces (Politie Eenheid Rotterdam, 2017).

Another severe threat to the safety and security of Rotterdam is undermining crime (Politie Eenheid Rotterdam, 2017). This includes the execution of crimes in cooperation networks of criminals (both above and below ground), often focussing on trafficking of humans and drugs, fraud, cybercrime and laundering. The danger of this type of crime is enhanced by the large availability of illegal fire arms on the black market. The police department of Rotterdam is regularly confronted with shooting incidents in public streets, of which the majority can be traced back to the drugs scene (Politie Eenheid Rotterdam, 2017). The port of Rotterdam is a hotspot for undermining crimes, especially when it comes to drugs trafficking; in 2016, a campaign of Meld Misdaad Anoniem[53] (rough translation: Report Crime Anonymously) aimed to decrease criminal activity in the port by alerting port employees and truck drivers of possible signals of crimes, and by asking them to report what they witness (Port of Rotterdam, 2016)[54]. The campaign is perceived as

[50] Actieplan Polarisatie en Radicalisering 2007-2011, Ministerie van Buitenlandse Zaken en Koningsrelaties9 2007: http://www.rijksbegroting.nl/system/files/18/vj-beleidsdoorlichting-van-het-actieplan-polarisatie-en-radicalisering.pdf

51 Rotterdamse Aanpak Radicalisering 2015-2018, Gemeente Rotterdam: https://www.persberichtenrotterdam.nl/uploads/programma%20radicalisering.pdf

[52] NRC, 2017: https://www.nrc.nl/nieuws/2017/12/19/zorg-over-groei-geweld-door-verwarde-mensen-in-rotterdam-a1585536

[53] Port of Rotterdam Meld Misdaad Anoniem: https://www.meldmisdaadanoniem.nl/haven

[54] Port of Rotterdam, 2016: https://www.portofrotterdam.com/nl/nieuws-en-persberichten/campagne-gestart-tegen-criminele-activiteiten-in-haven

successful: in 2016, 33 anonymous tips were reported, compared to only 14 in 2015, of which multiple have led to an investigation (AD, 2017).

Climate change mitigation and adaptation

Climate change is affecting the Netherlands. Predictions are that the country will become subject to milder winters with more rain, and hotter summers with more frequent and severe rainfall (Gemeente Rotterdam, 2013)[55]. Rotterdam is located near a river and below sea level, and large parts of Rotterdam, including the port, lie in outer-dike areas, which makes the city vulnerable to flooding (Runhaar, Mees, Wardekker, van der Sluijs, & Driessen, 2012). The Netherlands has already experienced the consequences of heat waves; in 2003, a 14-day heat wave claimed 40.000 lives in Europe, of which 1000-2000 in the Netherlands. Extreme events like heat waves and flooding may become more frequent if climate change and global warming continue (Runhaar et al., 2012).

In recent times, both the population and the economy of Rotterdam have increased considerably; as a result, it becomes more likely that the occurrence of events related to climate change lead to casualties, damage and (economic) losses, Therefore, Rotterdam is forced to be a progressive city when it comes to climate change mitigation and adaptation. This is expressed in multiple ways. First, the city is part of the 100 Resilient Cities Network (100RC)[56], as initiated by the Rockefeller Foundation. 100RC is a network of cities that are leading in movement towards become more resilience to climate change. The network tries to change how cities approach the social, economic and physical challenges that municipalities face in the 21th century (100RC, 2018). In the Rotterdam Resilience Strategy (2016)[57], the municipality expresses that the city should be a forerunner within the 100RC. The plans for 2030 are (among others) to have an efficient and sustainable energy supply, a completely resilient and cyber-proof water management system, and an urban system that is almost entirely self-organising (Gemeente Rotterdam, 2016).

