Environmental Change
Department of Thematic Studies
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Exploring the role of multi-functional solutions when planning for climate change: A case study of stormwater management in a Swedish city

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Master's Programme

Science for Sustainable Development

Master's Thesis, 30 ECTS credits

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1. ABSTRACT

Managing stormwater sustainably in the face of extreme weather events has increasingly been recognized as a strategy for climate adaptation in the urban planning context. Sustainable stormwater management intends to reduce urban vulnerability while ensuring the overall sustainability and robustness of future cities. To add to the emerging research field of green infrastructure, the objective of the study is to explore the role of multi-functional solutions as a climate change response in urban planning and development. This study has been driven by an inductive research process and draws on empirical data collection through workshops and interviews with City Hall officials in Motala City. The study concludes that despite the lack of preventative planning to anticipate climate change, city renewal and urban development of Motala City presented a window of opportunity to implement potential multi-functional stormwater solutions in the urban environment through urban planning. Further, increased focus on internal and external collaboration through the process of envisioning the future of the city have enabled new forms of governance and facilitated arenas for public acceptance and an integrative planning-approach. Lastly, discourses on attractiveness enabled greenery to be viewed from a social, economic and environmental perspective, supporting multi-functional stormwater solutions as a strategy for climate adaptation and urban sustainability.

Keywords: climate change, multi-functional solutions, stormwater management, urban planning, urban sustainability

2. INTRODUCTION

Cities have increasingly been targeted as important arenas for addressing urban sustainability and climate change response through spatial and urban planning (Biesbroek *et al.* 2009, Burch 2010, Dymén and Langlais 2012, Bulkeley and Tuts 2013, Klein and Juhola 2013, Steiner 2014). Planning for climate change involves policies and strategies to reduce greenhouse gas emissions through mitigation efforts as well as adapting cities to climate impacts in order to moderate harm and exploit the benefits climate change encompasses (IPCC 2012). As global temperatures are increasing, it is estimated that elevated levels of water vapor in the atmosphere will cause more intense rainfall over the Scandinavian region (IPCC 2013). However, due to the uncertain magnitude of weather extremes, local governments are increasingly being put to the test to ensure the safety of urbanized areas through local governance and development practices (Burch 2010, Mees *et al.* 2013, Renn and Klinke 2013, Peck *et al.* 2014). In 2011, the city of Copenhagen in Denmark received 150 mm of rainfall within 2 hours which is equivalent to a 1000-year rain. The intensity of the extreme rainfall caused damage to crucial infrastructure and restricted the mobility of emergency vehicles and services. The single event was estimated to one billion euros (approximately nine billion SEK) in insurance costs. In 2014, several Swedish cities experienced a 100-year rain that caused urban flooding and damage to infrastructure (Haghighhatafshar *et al.* 2014). The major challenge for urban areas in events of extreme rainfall (cloudburst) is to manage the water that accumulated on the ground, known as stormwater, in order to reduce damage to city structures as well as to ensure the safety of citizens (Barbosa *et al.* 2012, Peck *et al.* 2014). In the aftermath of the cloudburst event in 2011, the city of Copenhagen developed a Climate Adaptation Plan in order to mitigate urban flooding and manage stormwater through sustainable stormwater solutions. Hence, managing stormwater in the face of extreme weather events has increasingly been recognized by engineers, practitioners and research scholars as a strategy for urban sustainability and climate change response (Goonetilleke *et al.* 2005, McEvoy *et al*. 2010, Barbosa *et al.* 2012, Zevenbergen and Pathirana 2013). In combination with weather extremes and urbanization, urban areas face additional pressure due to urban intensification when more areas are built and paved that reduce the soils' capacity to infiltrate stormwater (Zevenbergen and Pathirana 2013). In order to reduce the risk of urban flooding and mitigate urban runoff, it has been argued that sustainable stormwater management offers a sound approach to improve the socio-economic and environmental conditions of urbanized areas (Barbosa *et al.* 2012, Bos *et al.* 2013). As Goonetilleke and colleagues (2005) conclude:

> we need to move beyond the dependency of customary structural measures and end-of-pipe solutions and [identify] the key role that urban planning can play in safeguarding urban water environments (p. 41).

While climate change, urbanization and biodiversity loss are central challenges in the 21st Century, finding solutions to generate desirable outcomes are crucial. In order to reduce urban vulnerability and cope with climate change, it has been argued that urban planning plays a crucial role in designing the urban environment to ensure urban safety, equity and sustainability (Ahern *et al.* 2014, Childers *et al.* 2014). However, studies have shown that urban planners are still in the beginning of recognizing the need for adaptation policies and strategies as a response to climate change and increased frequency of extreme weather events (Runhaar *et al*. 2012).

Recently, scholars have started to explore the role of green infrastructure when planning the future of contemporary cities as a no-regret strategy for urban sustainability and climate adaptation (Runhaar *et al.* 2012, Mees *et al.* 2013, Demuzere *et al.* 2014, Steiner 2014, Wamsler *et al.* 2014, Ahern *et al.* 2014, Norton *et al.* 2015). Research shows that green infrastructure provides urban environments with multiple benefits that in the long run enhance social, ecological and economic values and the perceived attractiveness of cities (Oberndorfer *et al.* 2007, Hunter 2011, Newell *et al.* 2013, Demuzere *et al.* 2014). In this thesis, the role of multi-functional stormwater solutions as part of a green infrastructure planning approach will be explored to better account for the constraining and enabling factors when planning for climate change in the context of urban planning and development. For example, cities around the world have started to incorporate green infrastructural aspects such as green roofs, bio-swales, rain gardens, planted green space, trees, and green streets in the urban environment to better cope with climate-induced extreme weather events such as heat waves and cloudbursts while supporting urban biodiversity and a sustainable urban form (Kazemi *et al.* 2011, Mees *et al.* 2013, Maimaitiyiming *et al*. 2014, Norton *et al.* 2015).

2.1. AIM AND FOCUS OF STUDY

Against this background, this thesis seeks to contribute to the emerging research field of green infrastructure as a climate change response by drawing on an illustrative case of stormwater management in a Swedish city. The study draws on practical climate adaptation research which aims at studying conditions in a local context and how change is managed based on processes and capacities of local governance structures (Smit and Wandel 2006). The aim of the study is to explore the role of multi-functional stormwater solutions as a strategy for climate adaptation in urban planning and development. In particular, the thesis seeks to identify determining factors constraining and enabling the implementation of stormwater solutions that have the potential to contribute to the overall sustainability and adaptive capacity of Motala City. The study draws on qualitative research, empirically originating from studying views and perceptions of City Hall officials (managers and planners) in Motala municipality. From a research perspective, Motala is interesting to study because it is a mid-sized city in the process of transition from a post-industrial city to a 'new and sustainable city' (Stadsvision Motala 2014). While views and perceptions are representations of the respondents' experience (Silverman 2006), this study is important to contribute to the understanding of how perceptions of climate risks shape (or do not shape) action to reduce urban vulnerability.

While earlier studies on climate risks and vulnerability in Sweden have focused on areas with high risk exposure such as the coastal regions (see e.g. Storbjörk and Hedrén 2011) and larger city regions (see e.g. Glaas *et al.* 2010), researchers have stressed the need to enhance the understanding of climate risks in regions experiencing moderate climate exposure (Johansson *et al.* 2009). Climate change is projected to be moderate in Östergötland[1], however, municipalities are still expected to manage climate risks and adapt to climate variability through spatial and urban planning processes (Johansson *et al.* 2009, Bratt 2014). Here, spatial planning refers to the management of land and water which in the Swedish planning context are governed by the comprehensive development plan that aims to ensure that land and water are managed sustainable though the spatial location of industries, business centra and residential areas. Urban planning, on the other hand, is the design and function of neighborhoods or buildings that are suggested by urban planners (e.g. architects and engineers) and ultimately decided by the local politicians and issued in local development plans. Hence, specifications such as the use of renewable energy sources in a residential area (e.g. district heating) can be made in local development plans which in the long run can reduce the city's environmental impact (Dymén and Langlais 2012).

In an earlier climate assessment of municipalities' capacity to cope with climate change in Östergötland, climate risks were not prioritized in Motala municipality due to low sense of risk exposure (Johansson *et al.* 2009). Since adaptation is highly context-specific and differs across scales, it has been argued that climate adaptation and risk reduction should go hand in hand (McEvoy *et al.* 2010, IPCC 2012, Wilby and Kennan 2012). In light of recent events of urban flooding in Motala City due to the cloudburst event in the summer of 2014, this study originated from studying views and perceptions of climate risks in Motala to better understand how risk perception of climate change influence spatial and urban planning for climate adaptation and stormwater management (IPCC 2014). The combination of urban growth and city renewal constitute an interesting arena to study urban planning and sustainable development in the context of sustainable stormwater management and climate adaptation policy response and measure implementation.

2.2. SITE DESCRIPTION

Motala is a mid-sized city and the largest city situated in Motala municipality in the county of Östergötland, Sweden. The city is build up around the Bay of Motala (part of Lake Vättern) and Motala Ström (waterway) and expands towards the west shores of lake Boren. Motala municipality is located on the north-eastern shores of Vättern and the municipality is characterized by forested, rural areas in the north and expanding agricultural fields in the south with a population of approximately 42 500 inhabitants (Statistics Sweden 2014). The topography of the city is characterized by the slopes of Bondebacka (recreational area) as well as the hilly south-side of the city around Holm (residential area) and Fålehagen (recreational

[1] See appendix I for future climate scenarios in Östergötland

area). The city center is located north of the Bay of Motala and characterized by the cultural heritage of Baltzar von Platen whom constructed the Göta Canal and designed the city center in its present folding fan-form[2]. Historically, Motala is known from its shipyard and engineering skills and have hosted some of Sweden's major manufacturing industries such as Motala Verkstad, Electrolux and Luxor (Rosén 2015). In the beginning of the 21st Century, the municipality of Motala experienced a negative growth trend with high unemployment rates due to the decommission of major industries. During the last few years, it should be noted that the negative growth trend has shifted and the population is now growing by the year, however unemployment rates are still high. The positive population growth is subscribed to the recent infrastructural development projects such as the building of twin-track rail road and the *Bana Väg* project of the national highway 50 between Mjölby and Motala that have improved communications to adjacent cities in the county of Östergötland. Further, the construction of the Motala Bridge in 2013 enabled the rerouting of heavy traffic from the city center, which resulted in better urban air quality as well as urban safety[3].

In 2012, the City Hall of Motala, together with the Regional Council (Östsam) and the Swedish Agency for Economic and Regional Growth (Tillväxtverket), initiated *The Future of Motala* project with the aim to develop visions for the 'new' Motala through the process of dialogue and collaboration with private actors, businesses, non-governmental organizations (NGOs), citizens and other societal actors of interest. The project led to the development of a city vision named *City Vision Motala 2030*[4] (hereafter referred to as the City Vision) that in late 2014 was adopted by the municipal council. During the same period, the City Hall, in collaboration with local business, citizens and private and public actors, developed a vision specifically focusing on the development of the city center, named *Motala City Center 2025 – Vision* (hereafter referred to as the City Center Vision). Now, development projects, anchored through dialogue and collaboration processes, are underway to redesign the urban environment into an attractive, friendly, lively and dynamic city center that citizens of Motala enjoy and are proud of (Motala Kommun *et al.* 2014). The visions have furthered been anchored in both the Local Development Program for 2015-2018 (LUP) and Goal and Resource Plan (MoR) after the local election in 2014. The political prioritized domains aim at ensuring an open and living city, a proud and attractive city and an innovative and sustainable city.

2.3. THESIS DISPOSITION

Next, key concepts and definitions will be introduced to anchor the study within climate risk and urban vulnerability-research and justify why urban planning plays a key role in climate-proofing urbanized areas (section 3). The section will introduce concepts such as stormwater management, green infrastructure, and urban sustainability, followed by a short description of the Swedish approach to urban climate adaptation. Towards the end of the background section, state-of-the-art research will be explored in order to interpret the research findings. After the given background, a section on materials and methods will follow (section 4). In this section, a description of the research design and process will be given along with

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[2] See appendix II for city map and a visual representation of the city's topography
[3]http://www.motala.se/sv/Invanare/Nyhetslista---Invanare/Motalabron-minskar-trafiken-i-centrum-och-vinner-pris-at-Motala-kommun-/ [26-10-2015]
[4] During the process of developing the City Vision, an action plan was also developed. However, the action plan was not adopted by the municipal council until the end of the research process and therefore it has not been part of the policy review. Still some of the development project are mentioned in the City Center Vision, and they are in this paper considered as ongoing/planned for development/infrastructure projects

methodological considerations of data collection and data analysis. Following is the presentation of the research findings in relation to earlier research, in which determining factors (enabling and constraining) for multi-functional stormwater solutions are presented (section 5). Lastly, in the discussion part (section 6) the research findings will be reflected upon in relation to the research aim, state-of-the art research, and the research process and how the findings contribute to the emerging research field of green infrastructure when planning for climate change. References and appendices (I-IV) can be found at the end of this paper.

3. BACKGROUND AND DEFINITIONS: MAKING SENSE OF KEY CONCEPTS

In the following section, key concepts are introduced along with a background to the prevailing challenges for anticipating and managing climate risks in urbanized areas.

3.1. CLIMATE RISKS AND URBAN VULNERABILITY

Historically, climate change was not until the 1980's raised as a political and scientific concern and was then to be solved through the reduction of greenhouse gas emissions, i.e. climate mitigation, to meet the 2°C-target decided under the United Nations Framework Convention on Climate Change (Bulkeley and Tuts 2013). Despite global, regional and local action to reduce the greenhouse effect, emissions are still on the rise. As greenhouse gases are increasing in the atmosphere, global climate systems are changing, leading to higher climate variability and change in average precipitation and temperature patterns (IPCC 2013). Global climate change will first and foremost be felt at the local level, affecting individuals, ecosystems, and socio-economic systems; however change will vary geographically and over time due the unpredictability of climate system function (Salas *et al.* 2012, IPCC 2014). As cities are starting to feel the effect of climate change and the need to address environmental and socio-economic vulnerability of urbanized areas (Peck *et al.* 2014), climate adaptation has been raised as an equally important strategy along climate mitigation to cope with and benefit from the impacts of climate change (Smit and Wandel 2006, McEvoy *et al.* 2010, IPCC 2012, Bulkeley and Tuts 2013, IPCC 2014). With increased climate variability, extreme weather events are projected to increase, leading to higher susceptibility to landslides, floods, fires, heat waves and cloudbursts with implications for food-water-energy security, environmental health, and damage to human settlements and infrastructure (IPCC 2014). In Sweden, change in average temperature is expected to lead to warmer winters and higher frequency of heat wave events during summers. Change in precipitation rates is estimated to increase the intensity of cloudbursts with implication for urban flooding and eroded water banks (Kjellström *et al.* 2014).

