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The role of scale in integrating climate change adaptation and mitigation in cities

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Abstract:	By using a scale framework, we examine how cross-scale interactions influence the implementation of climate adaptation and mitigation actions in different urban sectors. Based on stakeholder interviews and content analysis of strategies and projects relevant to climate adaptation and mitigation in the cities of Copenhagen and Helsinki, we present empirical examples of synergies, conflicts and trade-offs between adaptation and mitigation that are driven by the cross-scale interactions. These examples show that jurisdictional and institutional scales shape the implementation of adaptation and mitigation strategies, projects and tasks at the management scale, creating benefits of integrated solutions, but also challenges. Investigating the linkages between adaptation and mitigation through a scale framework provides new knowledge for urban climate change planning and decision-making. The results increase the understanding of why adaptation and mitigation are sometimes handled as two separate policy areas and also why attempts to integrate the two policies may fail.

1. Introduction

Cities need to mitigate greenhouse gas emissions and respond to the impacts of climate change by adapting. However, the translation of global climate policies into regional and local level management practices is not a straightforward process. Previous studies have indicated that adaptation and mitigation are complementary, interlinked policy areas. When dealing with climate risks in local urban contexts, adaptation reduces the city's sensitivity, while mitigation reduces to exposure to climate change impacts (Yohe and Strzebek, 2007). Nevertheless, some authors have stated that adaptation and mitigation should be handled as two separate policies due to differences in scales, where the policy formulation and implementation take place, and lack of knowledge about this (Tol 2005, Jones et al. 2007).

Previous research has revealed trade-offs and conflicts between adaptation and mitigation policies and practices in urban areas (e.g. Ayers and Huq 2009, Hamin and Gurran 2009, Anguelowski and Carmin 2011, Sugar, Kennedy, and Hoornweg 2013, Dymén and Langlais 2013, S. Barbhuiya, S. Barbhuiya, and Salim 2013). A comprehensive literature review shows some reasons why integration of adaptation and mitigation sometimes fail (see Landauer, Juhola and Söderholm 2015). For example, lack of financial resources or competing policy goals of city administrations can hinder the policy integration in cities. This means that depending on the goals and priorities of adaptation or mitigation in cities, trade-offs, i.e. "balancing" (Klein et al. 2007, 749) is required when beneficiaries and policy priorities differ between the two climate policies (Heidrich et al. 2013). Conflicts, defined by OED (2015) as "a serious incompatibility between two or more opinions, principles, or interests", can appear when an attempt to find integrated solutions for adaptation and mitigation in urban planning fails, or the two climate policies are implemented in "silos" which is not necessarily time and cost efficient especially in the long term (Walsh et al. 2011). In urban planning practice, conflicts can emerge when flood damage and heat island effects are avoided by urban greening that in turn requires more physical space in the city. This can counteract with densification of urban structure that is undertaken to reduce emissions by reducing travel distances (ibid.). In an ideal scenario, successful integration of adaptation and mitigation would generate synergies. By "synergies" we mean adaptation and mitigation policies or practices that gain greater benefits for cities to tackle climate change, if implemented together rather than in isolation (following Klein et al. 2007). For instance, integration of adaptation and mitigation actions can be considered synergetic, if time and resources can be saved while paying attention to both material durability and energy efficiency in building design when considering the life span of a building.

Differences in policy objectives across multiple scales have been frequently noted as a reason for the dichotomy between adaptation and mitigation when these two policies are being implemented (Goklany 2007, Biesbroek, Swart and van der Knaap Wim 2009). These scale-related differences have been addressed in the literature, for example noting the different time and spatial scale of policy implementation, and different levels of governance responsible for policy formulation and steering (Meadowcroft 2002, Bulkeley 2005, McEvoy, Lindley and Handley 2006, Bai 2007, Swart and Raes 2007, Ayers and Huq 2009, Laukkonen et al. 2009, Hamin and Gurran 2009, Williams, Joynt and Hopkings 2010, Walsh et al. 2011, Romero-Lankao 2012, Balaban and Puppim de Oliveira 2013, Dymén and Langlais 2013, Heidrich et al. 2013, Juhola et al. 2013, Villarroel Walker et al. 2014). The literature review of Landauer et al. (2015) also shows that many conflicts between the two policies in cities are driven by different policy priorities or by administrative processes or limited resources, or they appear in urban planning practice due to competing use of physical space. According to Walsh et al. (2011, 78), there is a further need to break down the complex interactions between adaptation and mitigation, and those related to differences in scales in particular. Moreover, Laukkonen et al. (2009, 291) have called for the development of procedures that could assist local decision-makers and planners to improve the formulation, evaluation and implementation of climate change responses in cities.