Second, Rotterdam is part of the C40 cities network[58]. The cities in this network have "tremendous power to act on climate ambitions – and their power only grows when they work together"; the network facilitates dialogue amongst city officials, ensuring the free flow of ideas, support and resources, in order to improve, replicate and accelerate climate action. Rotterdam is a successful C40 city, mainly due to the adoption of Rotterdam Climate Proof adaptation programme (2008)[59] of the Rotterdam Climate Initiative, and the Rotterdam Climate Change Adaptation Strategy

[55] Rotterdamse Adaptatiestrategie, Gemeente Rotterdam, 2013: https://www.010duurzamestad.nl/wat-wij-doen/lopende-projecten/rotterdamse-adaptatiestra/adaptatiestrategie.pdf
[56] 100 Resilient Cities: http://www.100resilientcities.org/
[57] Rotterdam Resilience Strategy, Gemeente Rotterdam, 2016: https://www.100resilientcities.org/rotterdams-resilience-strategy/
[58] C40 Cities: https://www.c40.org/
[59] Rotterdam Climate Proof Adaptation Programme, 2008: https://sdr.gdos.gov.pl/Documents/Wizyty/Belgia%20i%20Holandia/Program%20adaptacji%20do%20zmian%20klimatu%20w%20Rotterdamie.pdf

(2013)[60]. The former aims to make the city of Rotterdam resilient to climate change by 2025 by making the city permanently protected and accessible, with a central focus on linking sustainable and resilient water management to creating opportunities in making the city more attractive for living and working; this is done by applying both climate change adaptation and mitigation strategies (Rotterdam Climate Initiative, 2008)[61]. The latter aims at continuously adapting to the effects of climate change, using smart solutions, technical innovation and urban development that also contribute to creating a more attractive city and to boosting the economy. Similar to the Rotterdam Climate Initiative, the Climate Change Adaptation Strategy has a main focus of creating and maintaining a resilient water management system.

Natural areas in and surrounding the city

Rotterdam is the greenest city of the largest cities of the Netherlands. The city contains multiple parks, naturally managed river beddings, and a large number of street trees (Gemeente Rotterdam, 2014)[62]. But Rotterdam also has very diverse natural surroundings, including river landscapes, polders, dune landscapes and forest areas. Examples are the forests of the Kralingse Bos, the polder of Schieveen, and the recreational areas along the river Rotte, called the Rottemeren (Gemeente Rotterdam, 2014). Natural surroundings of Rotterdam are part of the Zuid-Hollands Landschap; parts of it are managed by the Dutch nature conservation organisations Natuurmonumenten and Staatsbosbeheer.

Nature management in Rotterdam is subject to the Dutch nature protection law (Wet Natuurbescherming, Wbn 2019)[63]; this law replaced three laws in 2017 (Natuurbeschermingswet, Flora- en Faunawet, Boswet) and is the new national implementation of the EU policy of the Bird and Habitat directive, and the Bonn and Bern agreement. The goals of the Wbn are to maintain and develop nature, to maintain and recover biodiversity, to sustainably use ecosystem services, and to create a policy for conserving valuable landscapes (Ministerie van LNV, 2018)[64]. Additionally, nature management of the city of Rotterdam has to comply with national red lists, showing what plant and animal species are nationally threatened or rare (Ministerie van LNV, 2018). Multiple plans and strategies address the urban green in Rotterdam; they can be divided in nature management in public areas, and nature management in the natural surroundings of Rotterdam.

[60] Climate Change Adaptation Strategy, Gemeente Rotterdam, 2013: http://c40-production-images.s3.amazonaws.com/good_practice_briefings/images/5_C40_GPG_CDC.original.pdf?1456788885
[61] Rotterdam Climate Initiative, 2008: https://repository.tudelft.nl/islandora/object/uuid:e54e78e1-734a-4e3c-87b0-0c045c1fe597/datastream/OBJ
[62] Natuurkaart Rotterdam, Gemeente Rotterdam, 2014: https://www.rotterdam.nl/wonen-leven/natuurkaart/Natuurkaart_Rotterdam_2014.pdf
[63] Wet Natuurbescherming, 2019: https://wetten.overheid.nl/BWBR0037552/2019-07-23
[64] Ministerie van LNV, 2018: https://www.rijksoverheid.nl/onderwerpen/natuur-en-biodiversiteit/wetgeving-voor-natuurbescherming-in-nederland