While human-induced climate change is one of the major challenges facing urbanized areas (IPCC 2014), an urban area is characterized by the amount of impermeable surfaces and land use modifications due to human development and rapid urbanization (Kazemi *et al.* 2011). As mentioned earlier, stormwater is defined as the surface water that originates from precipitation or snowmelt that accumulates on the ground. Depending on the characteristics of the surface, stormwater can either be infiltrated into the soil or continue over the surface as runoff. Unless stormwater is retained through green space or engineered stormwater systems (e.g. stormwater inlets and pipe networks that carry the water to a water recipient), surface runoff will continue towards the lowest point (geographically) (Goonetilleke *et al.* 2005, Barbosa *et al.* 2012). Traditional urban water management has been manifested by engineered end-of-pipe solutions and has until recently been successful in supplying water, securing public health and protecting urban areas from flooding (Goontilleke *et al.* 2005, Bos *et al.* 2012). However, in events of extreme weather and increased climate variability, stormwater systems are increasingly being put to the test due to changing water flows (McEvoy *et al.* 2010, Barbosa *et al.* 2012, Zevenbergen and Pathrinana 2013). In the case of the Copenhagen-event, stormwater systems failed to manage the elevated water levels causing overflows in stormwater systems, flooding of urban areas and damage to private and public property (Haghighatafshar *et al.* 2014). Hence, managing stormwater in urbanized areas is increasingly being regarded a planning issue (Hellström *et al.* 2013).

Within sustainability science, science seeks to assess possible solutions to ensure the well-being of human and ecological systems while ensuring the prospects of society without causing significant harm to future generations (Kates *et al.* 2001, Gibson 2006, Redman 2014). By finding new ways of reducing vulnerability of city structures to changing climate conditions, sustainable urban form entails a good built environment that ensures the physical safety and health of citizens and the city itself (Ahern 2011, Jabareen 2013, Zevenbergen and Pathirana 2013, Childers *et al.* 2014, Ahern *et al.* 2014, Steiner 2014). Managing stormwater in the face of extreme weather events has increasingly been recognized as a key strategy to reduce climate exposure and vulnerability of cities to better deal with changing climate conditions (Barbosa *et al.* 2012, Newell *et al.* 2013, Peck *et al.* 2014).

3.2. THE ROLE OF MULTI-FUNCTIONAL SOLUTIONS IN URBAN PLANNING

Despite the prevailing problems to mitigate urban stormwater pollution and adapting stormwater systems to climate variability, several good practice examples can be found in both Sweden and elsewhere where multi-functional stormwater solutions have successfully retained stormwater while contributing to multiple benefits of urban areas (Oberndorfer *et al.* 2007, Kazemi *et al.* 2011, Hellström *et al.* 2013, Li and Babcock Jr. 2014, Maimaitiyiming *et al.* 2014). Multi-functional solutions are in this thesis referred to as stormwater solutions that provide urban areas with multiple benefits (biophysical and socio-economic) and functions (e.g. ecosystem services) (Demuzere *et al.* 2014). For example, Kazemi *et al.* (2011) found that by replacing lawn-type green space with bio-retention swales along streets, species composition increased, leading to a richer urban biodiversity. In this context, multi-functional stormwater solutions are closely interlinked with the concept of green infrastructure and for the purpose of clarifying concepts[5], table 1 provides examples of what the literature defines as ‘green infrastructure’ and what Motala municipality lists as ‘technical stormwater solutions’ in the municipal stormwater policy (Motala Kommun 2007). The table also provides benefits and consequences of implementing stormwater solutions identified through the literature review.

In that sense, green infrastructure is the integration of green aspects within a city such as parks, gardens, planted green space, landscape architecture, green roofs, green streets, wetlands, or bio-swales. Unlike traditional pipe-based stormwater systems, green infrastructure uses vegetation and soil to retain, infiltrate and purify stormwater on site while enhancing the overall sustainability and perceived attractiveness of a city since greenery are

[5] It should also be noted that the concepts of multi-functional stormwater solutions have in the literature been referred to as ‘open stormwater solutions/systems’, ‘best management practices (BMPs)’, ‘sustainable urban development systems’, ‘low impact development’, ‘water sensitive urban design’ or ‘green infrastructure’. For the sake of this thesis, stormwater solutions are in this thesis referred to as multi-functional stormwater solutions and used synonymously to the concept of green infrastructure.

often associated with positive additive to the urban environment (EPA 2008, Kazemi *et al.* 2011, Newell *et al.* 2013, Ahern *et al.* 2014, Steiner 2014, Andersson *et al.* 2015). Even though contemporary cities are faced with extensive use of impermeable surfaces which leave little room for incorporating new elements in the urban environment (Mees *et al.* 2013), the process of greening a city has shown to contribute to the overall capacity of cities to cope with unprecedented climate change (Demuzere *et al.* 2014, Norton *et al.* 2015).

Table 1: Examples of green infrastructure/multi-functional stormwater solutions and associated benefits identified through a literature review

Example of Green infrastructure	**Examples of 'technical' stormwater solutions**	**Ecosystem services/benefits[6]**
Green roofs, Green allays and streets, Green façades, Bio-swales, Urban trees canopy, Green space, Rain gardens, Rainwater harvesting, Permeable pavements, Wetlands, Dams	*On private property:* Green roofs, infiltration through green space, permeable pavements, French drain, dams, rainwater harvesting, storage *On public property:* Permeable pavements, infiltration through green space, infiltration through pavements, temporary flooding of green space for retention purposes, dams and wetlands, swales, water canals, streams and dikes	*biophysical* Increased albedo, Water storage and infiltration, evapotranspiration, Biodiversity conservation, air-quality improvement, Biomimicry, leaching of nutrients, CO^2-sequestration, stormwater retention, mitigates the urban heat island effect, healthy ecosystems *Socio-economic* aesthetical, value enhancement, sound insolation, shade and cooling, fire resistance, fire prone during dry periods, increased building (roof membrane) longevity (green roof and façade), Less energy use (cooling/ warming effect), place identity, reduce physiological stress, asthma

By adding green infrastructural aspects to urban areas, it supports the provisions of ecosystem services that benefits human well-being while contributing to the sustainability of urbanized areas (Demuzere *et al.* 2014, Wamsler *et al.* 2014). Ecosystem services provide urban areas with, among other functions, stormwater infiltration and purification, biodiversity conservation, pollination, air and water cleansing, erosion and soil stabilization, recreational purposes, cultural heritage, food security, carbon sequestration and flood risk prevention (Oberndorfer *et al.* 2007, Hunter 2011, Smith *et al.* 2013, Ahern *et al.* 2014; Steiner 2014, Maimaitiyiming *et al.* 2014, Sussams *et al.* Eales 2015). For example, green infrastructure can be used as means to mitigate the urban heat island effect (urban areas generally absorb more sunlight due to dark surfaces and closed-in areas which increases the surface temperature locally) and decrease urban runoff through rainfall interception (temporal storage of water in

[6] For further reading see **www.**epa.gov; www.landarchs.com; Oberndorfer *et al*. 2007; Hunter 2011; Kazemi *et al*. 2011, Mees *et al*. 2013; Li and Babcock Jr. 2014; Gong *et al* 2014; Maimaitiyiming *et al*. 2014, Norton *et al.* 2015

tree canopy before it is absorbed by the ground) and soil infiltration (Maimaitiyiming *et al.* 2014, Norton *et al.* 2015). While trees and green spaces are beneficial for trapping pollution particulate matter and intercepting rain droplets (Demuzere *et al.* 2014), pollen can cause allergic reactions and reduce human mobility within the urban area. In terms of safety, new elements such as rain gardens can pose as safety issues while parks and green areas can be perceived as unsafe during nights. In addition, green space requires maintenance such as grass mowing and irrigation that indirectly cause an increase in greenhouse gas emissions through the use of motorized vehicles such as lawn-movers and tractors. As emphasized by Sussams *et al.* (2015), using green infrastructure as a climate adaptation policy response requires a thorough assessment of the benefits and trade-offs such an approach can bring to local capacity building.

3.3. THE SWEDISH APPROACH TO URBAN CLIMATE ADAPTATION

As climate variability is expected to increase, the Swedish government has shifted focus towards sustainable resource management and climate adaptation to reduce ecological, social and economic vulnerability of urbanized areas. In a recent government report, The Committee on Environmental Quality Objectives (SOU 2014:50) emphasizes that in order to prevent climate risks, strategic spatial planning and risk assessments play a key role 'to protect society against potential future risks and costs as a consequence of climate change' (SOU 2014:50 p. 64 author's translation). Here, climate risk is understood as the interaction of hazard, exposure and vulnerability that result in something of value to be at stake under uncertain outcomes. For example, a hazard can either be a short-term event (e.g. a storm) or a long-term trend (e.g. a persistent drought) exposing societies, ecosystems and people to risks. The level of exposure and vulnerability to a given event will be determined by the socio-economic and environmental preconditions existing at a given place and at a given time (IPCC 2014). In other words, assessing potential risks can be an important approach to increase the adaptive capacity of a system, i.e. the ability of the system 'to adjust to potential damage, to take advantage of opportunities or to respond to consequences' (IPCC 2014, p. 118).

In Sweden, the environmental policy instruments and measures have mainly focused on reducing greenhouse gas emissions in order to mitigate climate change while national policies for climate adaptation have remained absent (SEPA 2012, Nilsson *et al.* 2012, Dymén and Langlais 2012, Miljödepartementet 2014). Since climate adaptation is context-specific and varies across spatial and temporal scales (Smit and Wandel 2006), action for climate adaptation and the implementation of adaptation measures is expected to take place in Sweden's 290 municipalities due to the municipal planning monopoly. So far, the Swedish adaptation approach has evolved around knowledge production for managing climate risks, however, incentives remain for national, regional, and local institutions to take action on climate adaptation. While governmental agencies such as the Swedish Meteorology and Hydrology Institute (SMHI), the Swedish Contingency Agency (MSB) and The Swedish National Board of Housing, Building and Planning (Boverket) are important national institutions to provide climate risk data and guidelines for enabling climate adaptation, the prevailing lack of a national adaptation strategy and unsettled roles and responsibilities to realize climate adaptation measures have left Swedish municipalities awaiting guidelines and support for local action, as was found in a recent report by SMHI (Andersson *et al.* 2015).

Further, the planning and management of land, water and resources are realized through the municipal planning monopoly and Swedish municipalities bear the main responsibility for planning and building urban areas to ensure the well-being of humans and natural environments (Westlin *et al.* 2012, Miljödepartementet 2014). Spatial planning is mainly governed by the Swedish Planning and Building Act (PBL 2010:900) and the Environmental Code (MB 1998:808). Strategic spatial planning and the management of land is manifested through local development planning and municipal comprehensive planning guided by the Planning and Building Act in which spatial planning must consider environmental and cultural values as well as climate aspects throughout the planning process. While municipal comprehensive planning is not legally binding, it is strategically important to address long-term development goals and to ensure that national and environmental quality objectives are considered in overall spatial planning practices. Local development plans on the other hand, are detailed plans that aim to guide the design and performance of new buildings, roads and other facilities located within the municipal planning jurisdiction. Although the Planning and Building Act and the Environmental Code mandate municipalities to consider climate change issues through planning processes, planners are left with few guiding principles and weak top-down steering for approaching climate aspects in local planning (Dymén and Langlais 2012).

3.4. State-of-the-art research: Planning for climate change in the urban sphere

Despite the challenge of mainstreaming climate adaptation into existing planning practices (Storbjörk and Uggla 21014), there is a growing body of research pointing to the importance of local governments to mobilize urban response towards unprecedented climate change (Bulkeley and Tuts 2013, IPCC 2014). With a growing human population and more than half of the world population now living in cities globally (Richter *et al.* 2013), the foci of local governments is to ensure robustness and sustainability of urban areas while mitigating and adapting to climate change (Burch 2010, Ahern 2011, IPCC 2012, Jabareen 2013). In that sense, urban planning is an important arena in which urban sustainability and climate change policy response contributes to the long-term development of urbanized areas (Biesbroek *et al.* 2009) as also emphasized by Leichencko (2011):

> In order to contribute to long-term urban sustainability, efforts to promote urban resilience to climate change, including both adaptation and mitigation strategies, need to be bundled with broader development policies and plans (p. 165)

Adapting to climate change and managing climate risks requires urban planning and management to be flexible to ensure a more integrative and tangible approach to climate action and policy integration of climate solutions (Urwin and Jordan 2008, Wilby and Keenan 2012, Pahl-Wostl *et al.* 2013). The rationale of this thesis is built on the notion that cities are important arenas to address global problems through local development and management of urban areas. According to Lee and Koski (2012):

> The key to solving this collective action problem is the choice of a policy instrument that benefits a locality primarily, but one that also serves a global purpose (p. 619)

However, the challenge remains to translate policy-decisions and development plans into desirable outcomes that generated a sustainable and robust city structure (Burch 2010, Lee and Koski 2012, Stuart *et al.* 2014). The question is then, what is a desirable outcome? While contemporary cities are tackling problems such as aging infrastructure, urban sprawl and socio-economic inequalities (McEvoy *et al.* 2010, Zevenbergen and Pathirana 2013), the transition from contemporary city structures to sustainable city structures involve transformative practices that 'break free' from history and actively shape the future through the process of envisioning and common agenda setting across key institutions (Albrechts

2010). To realize the potential of cities as transformative arenas for addressing sustainability through urban planning and design, Steiner (2014) stresses that research must advance towards a transdisciplinary approach, involving ecosystem services, the role of green infrastructure, the renewal of urban areas and people's capacity 'to adapt to knowledge about their surroundings' (p. 304-305). According to researchers in the field of landscape planning and design, the integration of green infrastructure enhances urban sustainability and cities' robustness to future climate changes (Ahern *et al.* 2014, Steiner 2014). On the other hand, researchers in the field of climate adaptation governance stress the need to address climate change strategies to ensure the sustainability and robustness of future cities (Burch 2010, Tuts and Bulkeley 2013, Klein and Juhola 2013). In that sense, the multi-functionality of green infrastructure enables cities to cope with and reduce climate risks while increasing the adaptive capacity of the city (Demuzere *et al.* 2014).