In order to study adaptation-mitigation inter-relationships to be able to see where there is potential to integrate the two policies, we found the scale framework first presented by Cash et al. (2006) useful. This is because application of this framework allows us to study cross-scale interactions and to see how the policy interplay between adaptation and mitigation might influence the i) development and ii) implementation of adaptation and mitigation policies and practices along the management scale of the cities. We study this mainly from the public-sector point of view. Understanding the role of public sector is important because the public sector still plays an important role in implementing climate policies and practices in Nordic countries. This is despite the fact that the private and the third sector are gaining more ground (Wamsler and Brink 2014, 2015, Juhola 2013) and the fact that cities' own initiatives have proliferated to share responsibility to be able to tackle climate change with private actors or in form of partnerships on important sectors where climate actions can be implemented (Bulkeley and Betsill 2005, Bai 2007, Anguelovski and Carmen 2011, Klein et al. 2016a). Furthermore, it is not only due to cities' climate policy goals *per se* why cities are active in preparing for adaptation and mitigation actions, but quite often cities are becoming "climate-proof" also due to sustainability goals of other policies such as of transportation, water or waste and spatial planning (Urwin and Jordan 2008, Thornbush, Golubchikov, and Bouzarovski 2013, Rosenzweig et al. 2017 *in press*). In fact, while not the topic here, it is worth noting that climate policy can also take place within "non-climate" policies, intentionally or ad hoc (Urwin and Jordan 2008, Walker et al. 2017) and strategic planning in urban areas (McEvoy et al. 2006).

We study two Nordic cities, Copenhagen in Denmark and Helsinki in Finland to understand the dichotomy between climate mitigation and adaptation. We empirically examine these two cities to find out first, in which contexts 1) mitigation actions affect adaptation and 2) adaptation actions affect mitigation. Next, we examine multiple scale interactions to see whether these can reveal reasons for synergies, trade-offs or conflicts between adaptation and mitigation. For the reasons mentioned above, here we focus on actions on the management scale that are implemented by the public sector – adaptation and mitigation related strategies, projects and tasks of these. These actions located at the different levels of the management scale are the main units of analysis in this study and we study how other scales, along which climate policy is developing, interplay with the management scale of actions.

The empirical data are based on selected climate adaptation and mitigation policy documents (Appendix 1) and semi-structured in-depth interviews with key stakeholders conducting climate work in the case cities. These are local and regional public administrative bodies, but also private companies, NGOs and research institutes (Table 1). We then examine cross-scale interactions and identify examples that can help to explain the emergence of conflicts, trade-offs and synergies between adaptation and mitigation on the management scale. In conclusion, we contribute to the ongoing debate on how integration of adaptation and mitigation could be, or even should be, realized in cities.

2. Conceptual background

2.1. Importance of scale in climate governance

The question of scale and scale interactions has become of interest in the study of environmental governance for some time (Meadowcroft 2002, Bulkeley 2005, Bulkeley and Betsill 2005, Betsill and Bulkeley 2006, Cash et al. 2006, Urwin and Jordan 2008, Bulkeley 2010, Padt et al. 2014, Padt and Arts 2014). Despite this interest, it is argued that the concept of scale itself and its implications has been an understudied area, in social sciences in particular (Gibson et al. 2000, Padt et al. 2014) and a persistent issue of conceptual ambiguity and imprecision (Padt and Arts, 2014). Connections between scales are inherent in the complex "set" of arrangements that emerge in environmental governance, governance of common goods and multilevel governance (Bulkeley 2005, Gupta 2008, Ostrom 2008, Ostrom 2010). Yet, these scale-related issues have been described as one of the key challenges in addressing environmental change (Young 2002). It has further been argued that governance systems are currently unable to address the role that the scale interactions might have (Termeer and Dewulf 2014), leading to inadequate responses to environmental and socio-economic threats, such as climate change. This is despite governance being, by definition, decision-making across multiple scales, blurring the boundaries across the international, national, regional to the local (Bache 2005; Padt et al. 2014). This has been shown to be true in particular in the implementation of climate adaptation and mitigation policies.