Public areas

All public areas in Rotterdam are designed according to a certain style: the so-called Rotterdamse Stijl[65]. This style aims to create more unity, continuity and identity in the public areas, and to realise an attractive urban landscape. The plan has three pillars, which are roughly translated as City by the river, Attractive network, and Recognisable areas. The first one focuses on the improved accessibility of the port areas as living and working spaces, by making it more bicycle- and pedestrian friendly, and by improving and expanding urban green spaces. Attractive network aims to improve the infrastructure, both the functioning and the attractiveness; this is partly done by improving both the blue and the green infrastructure. The last pillar aims to further develop the characteristics of different areas (both natural, living and business areas) by expressing these characteristics in the design of public spaces.

All pillars are supported by the management theme "Groene stad" (green city); this aims to improve the overall quality of the urban green, to make it part of the Rotterdam style and to increase visibility, diversity and accessibility (Gemeente Rotterdam, 2010). Multiple plans and strategies are part of the Rotterdamse Stijl, including the vision in tree structure; this describes how trees can be used in designing public areas in the main structure of the city (Bomenstructuurvisie, Gemeente Rotterdam; 2009)[66]. The desire to improve green spaces in Rotterdam is also expressed in the vision regarding living environments (Woonvisie Rotterdam, 2016)[67], aiming to make Rotterdam stronger and more attractive, improving living conditions and overall contentment of the citizens.

The vision of urban green management in public spaces in Rotterdam is expressed in the management plan of public green (Beheeraanpak Openbaar Groen Rotterdam, 2017)[68]. In this document, the vision of this management is expressed by the distinction of three pillars: *natural*, *cultural* and *exclusive* (*natural* management focuses on green spaces with a natural look, with more natural dynamics and a higher diversity; *cultural* management is applied in the largest part of the city, with a lower species richness and a more managed, neat look to it; *exclusive* management is least natural and relatively high-maintenance, focusing on interaction with humans rather than on ecological value). The plan aims to expand the existing green, connecting the city with the natural environment by using the three different management pillars (starting with the natural outer-edges of the city, to the culturally managed urban areas and the exclusive city core. The areas are connected by the river, that flows through the city (Rotterdam, 2017).

[65] Rotterdamse Stijl, Gemeente Rotterdam 2010: https://www.rotterdam.nl/wonen-leven/rotterdamse-stijl/Handboek-RS-Compleet.pdf
[66] Bomenstructuurvisie, Gemeente Rotterdam, 2009: https://www.rotterdam.nl/wonen-leven/monumentale-bomen/Bomenstructuurvisie.pdf
[67] Woonvisie Rotterdam, Gemeente Rotterdam, 2016: https://www.rotterdam.nl/wonen-leven/woonvisie/DEFINITIEF-Woonvisie-Rotterdam-2030-dd-raad-15-december-2016.pdf
[68] Beheeraanpak Openbaar Groen Rotterdam, Gemeente Rotterdam, 2017: https://www.rotterdam.nl/wonen-leven/diversiteit-groen/Boekje-Beheeraanpak-Openbaar-Groen-jan-2017.pdf

Natural city surroundings

To map all the natural spaces, core areas and ecological connections in and around Rotterdam, the "Natuurkaart"[69] (nature map; Gemeente Rotterdam, 2014) was made in 2014, also as a supplement to the Rotterdam style. The aim of this map was to show the main ecological structure of the area, including where core areas with important natural values are (so-called "natuurparels", e.g. green cultural-historical heritage areas), which connection areas there, what they look like (what species composition, which habitats, etc.), are and where they can be improved or expanded, and where potential is to enlarge natural values (Gemeente Rotterdam, 2014). To realise the ambitions of the Natuurkaart Rotterdam, multiple projects are launched and will be launched in the future, mainly restricting to the natural areas within the municipality. The green main structure in the area, composed of forests, green zones and tree lanes, is improved; additionally, the ecological value of the river landscape and other waters will be improved (Gemeente Rotterdam, 2014). Projects outside municipality boundaries are often executed in cooperation with other parties, like nature conservation organisations and surrounding municipalities.