For example, the replacement of aging infrastructure, densification, revitalizing and redevelopment of neighborhoods and brown fields (i.e. sites of abandoned industries or commercial buildings) in a city provide windows of opportunity to actively shape and design the urban environment towards a sustainable urban form (McEvoy *et al.* 2010, Jabareen 2013, Zevenbergen and Pathirana 2013). The sustainable urban form entails a good built environment in which urban design reconsiders social, ecological, economic, technical, and equity aspects in order for humans and ecosystems to thrive within the urban environment (Jabareen 2013). While several strategies exist to ensure urban sustainability, such as densification and the use of sustainable transport, scholars have stressed the role of greening the city plays for urban sustainability as well as for climate change response (Demuzere *et al.* 2014, Norton *et al.* 2015, Sussams *et al.* 2015).

Hence, green infrastructure plays an important role in urban planning as a multi-purpose strategy and in order to enable the use of multi-functional solutions in urban areas, urban planners need to overcome barriers such as limited space of compact cities by for example introducing green roofs (Mees *et al.* 2013) and turn weak internal coordination into enabling arenas for collaboration (Storbjörk and Hedrén 2011). For example, studies on capacity-building for climate adaptation action have found that despite existing adaptive capacity to climate change response, climate adaptation policies have not translated into action on the ground (Urwin and Jordan 2008) due to lack of sense of urgency and budget constraints (Runhaar *et al.* 2012), inaction of decision makers (Carlsson-Kanyama *et al.* 2013), lack of national guidance and clear regulations (Wamsler and Brink 2014, Runhaar *et al*. 2012), inhibited work-environments for innovation and out-of-the-box-thinking (Burch 2010), and lack of political will (Hjerpe *et al.* 2014). While several barriers exist for successful policy integration, planning for climate change has often entailed the use of large scale climate models to show the need for climate mitigation strategies (Wilby and Dessai 2010). However, according to Dessai and Hulme (2007) the uncertainty and unpredictability of climate change often hampered action to take place at the local level and Wamsler and Brink (2014) found that the uncertainty of climate risks and impacts left Swedish decision-makers and planners to adopt wait-and-see approaches, stalling planning processes or avoiding responsibility towards risk assessments and safety margins. In Sweden, knowledge production of climate risks has been the main strategy to address climate adaptation (Nilsson *et al.* 2012), however, a Dutch study found that knowledge of global climate change did not necessarily translate into local action for climate adaptation (Runhaar *et al.* 2012). While spatial planning and risk assessments are increasingly being recognized by national governmental agencies and academia as key arenas to mainstream climate adaptation into existing policies (Mossberg Sonnek *et al.* 2013, Storbjörk and Uggla 2014, SOU 2014:50, IPCC 2014, Andersson *et al.*

2015), challenges remain for climate adaptation policy to translate into action on the ground (Urwin and Jordan 2008) in the Swedish planning context.

In the case of urban water management, scholars have found that local management is inhibited by path-dependency and traditional mandate, leaving little room for innovative thinking in the planning process (Pahl-Wost *et al.* 2013, Childers *et al.* 2014, Ahern *et al*. 2014). First, urban water systems are often pipe-based and limited to physically engineered technical solutions (Goonetillenke 2005). Second, urban water management is often managed by engineers and technical staff at the municipal level (Pahl-Wostl *et al.* 2013). The rigid, engineered structures have, according to Childers *et al.* (2014), built-in physical, institutional and social inertias that leave little room for flexibility of water systems to changing water flows, and thus inhibit adaptive urban planning to anticipate climate change.

In Sweden, municipal management has traditionally been organized around distinct departments in which social, technical, environmental and economic issues have been separated in terms of management (Dymén and Langlais 2012). The management of urban areas in separated 'silos' has been recognized as one of the major barriers to facilitate cross-sectoral collaboration in urban planning practices (Baard *et al.* 2012, Storbjörk and Hjerpe 2013). In contrast, managing urban stormwater has been found by scholars to require municipal government officials to collaborate across units (Newell *et al.* 2013) and involve multiple stakeholders (e.g. public actors, citizens, and local building actors) in the planning process (Barbosa *et al.* 2012, Bos *et al.* 2013). According to Demuzere and colleagues (2014), understanding the benefits and trade-offs of urban greenery are crucial to enable greening initiatives in local decision-making towards implementing policy objectives for multi-functionality. However, studies have found that benefits of multi-functional solutions such as green infrastructure are not realized due to the implementation deficit of perceived benefits and actual outcomes (Sussams *et al.* 2015). The literature on the role of green infrastructure as a climate change response indicates a knowledge-implementation gap in which knowledge fails to translate into tangible measures. For example, Wamsler *et al.* (2014) found in their study on adaptation planning in Sweden that climate adaptation and an ecosystem-based planning-approach together facilitated a conceptual foundation for urban sustainability; however, the integration of the two planning approaches were not realized due to traditional municipal management practices stressed above.

Mees *et al.* (2013) found in their study that public responsibility played a salient role in providing public spaces with 'adaptation goods', either by addressing it through local government processes or by initiating it through private actors. In that sense, private involvement was shown to push innovation forward and enable stormwater solutions through market and economic incentives. For example, the study found that the price of green roof had been declining, making the implementation of green roofs more economically feasible. Fostering participation and partnership at the community-level can accordingly enable action towards sustainable development 'from a truly collaborative and integrated process of development and implementation' (Stuart *et al*. 2014, p. 16). Engaging citizens and other private and public actors through participatory channels have been shown to foster stewardship and empowerment for local change and development (Gibson 2006, Stuart *et al.* 2014). Also, researchers have argued that leaders of city governments and strong political leadership play an important role in creating policies for climate action and sustainability transition (Burch 2010, Lee and Koski 2012).

4. MATERIALS AND METHODS

In the following section, a detailed account of the research design and research process will be given along with treatment and analysis of the empirical data collected. Towards the end of the section, the researcher reflects on some of the methodological difficulties and constraints encountered during the research process.

4.1. RESEARCH DESIGN

The research design of this study is based on an integrated research process in which the empirical data is collected inductively using qualitative methods for data collection and analysis (Creswell 2014). Interviews and workshops have been the main source of empirical data and the study has been driven by the endeavor to produce in-depth knowledge (Creswell 2014) to better understand the complexity of stormwater management in the context of urban planning and development. The views and perceptions of City Hall officials in Motala City have been the main drivers for moving this thesis forward in an inductive research process and thus shaped the thesis to address climate vulnerability and sustainable stormwater policy responses in the context of climate adaptation.

The empirical data is based on a triangulation of sources (Baxter and Eyles 1997). In addition to the interaction with officials at the City Hall of Motala City through individual interviews and workshops, a policy review of municipal documents has been conducted to get an overview of existing policies and political priorities at the local level. In order to anchor the findings in academia and the Swedish climate policy context, peer-reviewed articles, international reports, proceeding and national reports and policies have been reviewed to provide a relevant background and state-of-the-art research outlined in the previous sections to enable the interpretation of the research findings. The literature review has been a simultaneous process to the interviews and workshops, as well as during the phase of data analysis.

4.2. RESEARCH PROCESS

An initial scoping meeting was held in December of 2014 with three City Hall officials to discuss possible research ideas and framings for future collaboration. The meeting was of non-structural nature where the officials and the researcher together discussed possible research topics that would be both of scientific importance and relevant for Motala City.

A first workshop was held at the end of January in 2015 at the City Hall. The workshop lasted for two hours and constituted of five workshop participants and the researcher. An e-mail was sent to the participants prior to the workshop containing the aim of the study, a brief overview of the meeting and a request for permission to record the meeting. The workshop participants were from different municipal administrative units including water and environmental management, spatial and urban planning, and risk and safety management to ensure a heterogeneous group composition. The participants were chosen based on their experience with the previous cloudburst event in Motala during the summer of 2014. To set the stage for the first workshop, a preliminary literature review was initiated prior to the workshop featuring peer-reviewed research articles concerning climate adaptation and risk and vulnerability assessments of urbanized areas in the global and national context. The themes of the workshop covered topics related to risk and vulnerability, extreme weather events, climate change, stormwater and waste water systems, risk perceptions, adaptive measures (implemented and planned), relevant policies and institutional organization, enablers of action, and lessons learned. In order to facilitate the thematic analysis, the questions formulated in the interview guide were based on previous research in urban risk assessments (Renn and Klinke 2013) and enablers for climate change response at the local level (Burch 2010).

The set-up of the meeting was designed to initiate dialogue (Wibeck 2010) and contained, along with the thematic questions, participatory exercises[7], such as brainstorming and mapping of risk areas, to fuel discussions (Wilk *et al.* 2013). At the beginning of the workshop, the participants were asked to discuss what they associated with the concept of *climate change* as part of the brainstorming-session. They were also asked to identify areas within Motala City that are vulnerable to flood and what damage the cloudburst-event of 2014 had caused. Areas of stormwater infiltration dams were also identified during the exercise. The purpose of using a participatory research design of the workshop was to open up the box to clarify roles and responsibilities, local skills, internal capacities, past experience of climate extremes and the management of urban stormwater in light of climate change impacts. The knowledge and information possessed by the workshop participants were seen to be relevant to the research process and the aim of the first workshop was to broaden the understanding of the views and perceptions of City Hall officials in relation to climate exposure and urban vulnerability (Wibeck 2010, Glaas and Jonsson 2014) and whether perceptions of climate risks shaped action towards sustainable stormwater solutions. While researchers have recognized the need to engage stakeholders from different levels of the society (municipalities, national agencies, citizens, NGOs) to better facilitate climate adaptation responses (Welp *et al.* 2006, Ahern 2011, Renn and Klinke 2013, Glaas and Jonsson 2014), this study was delimited to only include officials employed by the municipality due to the time limit. However, during workshops and interviews, the respondents stressed the need to include actors such as local real estate firms, local businesses and citizens in the planning process to better anchor development projects among private and public spheres.

In preparation for the second workshop, a literature and policy review was initiated that covered topics such as climate change, sustainable development, stormwater management, and green infrastructure. Additionally, searches of stormwater solutions and design from the United States Environmental Protection Agency (EPA) and the Landscape Architect Networks webpages were also carried out. Designs of stormwater retention measures were used to illustrate multi-functional stormwater solutions during the workshop. An e-mail was sent prior the meeting to the invited participants explaining the set-up of the meeting and to remind them of time and place, however no preparations were asked of the participants prior to the workshop. The second workshop was held in the beginning of March in 2015 with the same group of participants as during the first workshop. The workshop was conducted at the City Hall and lasted for approximately two hours.

The workshop began with a presentation given by the researcher. The presentation started off with reconnecting to the problem of stormwater management in a densely populated area, a problem identified during the first workshop. The workshop moved forward by introducing and defining concepts such as climate change, sustainable development, green infrastructure and the difference between climate mitigation and adaptation. During the second part of the workshop, a group discussion followed on how stormwater solutions identified in the municipal stormwater policy-document (Motala Kommun 2007) could be used to enhance sustainable stormwater management in regards to increasing water flows while contributing to

[7] See Appendix III for further explanation and pictures of participatory exercises used during the first workshop

the overall sustainability of the city. In a participatory exercise, participants were asked to evaluate potential multi-functional stormwater solutions from a sustainability-perspective. By using the municipal stormwater policy and City Center Vision (Motala Kommun *et al.* 2014) as a starting point for discussion on sustainable stormwater management, potential multi-functional stormwater solutions were assessed using an adopted version of the sustainability analysis-tool developed under the Swedish research program *Climatools* (FOI 2011). The sustainability analysis is a decision-support and evaluation tool that provides planners and decision-makers a basis to develop strategies for climate adaptation and sustainable development at municipal level (Baard *et al.* 2012). The sustainability analysis was loosely based on a checklist available in the *Climatools*-material[8] and participants were asked to identify ecological, social or economic consequences of implementing multi-functional stormwater solutions in Motala City. Towards the end, participants were asked to identify costs and benefits, key actors and conflicts of interests in regards to potential stormwater solutions in the city center (FOI 2011, Baard *et al.* 2012).

In addition to the two (n=2) workshops, a total of four (*n*=4) individual interviews were conducted during the period of February to April with urban and spatial planners employed by the City Hall. The officials participating in individual interviews had not been present during the workshops and the interviewees were selected based on a snowball method and recommendations from earlier interviews/workshops. Qualitative individual interviews were conducted to add new dimensions and perspectives to the research aim and to expand the representation of different units at the City Hall (Darlington and Scott 2002, Silverman 2006). The first individual interview was held in February, prior to the second workshop while the other interviews (2, 3, and 4) were conducted afterwards from March to April. Each interview lasted for approximately 30-50 minutes and all were conducted at the City Hall. The interviews were designed to be semi-structured to open up for the interviewee to have the freedom to talk of topics he/she ascribed meaning to, while keeping it within the broader focus of the study (Silverman 2006). Each interview followed general proceedings based on guidelines from Wibeck (2010) and each interview guide was adopted to fit the profession and assumed knowledge of the interviewee. The range of topic raised during the interviews included challenges and opportunities for urban sustainability and climate-proofing, climate exposure and risks, roles and responsibilities in the planning process, internal and external actors, and the realizations of plans and implementation of measure in relation to stormwater solutions and green infrastructural aspects. Some questions were designed to clarify or broaden the perspective of a certain topic discussed in an earlier interview/workshop. Additionally, interviewees were asked to identify important policy and steering documents.

4.3. TRANSCRIBING, CODING AND ANALYZING

The workshops and the individual interviews were all recorded using a smartphone application and all respondents consented to the recordings. All recordings have been kept confidential and can only be accessed by the researcher. Each interview and workshop was transcribed, which is the process of writing what has been said. When transcribing an oral speech, nuances in voices are often lost which could have implication for the construction of meaning; however, having the possibility to re-listen and consult the recordings strengthened the validity of the transcription. In order to increase the reliability of the reproduced speech, the transcription included all spoken words, indicated emphasis on words, if it were meant as a joke or if the respondents laughed. The transcription also included words such as "mm" and

[8] See Appendix IV for sustainability analysis-matrix and picture of exercise

"aa", however, encouraging/listening words produced by the researcher (interviewer) were omitted. In section 5, quotes stated by the workshop participants and interviewees have been used to illustrate nuances and highlight the research findings. The quotes have been paraphrased to enhance the readability; however, the content remains the same (Silverman 2006, Kvale and Brinkmann 2014).

During the process of transcribing, the researcher started a preliminary process of analyzing and making sense of the data by taking notes and writing short memos in the margins of the transcriptions. A first step in the coding process was to code the content of each interview/workshop separately. The transcriptions were treated with equal weight and in the case of the coding the workshops, both individual points and those made collectively were included. The coding of interviews and workshops was done successively throughout the research process and based on the questions provided by Kvale and Brinkmann (2014) listed below:

- What issues are being discussed?
- What are the points made?
- What is important to the interviewee/workshop participant(s)?
- What is not important to the interviewee/workshop participant(s)?

According to Kvale and Brinkmann (2014) interviews are representations of experience and can tell different kinds of 'truths', hence, finding patterns in the empirical material by comparing the initial codes of content was part of the second step in the coding process. Along with the identification of general patterns, the identification of nuances and contesting views increased the depth of the analysis and allowed for a concentration of meaning. The concentration of meaning led to a categorization of five preliminary themes including challenges for sustainable urban development, challenges for implementing stormwater solutions in a dense city, rethinking stormwater management and adapting to change, roles and responsibilities to enable solutions, and last, transformative practices and envisioning the future of Motala City. The last step, and most time consuming part of the analysis, was to draw conclusions of the empirical findings and 'telling the story' in relation to state-of-the-art research. From the derived themes, the analysis of the empirical material progressed to identify a set of determining factors for enabling and constraining potential multi-functional stormwater solutions. In section 5, the key findings will be presented from conducted workshops and interviews organized around the views and perceptions of City Hall officials in Motala City.

4.4. Methodological considerations and constraints

During the research process, it was evident that the researcher's pre-understanding and conceptions of things 'going on' in the city were important to the sense making of what was discussed by the respondents. In other words, being a citizen of Motala enabled a more holistic view to better grasp the contextual setting in which the problem of stormwater management was formulated. As Brinkmann puts it, there are 'both symbolic and material factors that inform the microanalysis' (2014, p. 723) that the researcher will base his/her understanding on and in this case, the pre-understanding of the city's characteristics helped to inform the analysis. On the question of subjectivity, science can never be fully objective; however, being aware and reflexive of one owns preconceptions and thoughts throughout the research process are crucial to encompass possible biases and conflicts of interests (Baxter and Eyles 1997, Creswell 2014; Kvale and Brinkmann 2014). The stumbling on data is in itself an objective research process; however, it is the construction and framing of the research findings that will be influenced by the researcher's subjectivity. This is further emphasized through the interpretation of data. A text can be interpreted in multiple ways and decrease the quality of the research findings. However, remaining reflexive and ensuring validity throughout the research process is one way to overcome such limitations (Kvale and Brinkmann 2014).

In this study, workshops and individual interviews were given equal weight during data analysis; however, some constraints hampered the study to give a broader account of nuances and differences of perspectives. One constraint was that during workshop discussions, some of the participants were more dominant than others which had implication for what was being said and *not* said. It should also be noted that those participating in the workshops were co-workers. Despite the representation of different administrative units at the City Hall, the respondents work close together in different development projects due to fact that Motala is a rather small municipality. Hence, the level of involvement the respondents have in their day-to-day work environment might also have influenced discussions and, in extent, the result. To overcome the limitations of group dynamics, the researcher delegated questions to those less engaged; which, however, not necessarily led to a higher degree of involvement. Nonetheless, it was evident that during the participatory exercises the level of participation increased among all participants, especially during the sustainability analysis when each participant was given a pen and post-it notes to give their account of challenges and opportunities for multi-functional stormwater solutions. Despite the issue of group dynamics, the heterogeneity of the group enabled a broader discussion (Creswell 2014) on the problems of stormwater management in relation to climate risks. In addition, interviews were conducted with other City Hall officials who had not been part of the workshops in order to add new dimensions to the research objective. It was found that the interviews both supported and contested claims that had been stated during the workshops, enhancing the analysis to show both general patterns and contesting views. However, the difference in perceptions between individual interviews and workshops could also be explained by the influence of group dynamics discussed above. To overcome such limitations and to give a better account of nuances, follow-up interviews could have been made with the workshop participants; however this was not done due to the limited time frame of the study. Still, the differences of perspectives have been made visible in the research representation by treating each respondent i.e. both workshop participants and interviewees, as individuals. When there was a general agreement among the workshop participants they were treated as a group. In cases where there was a general agreement across both workshop discussions and interviews, the respondents were treated as an entity.

In line with qualitative research ethics (Creswell 2014), the names of the respondents have not been used in this study; instead officials are referred to as respondents (in general), workshop participants (those participating in workshops), or interviewees (those participating in individual interviews). In some cases however, the respondents are referred to their profession (but without being too specific) in order to show nuances and differences in perception among officials and how their roles and responsibilities influenced the research findings[9]. The City Hall officials participating during the workshops are hereafter referred to as workshop participant (WP) 1, 2, 3, 4 and 5, and officials participating during interviews are referred to as Interviewee 1, 2, 3 and 4, see table 2 for role description.

[9] The role description of the respondents refers to the work of the officials' in more general terms at the time when the workshop/interview was conducted. The professional role of the officials may have changed since the publication of the thesis.

Table 2: Presentation of the respondents participating in the research process and their professional role at the City Hall

Role description of respondents	Reference in text
Head of unit I	WP 1
Head of unit II	WP 2
Coordinator I	WP 3
Coordinator II	WP 4
Coordinator III	WP 5
Architect I	Interviewee 1
Head of unit III	Interviewee 2
Engineer	Interviewee 3
Architect II	Interviewee 4

5. FROM STORMWATER POLICY OBJECTIVES TO ACTION ON THE GROUND: DETERMINING FACTORS FOR IMPLEMENTING MULTI-FUNCTIONAL STORMWATER SOLUTIONS

In this section, the different perspectives of climate risks and urban development explored during workshops and interviews are used to identify the constraining and enabling factors for implementing potential multi-functional solutions for a sustainable stormwater management in Motala City. First, the need for translating policies into action is established in the context of stormwater management, followed by the factors determining the implementation of multi-functional stormwater solutions at the local level.

According to the existing municipal stormwater policy, multi-functional stormwater solutions[10] should 'as far as possible be applied in planning and building' of urban areas (Motala Kommun 2007, p.4). However, according to the Head of unit II, the 'as far as possible' more often constrained the implementation of stormwater solutions than enabled them due to the non-mandatory nature of the policy objectives. Still, implementing solutions to retain stormwater upstream was seen as a crucial measure among workshop participants in order to relieve the stress of pipe networks to changing water flows and to minimize diffuse pollutants in receiving streams (especially in the Bay of Motala) from urban runoff. The empirical findings indicate the need to view stormwater management in light of climate change to adapt stormwater system and mitigate urban runoff pollution.

In order to integrate aspects of climate adaptation into existing municipal policies, the respondents stressed the need for settling guidelines and long-term planning; however, existing climate policies and strategies in Motala municipality have mainly targeted emission reduction to mitigate climate change by promoting cycling, public transport and organic food in public procurements while little focus has been given to climate adaptation in terms of management practices and policy integration. The sole emphasis on mitigation strategies is not unique for Motala, but rather a common trend across Swedish municipalities. For example, studies on institutional capacities for addressing climate adaptation in the Swedish planning context have found that the long tradition of tackling climate change through

[10] In the policy document, stormwater solutions are referred to as 'open stormwater solutions', see table 1 in background-section for examples of solutions

mitigation strategies is linked to the Swedish Environmental Quality Objectives which have undermined perspectives of climate adaptation to be addressed through municipal management and planning (Nilsson *et al.* 2012, Dymén and Langlais 2012, Carlsson-Kanyama *et al*. 2013). In support of Urwin and Jordan (2008), this study found that incorporating climate adaptation policy objectives into the existing municipal stormwater policy presented opportunities to frame stormwater solutions as multi-purpose, meaning that solutions both contribute to the sustainability and adaptive capacity of the city. In order to enable the translation of policy to action in the case of sustainable stormwater management in Motala City, the study found several determining factors crucial for enabling potential multi-functional stormwater solutions. As they appear in the text, the identified determining factors are: an operational policy cycle, local perceptions of climate risks, clarified benefits of multi-functionality, availability of space and acceptance for new elements, establishing clear roles and responsibilities, knowledge brokerage, dialogue and collaboration in the planning process, and last, political will and support for sustainable urban development.

5.1. Operational policy integration

Based on workshop discussions, translating existing policies into action was seen as determined by an operational policy cycle. It was stressed by the workshop participants that existing guidelines and municipal policy documents needed to be integrated into day-to-day planning and revised in order for policies to stay operational and up-to-date. According to Coordinator I, current management practices were still perceived to be inhibited by path dependencies, financial constraints and lack of feedback into the policy cycle:

> The overall perception has been that if something is decided it's executed, but it's not that simple for different reasons. One of the reasons is that it's not as 'fun' to talk about resources as it is to talk of the things one can do. The sad truth is that many of the policy documents are underfinanced /…/ we need to be better to follow up and feed back to the politicians with the results and operationalize the whole chain from policy document, implementation, operating control to feedback. That is something we need to clarify through our roles and responsibilities, through technical assistance and through overall understanding of the governing processes (WP3)

In the case of the existing stormwater policy of Motala municipality, workshop participants agreed that the stormwater policy was an important steering document when planning urban areas and neighborhoods, however during individual interviews it became clear that the stormwater policy objectives were perceived as too 'old', or hard to implement because the policy was 'too technical' (Interviewee 2 and 4). In fact, the diverging perception of the importance of the stormwater policy objectives seemed to have hampered stormwater policy objectives to translate into tangible measures in the planning process. The perception of stormwater solutions as hard to implement was further contested by the diverging perception of what the concept of multi-functional stormwater solutions entailed. According to the municipal stormwater policy, 'open stormwater solutions' are defined as a collection of measures that aim to retain and manage stormwater upstream that does not involve traditional water drainage system solutions (i.e. pipe-based). Interestingly, the stormwater policy lists 'technical solutions' that are identical to what water management and urban sustainability-research[11] refers to as 'sustainable urban drainage systems' or 'green infrastructure' (Ahern *et al.* 2014, Demuzere *et al.* 2014) which indicates that the stormwater policy objectives have

[11] See table 1 above

the potential to translate into multi-functional stormwater solutions in order to increase the adaptive capacity of the city in events of extreme weather events.

In research on climate adaptation policy response, municipal risk and vulnerability assessments have been identified as possible policy documents in which climate adaptation can be mainstreamed. Mossberg Sonnek *et al.* (2013) conclude in their study that municipal risk and vulnerability assessments can provide a comprehensive approach to identify and address the effects and impacts of climate extremes; however, the lack of resources and sufficient knowledge could hamper the feasibility of such approach. In line with their study, Coordinator I emphasized that the risk and vulnerability assessment was a 'strategic document' (WP3) to implement climate policies, however, the incorporation of climate issues had not (yet) been fully explored as stated by Coordinator II:

> We have discussed to incorporate climate issues in the risk and vulnerability assessment, but we haven't gotten that far yet. We have looked at heat waves and the risk of parasites in the drinking water but we haven't looked at the risk of flooding or landslides or anything like that (WP4)

While some barriers exists for implementing stormwater policy objectives, City Hall officials stressed the need for an operational policy cycle in which policies and strategies for a sustainable stormwater management should be an integrated part in planning processes.

5.2. LOCAL PERCEPTIONS ON CLIMATE RISKS

Despite the increased recognition to anticipate extreme weather events and climate change by the Administrative County Board in Östergötland (Bratt 2014), climate risks were perceived to be low among City Hall officials in Motala. Still, heat waves and cloudbursts were perceived to be the most likely events to cause damage to infrastructural systems and societal services due to increasingly 'drier and wetter' (WP2) periods which is consistent with scientific findings on climate change impacts (IPCC 2014). While the possible implication for climate extremes to occur in Motala was associated with high uncertainty among the respondents, they agreed that robust data and common understanding of possible impacts played a key role when planning for climate change. Still, uncertainty and unpredictability of climate change impacts have been found in other studies to constrain climate adaptation action to take place at the local level (Dessai and Hulme 2007, McEvoy *et al.* 2010, Renn and Klinke, IPCC 2014), as was also stressed by one of the respondents:

> An important prerequisite is that we have a common understanding: what's the status today? Are we to some degree already safe [from climate change], or if not, what do we need to do? (WP1)

Despite the recognition of climate data as means to address climate impacts in urban planning, there seemed to be a gap in perceived awareness and action taken to reduce urban vulnerability, which was further aggravated by differences in knowledge of possible climate risks to occur. For example, some of the respondents had little knowledge of the susceptibility to landslides in Motala City while several of the urban planners were aware of the risk of lahars along the slopes of Bondebacka (recreational area) and Motala Ström (urban water catchment) in events of intense precipitation. Even though the risk of landslide was evident, it was still not perceived among urban planners as an immediate threat to the city. Since Motala City has (so far) been spared from such events, policies and strategies to address climate adaptation had 'not really been thought of' (WP3) which seemed to be explained by the low expectation of climate risks to occur:

> One constraint is, as I see it, that we've been spared from bigger changes, which has made it hard to implement [adaptation] measures that might be needed. It is easier when you have a more apparent threat (Interviewee 1)

Instead, climate change was framed by the respondents as a global problem manifested through rising sea levels. Hence, Motala was perceived to be spared from changes since water levels in Vättern were considered to be stable. In combination with minimal likelihood of risking water levels and the geographical location of the city, there was a general perception that Motala was speared from climate change impacts:

> We're pretty lucky /…/ we're 88 meters above sea level and we don't have any landslides. I think we're pretty safe but maybe that's why nothing has happened yet (WP1, also WP2)

Although the risks of climate-related events to occur were seen as small among respondents, a potential increase in extreme weather events were still associated with system failure and implication for stormwater management and maintenance of stormwater systems as emphasized by Architect II and the Head of unit I:

> Then of course, if weather events such as cloudbursts increase, then our systems will be tested (Interviewee 4)

> Our systems might become more sensitive [to climate extremes] and then we need to think of new pipe dimensions (WP1)

On the one hand, events of extreme weather (heat waves followed by cloudbursts) during the summer of 2014 did not seem to have triggered an increased focus on climate adaptation action. During the summer of 2014, cloudbursts and thunderstorms caused stormwater and wastewater systems to flood due to the intensity of the rainfall (local measurements recorded precipitation around 60-90 mm/hour). Approximately 120 households experienced some kind of flood damage caused by stormwater overflows or failure in retaining stormwater upstream and the Coordinator II estimated the insurance costs to approximately ten million Swedish Kronor (SEK). In addition, roads and tunnels were flooded restricting the mobility of motorized vehicles and citizens. Despite the rather damaging event, it was still perceived among respondents that something more drastic needed to happen in order for measures to be implemented. The result is in contrast to other studies, which have found that damaging events caused by climate-induced extreme weather have sparked local adaptation action towards climate change (Storbjörk and Hedrén 2011, Runhaar *et al.* 2012). For example, after the Copenhagen-event, the local City Hall developed a Climate Adaptation Plan, adopted a green infrastructure-planning approach and developed a 'climate-quarter' in which different stormwater solutions were implemented in order to increase the adaptive capacity of the city to better cope with future climate change (Haghighhatafshar *et al.* 2014). On the other hand, Motala has had little previous practical experience of climate hazards and with few incentives to implement adaptation measures, preventative planning for increased climate variability has not been a prioritized planning issue.