[69] Natuurkaart Rotterdam, Gemeente Rotterdam, 2014: https://www.rotterdam.nl/wonen-leven/natuurkaart/Natuurkaart_Rotterdam_2014.pdf

Appendix B: questions for the semi-structured interviews

Questions for the Rotterdam-case

Introduction

- What is your function, including main tasks and responsibilities?
- What does a regular workday look like for you?

Nature-based solutions

- What is urban green to you?
- To what extent are nature-based solutions used in the city?
- What is your view on nature-based solutions in the city?
- Does your point-of-view differ from the ones from colleagues/the public/other actors? (how are NbS perceived in general, from your perspective?)
- Have perspectives on NbS changed over the years (e.g. during different cabinets)?
- Why are they (not) used, what are the goals?
- What and how important is ecological value of natural areas?
- What are the possibilities/opportunities of NbS?
- What are the challenges in implementation?
    - Political context and structures of governance (e.g. lack of awareness of policy makers, short-term goals, priorities, etc.);
    - Public involvement;
    - Biophysical characteristics of the built environment.
- What causes these challenges? (e.g. economic situation)
- What are the goals of nature management in and around the city?
- What and how important is the ecological value of the natural areas?
- What is the potential of nature in and around the city when it comes to climate change adaptation and mitigation?
- How does nature in and around the city relate to (the feeling of) safety and security in the city?

Questions for the international study

Introduction

- What is your function?
    - What organisation do you work for?
    - What are responsibilities and tasks?
- How important are cities for solving climate-related issues?
    - And for biodiversity?
    - Inequality and exclusion, how do these relate to cities and nature?
- Paris Climate Agreement
    - What role will nature have in this agreement?
- Cities in general
    - Differences worldwide, both in developing and developed countries;
    - Differences in approach
    - Differences in implementation, challenges

Nature-based solutions

- Multiple approaches to NbS: which have the most potential, are most used?
- To what extent are nature-based solutions used in cities?
    - What differences are there between cities; why?
- What kind of nature-based solutions are used outside of the cities?
- What is your view on nature-based solutions in the city?
    - Does your point-of-view differ from the ones from colleagues/the public/other actors? (how are NbS perceived in general, from your perspective?)
    - Have perspectives on NbS changed over the years (e.g. during different cabinets)?
- Why are they (not) used, what are the goals?
    - What and how important is ecological value of natural areas?
    - How do these values differ per country?
- What are the possibilities/opportunities of NbS?

    - How do they vary between countries/cities?
- What are the challenges in implementation, and how do they differ per city/country?
    - Political context and structures of governance (e.g. lack of awareness of policy makers, short-term goals, priorities, etc.);
    - Public involvement;
    - Biophysical characteristics of the built environment.
- What causes these challenges? (e.g. economic situation)
- What are the goals of nature management in and around the city?
- What and how important is the ecological value of the natural areas?
- What is the potential of nature in and around the city when it comes to climate change adaptation and mitigation?
- How does nature in and around the city relate to (the feeling of) safety and security in the city?

Extra questions, used for both the Rotterdam-case and the international study

Climate change

- How is mitigation and adaptation of climate change implemented in the city?
- What are the main threats, caused by climate change, to the city and its population?
- What are solutions?

Economic situation

- How does this economic situation affect management regarding the urban environment?
- Do urban green spaces affect the economic situation in any way (e.g. via management)?
- What are solutions to improve the economic situation?