5.3. Clarifying benefits for multi-functionality

Even though stormwater management was not associated with climate adaptation action *per se*, it was still perceived by workshop participants that the problems of stormwater overflows needed to be managed to address the deteriorating water quality in the Bay of Motala and Motala Ström due to urban runoff finding its way to the water basins. In order to adapt stormwater systems to changing water flows and mitigate the effects of water pollution in the receiving stream (e.g. during the cloudburst event of 2014, the water in the Bay of Motala was unfit for bathing due to stormwater overflows), the Coordinator I emphasized that the multiple benefits of stormwater solutions needed to be clarified from a holistic point of view:

> I think that if you want to introduce such a technical solution we need to really work together and look at the bigger financial picture and show that it's actually a technical solution that also solves problems elsewhere (WP3)

This indicates that the framing of stormwater solutions as multi-functional was seen as a determining factor and presented win-win situations and opportunities to adopt no-regret strategies to deal with uncertain changes (Ahern 2011, Wilby and Keenan 2012, Smith *et al.* 2013, Wamsler and Brink 2014). For example, an installed stormwater solutions could both serve as a measure to retain stormwater, as well as for recreational purposes. While officials associated with water and environmental management perceived stormwater solutions as technical with the purpose to minimize the risk of overflows and stormwater system failure, others associated stormwater solutions as a combination of social (attractive living and the social benefits of recreational activities), environmental (reduced urban runoff and enhanced urban biodiversity) and economic values (an attractive urban environment attracts commerce and tourism and boost the price of housing).

Assessing the attractiveness of the perceived urban area enabled stormwater to be viewed from a sustainability perspective (Gibson 2006) and open up the box of the benefits of multi-functionality. During the sustainability analysis, it was evident that workshop participants perceived the concept of stormwater solutions differently depending on the participants' profession and knowledge of stormwater management. Still, there was an overall consensus that the integration of trees and green space in the urban sphere created environments that enhanced the perception of the city as green and attractive as illustrated in the summarizing table below (table 3).

Table 3: Identified consequences and benefits of potential multi-functional stormwater solutions during the second workshop

Environmental consequences and benefits of multi-functional stormwater solutions
▪ Green spaces are positive for the surroundings (support biodiversity)
▪ Trees have a cooling effect during heat waves
▪ Solutions can reduce the risk of urban flooding by retaining stormwater upstream
▪ With less hard surfaces, metals, nutrient salts and bacteria are reduced in surface runoff
▪ Solutions such as open ditch systems/rain gardens might produce odor during dry periods and mosquitos during wet periods
▪ Need to visualize the stormwater-issue at an "early" stage – where does the water go and how can it be retained to minimize overflows and damage of assets? (combination of environmental, social and economic consequences)
Social consequences and benefits of multi-functional stormwater solutions
▪ With the right formation and design of a stormwater solution, it can contribute to a good/positive urban environment and attractive living environment (residential areas and neighborhoods)
▪ Stormwater solutions as a value-enhancers: can be aesthetically pleasing and used for recreational purposes
▪ Flowerbeds and trees is associated with a more enjoyable environment
▪ Can be problematic for pollen allergies

▪ Dealing with different perceptions can be problematic in the planning process; how to deal with 'tree-haters' and 'tree-lovers' to satisfy different interest groups ▪ Solutions such as open ditches/rain gardens are unfamiliar in the urban environment: need to consider possible safety risks such as drowning (especially for playful children) ▪ Can both increase and decrease the sense of safety/unsafety (e.g. parks can be associated with 'darkness' and unsafe during evenings/nights) ▪ Need for acceptance of new ways of doing things (in regards to planning and management of stormwater solutions)
Economic consequences and benefits of multi-functional stormwater solutions
▪ Pretty flowerbeds and green spaces create a more attractive city center which attracts commerce and tourism ▪ Clean water is a socio-economic benefit ▪ Polluter Pays Principle should be applied on stormwater management ▪ Increased cost associated with management of new measures can be barriers for introducing open stormwater systems ▪ Increased investment costs for operators such as Street and Park-unit and real estate concerns ▪ Increased management costs for maintenance of green space and stormwater solutions by the Street and Park-unit, real estate concerns and private property owners

In addition, the attractiveness was perceived to be important to the growth and development of the city to attract newcomers and tourists and linked to the adopted trademark to market the city as 'the seaside town of Östergötland'. It seemed that the notion of the city as being attractive was much linked to the greening of the city, and even though the implementation of stormwater solutions had not been viewed in light of climate adaptation response, the awareness of trees and green space as important to meet future changes was still evident among respondents as emphasized by the Coordinator II:

> I'm not an expert on climate adaptation, but the little I've learned about heat waves is that it's really important with green areas and trees in the city center (WP 4)

In general, the benefits of trees and green space seemed to be known among urban planners, however, the Engineer experienced in her professional role that trees and other green infrastructural aspects were downplayed in the planning process to leave room for more 'important' infrastructures such as roads:

> There are a lot of interests that need to be considered. There always has to be a road with a certain width, so cities are often planned so that the most important things are considered first. Then we can add the green, 'decorative stuff' (Interviewee 3)

The perception of trees and green space as merely decorative seem to be explained by the lack of framing stormwater solutions as multi-functional for urban areas. Whether or not green aspects were considered in the planning process to a favorable degree, the Engineer subscribes the lack of an ecosystem-based approach for urban development as a 'question of generation' (Interviewee 3). Accordingly, the ecosystem services-concept was considered a rather modern concept in the context of urban planning; it was more often used by the younger generation of officials. In support of earlier research, studies have found that water management has traditionally be managed by technical units and patronage networks (Pahl-Wostl *et al.* 2013, Ahern *et al.* 2014) hampering innovative by 'we do as we always have done'-mentality. This seemed also be true in the case of water management at Motala City Hall which was stated by the Head of unit II:

> I think we all know what needs to be done, but we're not getting there because of other constraints, not at least the economy, and then maybe it's easy to say ' it's not possible' and then it is easier to decide that we do as we always have done (WP2)

Even though the implementation of stormwater solutions was associated with increased management and maintenance costs, it was perceived that the real cost for society as a whole was overlooked. According to the Engineer, this was rooted in the lack of monetary value for ecosystem services associated with ecological and social values. For example, trees and managed green spaces provide urban areas with ecosystem services such as biodiversity conservation, pollination, stormwater retention, shade and recreational purposes that are inherently free (Hunter 2011). Trees were perceived as an integral part of Motala City's identity but incorporating trees and green space as a potential strategy for retaining stormwater upstream seem to be hampered by budget constraints. While the Engineer emphasized that there were signs of change towards the perception of incorporating multi-functional stormwater solutions and green space in the city center as a possible climate change response, the Head of unit I stressed that viewing stormwater management from a climate perspective needed to be clearly motivated economically. If costs and gains of investments were not known, measures risked not being prioritized:

> To succeed we need to show that the costs are bigger if we don't do anything compared to if we implement measures that might prevent [climate risks] /…/ We need to be able to show the costs change in precipitation brings /…/ and that investments are cost efficient. If we can't show the benefits of investing, business as usual will continue and we will deal with the costs of damages every tenth year they happen because it costs less. This is my guess (WP1)

As emphasized by the quote above, climate risks need to be thoroughly assessed in order to plan for the uncertainties climate change brings and here risk and vulnerability assessments can be an important tool as stated above. While the lack of economic resources and low sense of urgency towards climate risks hampered City Hall officials to implement preventative measures (such as stormwater solutions) similar obstacles for climate adaptation action have been found in other Swedish municipalities (Nilsson *et al.* 2012, Wamsler and Brink 2014). However, Swedish municipalities have the ultimate responsibility to cover the cost in case of a hazardous event and therefore it is in their interest to reduce urban vulnerability through preventative planning (Nilsson *et al.* 2012, Storbjörk and Uggla 2014). While scholars argue for a more ecosystem-based, adaptive planning approach in order to contribute to the overall robustness and sustainability of a city (Ahern *et al.* 2014) the challenge remain to account for the values that are inherently free by clarifying the benefits of multi-functional stormwater solutions in the urban environment. In that case, multi-functional solutions risk being downplayed because the benefits of ecosystems and urban biodiversity are 'invisible' and not monetized into the municipal budgets.

5.4. FINDING SPACE AND ACCEPTANCE FOR NEW ELEMENTS

To enable multi-functional stormwater solutions in the city center, the empirical finding suggested that planning for stormwater solutions was determined by land use and acceptance for new elements. Traditionally, pipe networks carry stormwater underground from its source (e.g. a roof) to a receiving stream, and in some cases stormwater is collected in dams (natural or artificial) in the outskirt of the city for natural infiltration and purification 'where no one sees it' (WP2, also Interviewee 4). However, one of the major barriers for implementing multi-functional stormwater solutions in the city center was the limitation of physical space:

> The problem in already built environments is that there's not much space to use and everyone wants as much space as possible to be built. There are a lot of hard surfaces (WP2, also Interviewee 3)

According to the Head of unit II, multi-functional stormwater solutions were more often implemented in newly developed areas in the outskirts of the city than in the city center. It was perceived to be 'easier' (WP2) to plan for and implement stormwater solutions in newly developed areas where the issue of space was not a limiting factor. Even if newly developed areas in the outskirts of the city were perceived to be easier to think of in terms of 'smart building', (WP2) ongoing infrastructure replacement also presented opportunities to bring green aspects to the table in an early stage of the planning process and into the urban realm. According to the Head of unit I, the common goals stated in the visions to develop the attractive city presented opportunities to integrate more green aspects in local development planning:

> Our ambition is to create a more attractive city center and part of that might be to have more trees along the streets and less hard surfaces (WP1)

To enable the implementation of stormwater solutions in the city center, the Head of unit II emphasized that stormwater management needed to be rethought and a change of perspective was needed to think differently, both in terms of public acceptance and traditional management of stormwater:

> [we need to] think differently and accept that we can't have full street breadth, you can't walk on both sides because we need trees. It's all about accepting what is different /…/ sometimes you have to accept that that your shoes get wet a few minutes when it rains so that we can retain the water and minimize the risks of overflows (WP2)

It was emphasized by the workshop participants that public acceptance (in general) was a determining factor for implementing solutions in the public space. However, the implementation of new elements in the city center such as rain gardens, open water canals or green roofs seemed to be prevented by the perceived unfamiliarity and fear of resistant from citizens and other societal actors to such elements. If stormwater solutions were to be implemented in the urban environment, it was considered important among workshop participants that new elements contributed to the overall safety and perception of the city as attractive though public and private acceptance. Similar results have been found in other studies (Barbosa *et al.* 2012, Newell *et al.* 2013, Mees *et al.* 2013) and Mees *et al.* (2013) highlight that

> public adaptation goods need public responsibility /…/, either to provide that good directly or to develop policy that motivated private actors to provide that good (p. 820)

In that sense, the ongoing infrastructural development projects in Motala City, that have been anchored among social actors through the process of envisioning the future, seem to support acceptance of new elements within the urban environment. As noted by Albrechts (2010), transformative practices such as city renewal are often enabled through clearly stated visions and development goals and the involvement of different actors which seems to be the case in Motala. There also seems to be change of perspective among urban planners and the importance of involving different actors in the development of the city:

> You can't just sit and wait for the urban planning unit to develop the ultimate comprehensive plan where all problems are solved. All parts of the society will need to contribute with their part (Interviewee 1, also Interviewee 4)

In the city of Motala, city renewal and urban development have been part of the ongoing efforts to develop and transform Motala City from a post-industrial city towards an attractive and sustainable city. The revitalization and densification of the city center to remedy 'old sins' (Interviewee 1) was perceived among urban planners as one of the major challenges for a sustainable urban development. Notably, ongoing development projects presented 'windows of opportunity' (Zevenbergen and Pathirana 2013, p.76) to incorporate multi-functional stormwater solutions in the city center as a way to develop the city towards a desirable state. In that sense, urban development also presented opportunity to develop the city towards sustainable trajectories.

5.5. ESTABLISHING CLEAR ROLES AND RESPONSIBILITIES

According to the Environmental Code and the Planning and Building Act that governs spatial planning in Sweden, municipalities are first and foremost responsible to ensure the well-being of citizens and manage land and water through sustainable practices. Even though urban planning has been recognized to play a key role in planning for climate change in Sweden (Dymén and Langlais 2012), urban planners are (often) left with little incentive to orchestra the transition (Nilsson *et al.* 2012, Wamsler and Brink 2014). Enabling the implementation of multi-functional stormwater in the urban environment indicated that roles and responsibilities towards sustainable stormwater management were not limited to be determined by the daily work of City Hall officials. While officials are responsible to design and plan public spaces through legal frameworks and policies, they also have a responsibility to communicate obligations towards private actors and involve stakeholders in the planning process.

One of the major constraints to enable stormwater solutions in the city center was the concern that much land was owned privately and that City Hall officials had few instruments to demand measures to retain stormwater on private property. Based on workshop discussions, the perceived lack of legal guidelines and toolboxes for making necessary demands seemed to inhibit stormwater policy objectives to be translated into tangible measures:

> What legal support do we have to demand green roofs? (WP2, also WP3)

According to the general regulations for water and drainage that control water and sewer management at the municipal level[12], private property owners are obligated to retain stormwater within the boarder of the property to minimize the risk of overflows in municipal stormwater systems. When it is considered suitable (based on geo-physical conditions), LOD[13]-solutions can be demanded in local development plans and through issued building permits towards e.g. private property owners or real estate concerns:

> What we do, actively or inactively call it what you like, is to limit the accessibility to the [pipe] dimension. You get a certain quota to use for stormwater and then it's up to you to manage stormwater on the property. I guess that's what we can do and what we've done so far (WP2)

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[12] Allmänna bestämmelser för vatten och avlopp (ABVA) för Motala och Vadstena kommun

[13] Lokalt omhändertagande av dagvatten (LOD), Locally retained stormwater. LOD-solutions are stormwater solutions confined to the limitations of the boarders of a private property.

To overcome traditional management practices and path dependencies of stormwater management, it was stressed by City Hall officials that clear roles and responsibilities in the planning process were determining factors for internal and external communication and awareness-raising. After the cloudburst events during the summer of 2014, communicating responsibility of retaining water on private property had been raised as crucial measure to minimize future hazards for private (and public) assets:

> I think that we need to better [to inform of the responsibilities and the risks in case of flooding]. The information is available at the City Hall's webpage but I don't know if it's something people read (WP4)

Whether private property owners possessed the required knowledge or were aware of their responsibilities to retain stormwater within their respective property, the implementation of LOD was perceived to be an important strategy to enable stormwater solutions on privately owned land. Despite the possible use of LOD-solutions towards private actors, it was raised among respondents that the lack of settled guidelines for enacting stormwater solutions in the city center resulted in stormwater solutions being considered on a plan-by-plan basis:

> We don't have any guidelines but we can make demands in a specific plan if we arrive to the conclusion that is necessary [for stormwater retention] (Interviewee 2)

While the findings correspond to earlier studies of urban planning in the Swedish context (Storbjörk and Hjerpe 2013), the quote clearly illustrate that stormwater is not (yet) managed comprehensively nor in accordance with the stormwater policy objectives:

> You would almost want a stormwater assessment that was geographical and that took into consideration the geo-physical conditions in relation to groundwater catchments and such. I would like that kind of decisions basis, but I don't have that unfortunately (Interviewee 2)

It was suggested by the Head of unit III that a comprehensive study of possible locations for stormwater solutions within the urban environment (based on the geophysical and hydrological conditions) could enable the implementation of multi-functional stormwater solutions during the planning process and thus making necessary demands in local development plans in line with current stormwater policy objectives.

5.6. FACILITATING DIALOGUE AND COLLABORATION IN THE PLANNING PROCESS

As stormwater management requires the involvement of different units to translate stormwater policy objectives into tangible measures (Newell *et al.* 2013), workshop participants emphasized the need for dialogue and collaboration in the planning process as determining factors for enabling the implementation of potential multi-functional stormwater solutions:

> We need to have a dialogue and collaboration during the planning process. But then it can always be better, and better solutions in the end (WP3)

In general, facts and knowledge were perceived to be important when addressing complexities and abstractness of climate and environmental issues. However, it seemed as if the lack of coordinated work to gather and collect data comprehensively inhibited learning to take place across units. It appeared that traditional municipal management resulted in knowledge being constructed unit-by-unit:

> Generally, a lot of things are done but it's done at different units and without anyone knowing each other's work. I think that in order to get better and benefit from each other's work we need to start collaborating. So far, we do what *we* can do at the planning unit! (Interviewee 2)

Based on the local policy review, the Nature Conservation Program adopted by the municipal council in 2014, suggests several measures and strategies to address urban biodiversity and 'a good built environment'[14] by adopting green infrastructural aspects in the urban environment (Motala Kommun 2014). While the knowledge base presented in this particular policy document aimed at facilitating knowledge across municipal units, it seemed to fail its purpose since respondents did not seem to be aware of the measures and strategies suggested in the Nature Conservation Program. For example, the program suggest several measures and strategies for a good built environment and clarifies benefits of ecosystem-based planning approach in which multi-functional solutions play an important role in supporting urban biodiversity and urban development. Based on the interviews and workshops, it seemed as the construction of knowledge and internal expertise was not utilized due to a fragmented planning environment. Storbjörk and Hjerpe (2013) found similar results, namely that the fragmentation of spatial planning often lead to plans being settled in 'silos', inhibiting knowledge to be spread across units. As this seemed to be true for the case of stormwater management in Motala, the Engineer emphasized the need for co-produced learning by comprehensively gather new and existing knowledge of the multi-functionality by visualizing the benefits of green space and trees in the urban environment:

> If you really fight for something that is important, you need facts! If you can *show* different scenarios and what actually *happens* it's really good. Like 'this is what it looks like if we have trees and this is what it looks like if we don't'. /…/ we hope that this new tree plan will secure all the knowledge we have of trees and to be able to show why they are important (Interviewee 3)

In line with earlier studies on institutional capacity building (Nilsson *et al.* 2012), the empirical findings suggest that the construction and conceptualizing of knowledge for green infrastructure presented opportunities for stormwater solutions to be viewed in light of urban sustainability and climate adaptation in Motala City. Even though the construction of knowledge still presented challenges in terms of how it should be organized and produced across municipal units, the Head of unit II and Architect I emphasized that during the initiation of new local development plans, officials and experts from different municipal units were invited to ensure that different aspects such as water supply, public transport, mobility and social inclusion were considered at an early stage of the planning process. Facilitating arenas for collaboration throughout the planning process indicated a beginning of a more integrated management approach at Motala City Hall, which has been found to be crucial for managing 'wicked' problems such as climate change (Wilby and Keenan 2012). According to the Engineer, focus on collaboration and dialogue at an early stage of the planning process had enabled the incorporation of trees and green space in the city center in a recent city renewal-project:

> [It is] the first project in town that has had this good, collaborative thinking from the beginning of the planning process and onwards. So I think [the result] it's going to be great! (Interviewee 3)

Still, respondents stressed that challenges remained for facilitating cross-sectoral collaboration, however, personal commitment and an interest of climate issues in general

[14] One of Sweden's 16 Environmental Quality Objectives

were seen as an important enabling factor to ensure that such questions were raised throughout the planning process. While internal collaboration was crucial to the production of knowledge for sustainable urban development and ensure that stormwater policy objectives were considered in the planning process, respondents raised the need for external dialogue and collaboration with citizens, local companies and businesses, NGOs, and regional administrations such as the Administrative County Board and the Regional Council:

> It's important with other actors. The City Hall cannot decide on its own, we thought that once but that's not the case anymore. We are dependent on the market and other actors [of the society] (Interviewee 4, also Interviewee 1)

Interestingly, citizen dialogue and public participation had been an important feature when developing the City Vision and City Center Vision. The respondents were keen to emphasize that such processes needed to continue in the future to ensure public acceptance of envisioned development goals and ongoing development projects:

> It is important that the vision is anchored, not just within the City Hall, but in politics and among the citizens (Interviewee 4)

In line with other studies (Gibson 2006, Albrechts 2010, Stuart *et al.* 2014), involving community-based groups in the planning process facilitate a broader understanding and acceptance for development plans and new elements in the urban environment. For example, Bos *et al.* (2013) found that involving different stakeholders in the process of managing an urban water catchment through sustainability initiatives facilitated learning to take place on both an individual and collective level. The raised concern to involve stakeholders in the planning process indicated a turn towards new forms of governance and management of urban areas.

5.7. The need for political will and support

Even if this study was limited to the views and perspective of City Hall officials, political will and leadership was identified as a determining factor to address climate adaptation and overall sustainability goals of the municipality. Knowledge of local risks (such as susceptibility to landslide) and political engagement in local development planning processes were raised as determining factors to ensure that the urban environment was robust to future changes:

> Fact is important for politicians to ground their decisions on. But then there also needs to be a political will and priority (WP1)

Interviews suggest that both politicians and officials needed to work 'towards the same goal' (interviewee 1, also interviewee 3) in order to address complex issues and realize envisioned development goals. While studies on climate adaptation in Sweden have found that local development planning entails political compromises and competing planning agendas (i.e. climate adaptation is just one of several issues to be addressed within the political decision arena) (Nilsson *et al.* 2012, Hjerpe *et al.* 2014), City Hall officials stressed that in order for climate adaptation to be considered, climate adaptation needed to be framed as *both* a planning issue and a political priority. In general, respondents agreed that sound political decisions were important to address climate risks and sustainability aspects in urban planning and development:

> [We need] clear political goals and that [the politicians] *dare* to decide that 'now we do like this', /…/ they should do it to a 'thing' to show that we are sustainable and that we are proud of it (Interviewee 3, also Interviewee 1)

As emphasized by the quote above, sound political decisions needed to be grounded on willingness to take 'tough' decisions to ensure the robustness and sustainability of Motala City. Based on the local policy review, the work on the visions seemed to have enabled a more sustainable-thinking across the political arena. In the politically adopted local development program (LUP) and goal and resource plan (MoR), political decisions take into consideration the social, ecological and economic sustainability of urban development. According to international studies on municipal capacity-building towards climate adaptation, strong political leadership and political support (Burch 2010, Lee and Koski 2012, Runhaar *et al.* 2012) has been raised as important enablers to 'translate policy into action on the ground' (Urwin and Jordan 2008, p. 183). Since urban planners execute the decisions taken by the politicians, climate adaptation needs to be mainstreamed into the political and planning arena to ensure that existing policies and strategies are 'climate-proofed' (Urwin and Jordan 2008). However, the implementation deficit of long-term planning and short term of local government electoral cycles is a major challenge to the implementation of climate adaptation strategies when politicians favor short term, tangible measures (Hjerpe *et al.* 2014), as was emphasized by the Coordinator II:

> The politicians only stay in office for four years at a time and then they want to remain in power. So of course it is easier to do something that has an impact today rather than something that won't be visible until 15 years from now. You need to understand their ways of thinking in order to better ague for the benefits [of climate adaptation]. It's not always easy to argue for the long-term solutions (WP4)

Enabling the implementation of long-term goals and visions thus required such goals and visions to be translated into policies and strategies that are integrated into the daily work of planners, mangers and coordinators. Based on the policy review, several of the adopted policies and the work done on envisioning the future seem to have increased knowledge and learning of urban sustainability. While sustainability is one of the municipalities overarching development goals, Motala is at crossroads to decide what development path it should embark on. While some work still needs to be done to address climate adaptation in political decision arenas as well as in urban planning practices, the responsibility to implement climate adaptation measures were perceived among the respondents to be a shared responsibility across all level of society.

6. DISCUSSION AND CONCLUDING REMARKS

This study set out to explore the role of multi-functional stormwater solutions as a strategy for climate adaptation in urban planning and development. Empirically, the study found that despite the prevailing lack of preventative planning for climate change in Motala municipality, city renewal and ongoing development projects in Motala City center presented a window of opportunity to implement potential multi-functional solutions into the urban realm. By framing multi-functional stormwater solutions as a strategy for climate-proofing, the multiple benefits of integrating stormwater solutions in the urban environment were also viewed from a sustainability perspective. As has been illustrated by the case study of stormwater management in Motala, incorporating multi-functional stormwater solutions in the city center, where urban runoff is aggravated by the extensive use of impermeable surfaces and the steep descent of the area, a sustainable stormwater management plays a crucial role in managing water pollution and adapting stormwater systems to changing water flows due to human-induced climate change (Barbosa *et al.* 2012). Notably, in order to mitigate the effects, the urban environment needs to be *adapted* to ensure the benefits of multi-functional solutions are realized. Accordingly, a sustainable urban form entails a good built environment in which citizens and the city itself can prosper without undermining future generations' needs (Childers *et al.* 2014, Steiner 2014) which in turn requires urban areas to be robust to future changes. By incorporating stormwater solutions that serve multiple benefits through local development planning and ongoing infrastructural replacement, the empirical findings of this study suggest that urban planning plays a salient role in ensuring a good built environment and the sustainability of urban areas.

Further, the empirical findings suggest that several ongoing development projects and infrastructure replacements that aim to transform the city into the 'new' attractive Motala created momentum for ensuring urban sustainability. As emphasized by Albrechts (2010), the transition from contemporary to sustainable cities demands transformative practices that shape and design the city into a desirable state, which in the case of urban development of Motala City has been enabled through the process of envisioning the future. Discourses on attractiveness seem to support the greening of the city as a strategy to transform the city into a desirable state. In other words, the envisioned development projects were motivated as transformative practices in which Motala City was transforming from a post-industrial city to the new, attractive 'seaside town of Östergötland'. Interestingly, an attractive city was closely associated with the process of greening the city, which enabled green infrastructure and stormwater solutions to be viewed from a social, economic and environmental perspective among urban planners and managers. In that sense, planning and designing the new, attractive Motala City was motivated economically – a green and attractive city attracts tourists and new settlements which is important to the growth of the city – socially –greenery contributes to a good built environment for urban dwellers and enables recreational activities – as well as environmentally – greenery supports urban biodiversity and mitigate urban water pollution and the urban heat island-effect.

In a similar study on urban planners' perception of climate risks, Runhaar *et al.* (2012) found that perceptions towards climate change was not the main reason for adopting green infrastructural aspects in urbanized areas but rather seen as measures contributing to the overall sustainability of the city. Accordingly, the integration of green infrastructural aspects within urban areas were considered a potential strategy for climate change response (Demuzere *et al.* 2014), however the benefits of green infrastructure as a local climate regulator was not necessarily the main rationale for integrating greenery in the Dutch study (Runhaar *et al.* 2012). While the case study in Motala shows similar results to the research made by Runhaar and colleagues (2012), this study also found that stormwater management was not necessarily associated with climate adaptation measures *per se*. Although the risk of climate-related events to occur in Motala were associated with low probability, there was a sense of awareness among urban planners at Motala City Hall towards problems of urban runoff being aggravated in cases of extreme weather events and increased climate variability. This had for example been made clear after the cloudburst event of 2014 in Motala, when the water quality in the Bay of Motala became unfit for bathing due to overflows in the stormwater systems. Even though the risk of urban flooding had been made more visible, the single event did not seem to trigger action towards climate adaptation, which is in contrast to other studies (Burch 2010, Storbjörk and Hedrén 2011, Haghighhatafshar *et al.* 2014). In line with the reasoning of Klein and Juhola (2013) that action on climate adaptation is determined by the perceptions towards climate risks, the empirical findings of the case study suggests a fundamental awareness-implementation gap in which the link between climate risks and action responses remain weak in urban planning. While an improved knowledge base and cross-sectoral collaboration has been found to support capacity building when planning for climate change (Nilsson *et al.* 2012, Storbjörk and Hjerpe 2013), inadequate knowledge of climate risks and the lack of long-term planning have been found to hamper the implementation of preventative measures elsewhere in Sweden (Wamsler and Brink 2014). In the case of urban planning and stormwater management in Motala, it was evident that the level of climate exposure needed to be clarified; otherwise measures risked being postponed until climate change was perceived as an immediate threat.

In general, most of the urban planners and managers at Motala City Hall were aware of potential climate risks; however, the risks seemed to be downplayed due to few incidents of damaging events during the last decade. Instead, preventative planning to reduce urban flood and adapt stormwater systems to changing conditions were associated with increased maintenance and replacement costs that in turn seem to be justified by a wait-and-see-approach for climate risks to occur in the future. Wamlser and Brink (2014) found similar results, namely that the uncertainty of climate risks left urban planners with few incentives to address the climate issue in local development planning. In other words, the lack of 'threatening' climate change to the city of Motala hampered urban planners to perceive climate adaptation as a planning priority, leaving little room to address climate adaptation strategies and mainstream climate adaptation into existing policies.

In the process of understanding how perceptions of climate risks shaped or did not shape action to reduce urban vulnerability, several constraining and enabling factors for addressing climate change and sustainable stormwater solutions in urban planning and development were identified. While the low expectation of climate risks to occur resulted in the lack of viewing stormwater management from a climate change-perspective, other constraining factors such as strong traditional management of stormwater, 'we do as we always have done'-mentality among managers and the lack of physical space due to extensive use of impermeable surfaces seem to have inhibited stormwater policy objectives to be realized in the city center. On the other hand, increased focus on internal and external dialogue and collaboration through the process of envisioning the future seem to have enabled new forms of governance and increased public acceptance for new urban elements and urban change. By involving private and public actors through participatory channels and engaging citizens in local change and development (Stuart *et al.* 2014), urban development plans in Motala have been anchored among the public, private and political sphere. As was emphasized by the respondents, the City Hall was no longer the only actor shaping the urban environment, indicating a change of perspective in urban planning practices. In line with the reviewed literature which have emphasized the need to manage stormwater on a cross-sectoral basis (Barbosa *et al.* 2012, Newell *et al.* 2013), the emphasis on the 'need to think differently' about urban water management as stated by the Head of unit II – both in terms of public acceptance and the management of stormwater – indicate 'seeds of change' in municipal management practices to focus on a collaborative planning environment. In other words, stormwater management does not only involve the water management unit but needs to be put into the bigger context of urban planning and development. Stormwater solutions need to be consider at an early stage of the planning process and stormwater solutions also need to be motivated economically and socially to ensure that new elements or unconventional stormwater management are accepted by citizens and other actors that share the public space (Barbosa *et al.* 2012, Bos *et al.* 2013). For example, in events of extreme rainfall, a football (soccer) field can be used to retain stormwater, however it demands that such measures are accepted and known to citizens that otherwise use the field for activities. In such cases, citizen dialogue plays an important role in communicating roles and responsibilities. The facilitation of dialogue and collaboration in day-to-day planning practices at Motala City Hall thus seem to indicate an integrative planning-approach in which different societal aspects are considered in an early stage of the planning process.

The combination of urban growth and city renewal indeed constitute an enabling arena to re-shape planning practices and re-design the urban environment towards a sustainable Motala City. While local municipal policies and political priorities highlighted the need for social, economic and ecological sustainability to ensure a good built environment in Motala City, stormwater policy objectives have failed to translate into sustainable stormwater solutions due to weak institutional capacity, perceived resistance of new elements in the urban environment, lack of legal guidelines, few instruments for making necessary demands, and a fragmented planning environment. The study stresses the need for sound political decisions along with relevant legal frameworks and shared responsibility to enable a sustainability transition in which sustainable stormwater management can be enacted.

Nonetheless, Motala City is at crossroads to ensure that urban development projects results in desirable outcomes in terms of sustainability. Even though municipal policies and local political manifestation highlight the need for a *sustainable* development and management of Motala municipality, rushed development projects risk being maladaptive and unsustainable unless projects are thoroughly assessed in order to prevent urban vulnerability in the future (IPCC 2014). While the framing of stormwater solutions as multi-functional presented several benefits for city structures and functions to cope with events of extreme weather and climate variability, greening cities pose several challenges to overcome in relation to human health and safety as well as management and maintenance of green spaces (Hunter 2011). The empirical findings suggest that the prevailing complications for stormwater solutions to be integrated in urban areas need to be assessed comprehensively in order to weigh strengths and weaknesses of a green infrastructure planning approach.

According to Barbosa *et al.* (2012), sustainable stormwater management is determined by the geophysical, social, economic, technical, legal and political context in which decisions are decided on. As the case study illustrates, the complex nature of managing stormwater in a densely populated area leave little room to incorporate new elements which demands new ways of designing the public space. For example, in the Netherlands, green roofs have been gaining ground to overcome the problem of limited space for stormwater retention (Runhaar *et al.* 2012, Mees *et al.* 2013) and in Malmö and Copenhagen neighborhoods have been spatially planned to manage excess water in events of intense rainfall (Haghighhatafshar *et al.* 2014). While the topographic characteristics aggravated urban water pollution due to the steepness of Motala city center, the deteriorating water quality of the Bay of Motala was considered a social, economic and political issue among City Hall officials since it contested the view of Motala as the attractive 'seaside town of Östergötland'. In that sense, stormwater management needs to be put into a bigger context that expands beyond the dimensions of the pipe network. By identifying determining factors for implementing multi-functional stormwater solutions, the findings of this study stress that managing urban stormwater is more than implementing technical solutions – it is indeed a socially, technologically, environmentally, legally, politically and economic complexity since it involves the public perception of the urban environment, the legal context in which solutions can be demanded, the internal management practices among urban managers and planners, the economic margins of the municipal budget, the geophysical characteristics of the city, and the politically adopted goals and policy objectives that ultimately guide urban planning and the design of the public space. Thus, 'accepting what is different' in terms of stormwater retention as emphasized by the Head of unit II is crucial to increase the capacity of the city to deal with future changes by simultaneously reviewing the role of multi-functional solutions as beneficial for urban biodiversity, urban sustainability, and urban attractiveness. The study concludes that ongoing development projects, supported by the process of envisioning the future, presented a window of opportunity to implement potential multi-functional stormwater solutions through the integration of green infrastructure in the urban environment in order to support urban sustainability and strategies for climate adaptation.

While several challenges remain to enable a sustainable stormwater management paradigm, a few words on the research process are crucial. In the case of stormwater management, workshop discussions tended to lean towards the technicality of network-based stormwater systems rather than the multiple benefits stormwater solutions could contribute with. During discussions, it became evident that framing stormwater solutions as a climate adaptation measure by the researcher lead discussions to a dead-end due to unfamiliarity of the climate adaption-concept among City Hall officials. In fact, the study found that urban planners often understood climate mitigation and climate adaptation as synonymous concepts. This diverging perception of the ‘climate adaption’-concept between the scientific community and urban planners has also been stressed by others (e.g. Runhaar *et al.* 2012) and the realization was a crucial to understand why climate adaptation was not a prioritized planning issue at Motala City Hall. However, by viewing stormwater solutions in the context of green infrastructure and sustainability seem to open the box of stormwater solutions to be considered multi-functional. By integrating participatory exercises in workshops to assess the multiple benefits of stormwater solutions in the context of sustainability and climate change, this study has expanded discussions beyond viewing stormwater as purely technical. In doing so, stormwater solutions were discussed from different stand-points and the participatory exercises seem to motivate officials who had little experience of stormwater management to participate in discussions and give input based on their professional roles in other areas. Participatory research has been gaining ground in the climate risk governance and climate adaptation literature (Ahern 2011, Renn and Klinke 2013, Glaas and Jonsson 2014) and this study also supports earlier findings of the importance of involving stakeholders to participate in research processes. From a research perspective, closing the gap between the scientific community and urban planners by exploring the role multi-functional solutions in order to decrease urban vulnerability is of societal concern. Even though this study was limited to include City Hall officials as the only ‘stakeholder’, involving officials from different municipal units contributed to nuanced discussions while justifying the complexity of managing stormwater in urbanized areas.

At first, the study set out to explore the views and perceptions of City Hall officials in relation to stormwater management after the cloudburst events during the summer of 2014 and the prevailing challenge of managing stormwater under changing climate conditions. However, the inductive research process, in which the workshop discussions and individual interviews drove the research process forward, lead to a shift of focus which enabled this study to be framed within the emerging research field of green infrastructure as a climate change response. This study has contributed to understanding of the role of green infrastructure as a potential planning strategy for urban climate adaptation as well for its contribution to urban biodiversity and sustainability. While the research presented in this study aimed to explore the role of green infrastructure, it can also support local decision-making for a green infrastructure planning approach in which stormwater solutions play a central role for urban sustainability and robustness.

At the end, clarifying benefits of stormwater solutions as a possible multi-purpose strategy to meet future changes is a first crucial step in starting to ‘think differently’ about sustainable stormwater management and the overall contribution to sustainable urban development. For further research in the context of stormwater management in densely populated areas, the study stresses the need for conducting comprehensive studies of potential locations for stormwater solutions in city centers as well as analysis of the impacts of having stormwater solutions as an integrated part of the city center (from an environmental and social standpoint). For example, spatial analyses of climate impacts using GIS-software can be useful in assessing potential risks of flooding and heat accumulation in the urban area. Such studies could be instrumental in supporting the integration of trees and green space in the urban environment as well as supporting climate adaptation to be mainstreamed into existing policies. As the study found, untangling the concepts of climate adaptation and multi-functionality through the lens of sustainability (Baard *et al.* 2012) presented opportunities to assess the outcomes of implementing stormwater solutions in the urban area. To ensure the sustainability of urban areas, the ecological, economic and social aspects need to be considered equal weight to ensure the development of a just and climate-proof city. The study concludes that urban planning plays a salient role in ensuring the safety and sustainability of urban areas and the integration of green infrastructure can serve as a multi-purpose strategy to meet future (uncertain) changes.

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9. APPENDICES

9.1. APPENDIX I: CLIMATE CHANGE SCENARIOS FOR ÖSTERGÖTLAND

For the county of Östergötland, the downscaled climate models project an increase in the average temperatures from 2-5 °C during the next century. Heat waves (consistency of days with temperatures exceeding 20°C) are predicted to sustain over longer time periods and increase in occurrence from every other summer to occur every summer by 2100 (Ehrnsten *et al.* 2011). Increasing average temperatures and temperature anomalies manifested by heat waves may cause health risks and threaten human life. Sensitive groups such as children and elderly are especially vulnerable to high temperatures and in combination with air pollution, the risk may be aggravated. By 2100, the number of days with snow will decrease, however, precipitation is estimated to increase, and rain will be more common than snow during winters. Precipitation is estimated to increase by 20 % for spring, autumn, and winter while the amount of precipitation during summer stay close to baseline values. Extreme precipitation events (cloudbursts) will increase by number of days per year by 2100, see table 2 (Ehrnsten *et al.* 2011, Bratt 2014).

Table 4: The values are based on downscaled climate models and show predicted values in two different emission scenarios (RCP 4.5 and RCP 8.5) compared to the baseline values. Table adopted from the Count Administrative Board of Östergötland, see Bratt (2014)

Climate index	Baseline (1961-1991)	RCP 4.5 2040	RCP 4.5 2100	RCP 8.5 2040	RCP 8.5 2100
Average temperature (in Celsius degrees)	6	+ 2,1	+2,5	+2,2	+4,5
Average precipitation rate	615 mm	+8 %	+10 %	+10-20 %	+20-28 %
Number of days with extreme precipitation	13	+3,5	+5	+5	+9
The length of vegetation period, in days	201	+30	+50	+38	+100

9.2. APPENDIX II: MAPS OF MOTALA CITY

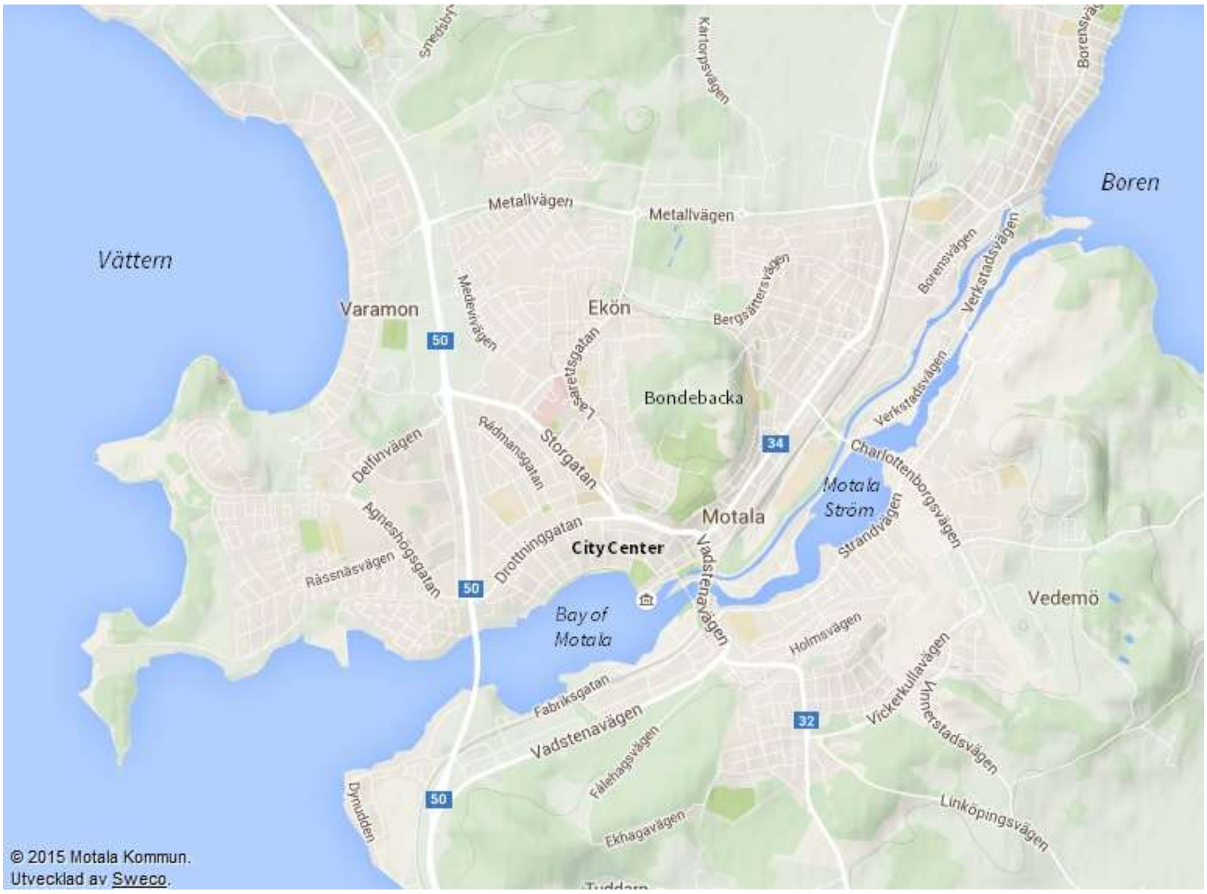

*Figure 1: Map of Motala City, modified from Motala.se/karta. Use direct link for zoom-function:***http://motala.eposkarta.se/#0&1;0&10&1676445.1834004;8078993.3304028&-3&&** *[accessed 26-10-2015]*

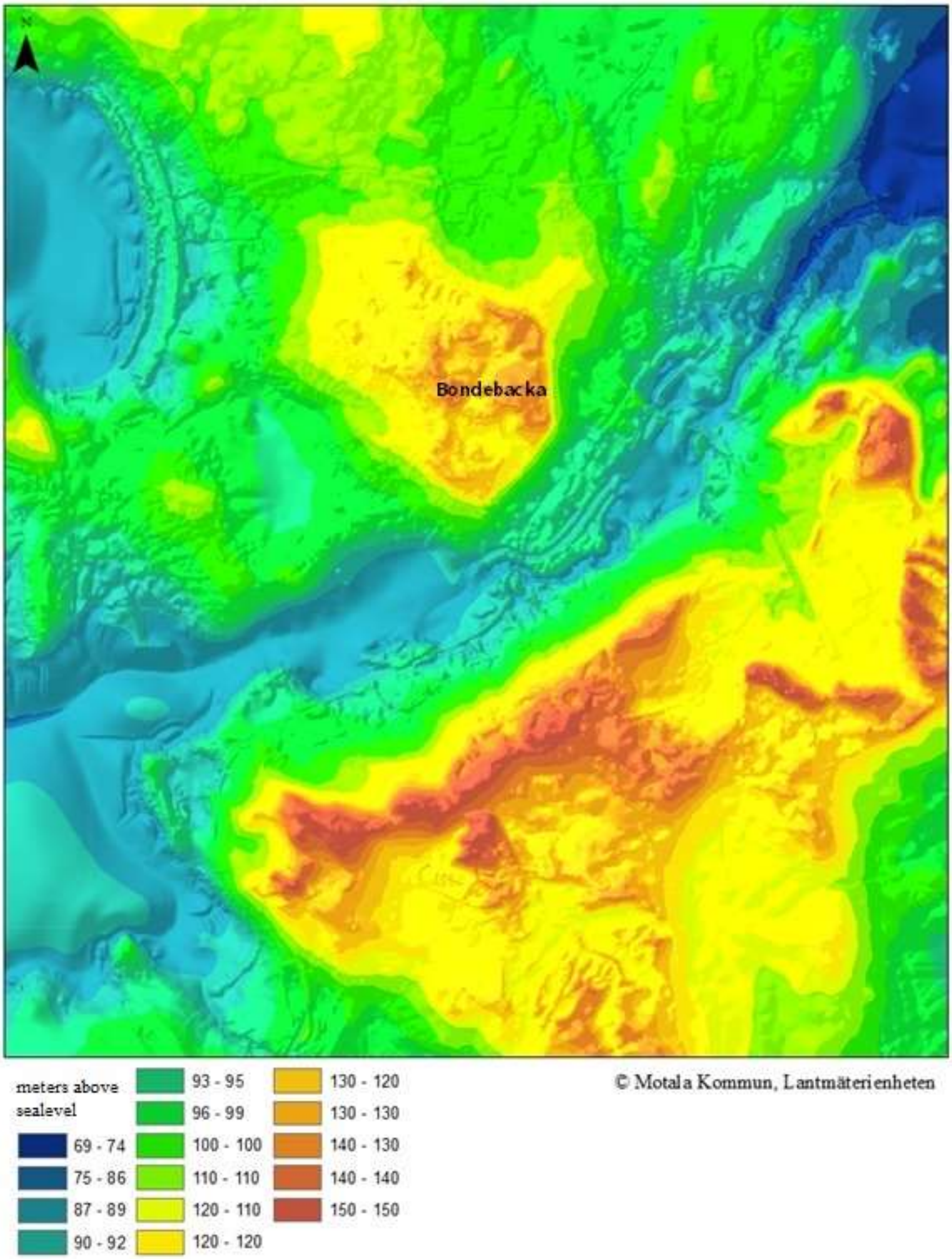

Figure 2: Topography of Motala City, produced in ArcMap using the 'topo to raster' tool. With reservation for anomalies in the visual representation along the shores (the shoreline begins at approx. 88 m, see figure 1 for better representation of the shoreline). The objective of the produced map is mainly to show landscape characteristics such as the slopeness of the urban area

9.3. Appendix III: Participatory exercises used during the first workshop

During the first workshop, the participants were asked to discuss what they associated with the concept of *climate change* while the researcher noted the answers on the whiteboard (see Figure 3a and 4). The participants were also asked to identify areas within the city that were vulnerable to flood, so called risk-mapping, and what damage the cloudburst event during the summer of 2014 had caused (figure 3b). Areas of stormwater infiltration dams were also identified on the map.

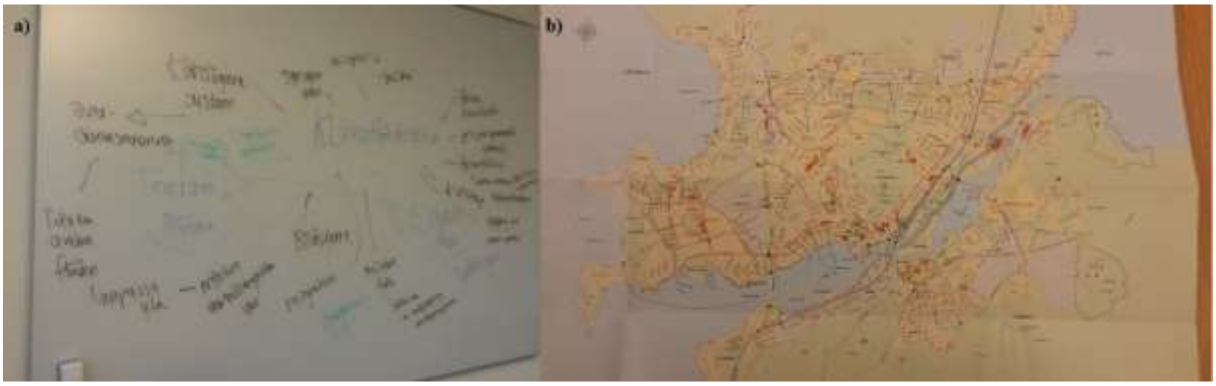

Figure 3: Pictures of participatory exercises during the first workshop, a) shows the exercise of brainstorming on climate change and b) shows the map used to identify vulnerable areas through risk-mapping. Photo by ©Line Holgerson

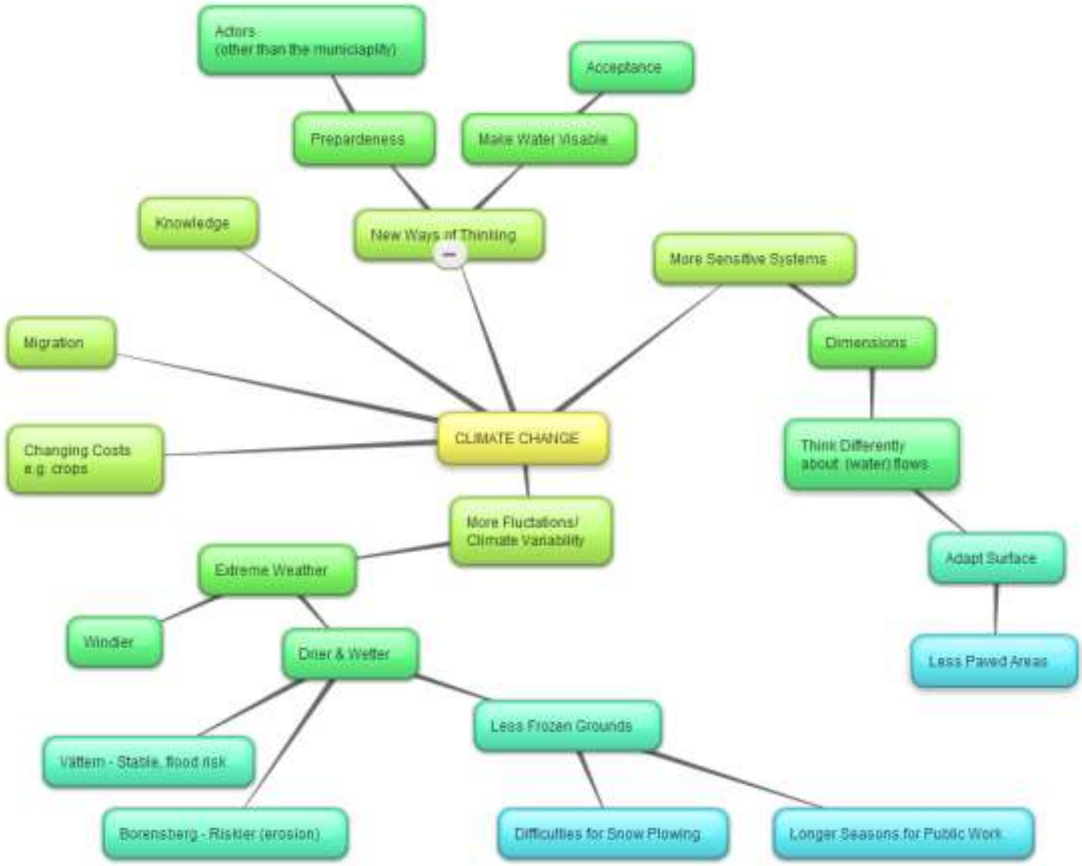

Figure 4: The reproduced result from the brainstorm session done on a white board with workshops participants during the first workshop. The participants were asked to discuss what they associated with the concept of climate change. The visual representation was created using bubble.us, an online software available at: https://bubbl.us/mindmap (produced: 11-02-2015)

During the second workshop, a sustainability analysis was carried out as a participatory exercise. The sustainability analysis-tool is a decision-support tool developed under the Swedish research program Climatools (FOI, 2011). The tool is an evaluation tool that provides planners and decision-makers a basis to develop strategies for climate adaptation and sustainable development at municipal level (Baard *et al.* 2012). The tool was used to assess the sustainability dimensions (environmental, social and economic) of stormwater solutions.

The discussion was carried out on a general basis, where each participant wrote down answers to the questions presented on post-its and placed them where he/she though suited (see figure 5).

9.4. Appendix IV: Sustainability analysis

During the second workshop, a sustainability analysis was carried out as a participatory exercise. The tool was used to assess the sustainability dimensions (environmental, social and economic) of stormwater solutions. Figure 5 shows the result of the sustainability analysis carried out with the workshop participants.

Figure 5: Picture of sustainable analysis during the second workshop. Here, the participants were asked to reflect on the implementation of potential stormwater solutions in the city center from a sustainability perspective. Photo by ©Line Holgerson

The questions were loosely based on a checklist presented in the *Climatools*-material (FOI 2011) and presented to the participants during the exercise (see table 4). After approximately five minutes of writing, the researcher went through the notes successively together with the participants and some of the answers where further discussed among the participants.

Table 5: Questions asked during the sustainability analysis, based on the checklist presented in the Climatool-material

Environmental
▪ How does the measure affect the urban environment? ▪ How is the measure affected by extreme weather events (e.g. heat waves, storms and cloudburst)?
Social
▪ How does the measure affect traffic security and the perceived safety? ▪ How does the measure affect city residents? ▪ How does the measure affect maintenance and management practices of the urban environment? ▪ Does the measure affects segregation and are there groups that can be effected negatively and/or positively of the measure?
Economic
▪ How does the measure affect commercial and industrial practices? ▪ How does the measure have any implication for growth and development? ▪ How does the measure affect mobility and infrastructural communication? ▪ How does the measure affect recreational and tourist activities?
Continued analysis
▪ What are the short term and long-term costs and benefits of open stormwater solutions? ▪ Can proposed measure come in conflict when reailsing other municpal goals? ▪ What is necessary to realize and implement measures? ▪ What are the consequences of not implementing measures (environmental, social/health-related, economic/growth)? ▪ Is there alternative measures/way of doing things? ▪ What are the preconditions to develop and build the climate-smart, environmental-friendly city of Motala? ▪ What is needed to enable the transition to a sustainable society? ▪ What actors are important to include if similar processes (research-driven) were to be realized at the City Hall?