With regards to governance of climate change, typical scale-related differences of adaptation and mitigation "on the ground" emerging from the literature are found at spatial and temporal scales. For example, IPCC (2007) states that mitigation efforts are mainly a global responsibility and provide global benefits. Additionally, considering the temporal scale, greenhouse gases have a long residence time in the atmosphere and the benefits of mitigation will be evidenced after several decades, although co-benefits such as air pollution reduction can be observed in the short run. Considering the spatial scale, adaptation actions are mainly beneficial at the local level. Adaptation measures can reduce vulnerability to climate variability in the long term also, but the effectiveness of adaptation measures can become "visible" immediately (IPCC 2007).

Cities across the world are now managing both climate adaptation and mitigation to prepare for risks and impacts (Rosenzweig et al. 2017 *in press*) with their own initiatives and by means of networks, such as the Cities for Climate Protection (CCP) (Betsill and Bulkeley 2006). Cities implement various climate actions that are initiated by different jurisdictions, by national, local and regional administrations, and steered by various rules, laws and regulations across different levels of institutional scale, and increasingly also by means of multi-level governance approaches (Bulkeley 2010). The influence of institutional settings and administrations at different jurisdictional levels can happen along established hierarchical and spatial structures, but networks and cooperation among cities have become an important factor in cities' climate change activities. This means that climate change initiatives of city networks can drive local adaptation and bypass the state. This makes cities to "translocal sites" rather than a level embedded in a hierarchical structure of city and state (Bulkeley 2005, p. 887, Bulkeley and Betsill 2013). New governance mechanisms are clearly a much-needed complementary addition to the "conventional" government structures and play an important role in the agenda setting for adaptation and mitigation. Nevertheless, in many Nordic cities the implementation of climate change related measures happens within the framework of national policy and regulations, a trend also observed elsewhere (cf. Jordan, Wurzel, and Zito 2005, Peters 2014). However, this often takes place without proper coordination or available resources from the state for adaptation and mitigation and their implementation would still quite often require state involvement and public policy-making (Juhola and Westerhoff 2011, Dannevik, Rauken, and Hovelsrud 2012, Dymén and Langlais 2013).

2.2. Cross-scale interaction

We draw on the definition of scale put forward by Cash et al. 2006 as “the spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon, and ‘levels’ as the units of analysis that are located at different positions on a scale” (Cash et al. 2006, 2). The authors identify a number of scales that we find relevant to our study (see Cash et al. 2006, 2-3). Spatial and temporal scales naturally denote where and when climate governance activities take place: at different spatial levels at different times, covering different spatial dimensions and time spans. Hence, the temporal and spatial scales are the general background within which the implementation of climate policies takes place in society, in this case, in a city. The other scales are “socially constructed” (see Padt and Arts 2014, 9-11) and they exist because of social organization. For example, steering of cities’ climate adaptation actions by rules and regulations (institutional scale), and implementing the actions by different administrative bodies (jurisdictional scale) make them relevant as study objectives, when assessing their implementation (management scale) of climate policy (adaptation or mitigation separately, or integrated) in the cities. Fig. 1 provides an illustration of the three scales of social organizations, which we used to operationalize the scale framework for our analysis.

<<Insert Fig. 1>>

Drawing on the Cash et al. (2006) framework, the cities’ climate management scale consists of strategies, individual projects and tasks, i.e. this is how climate policy is implemented. Conceptualized in this way, cross-level interaction within the management scale means that strategies influence the types of projects and tasks that are undertaken in implementing climate change policies, although not necessarily in this hierarchical order.

The jurisdictional scale is an important study objective in order to understand the way the cities have organized their decision-making, i.e. across the levels of political units and types of governance. Public policy processes, such as of adaptation and mitigation, are being administered on a jurisdictional scale. The different levels of the jurisdictional scale can cover, for instance, the local, provincial, national and intergovernmental administrations, consisting of public and private actors, or public-private partnerships, or networks. These levels form the jurisdictional framework for adaptation and mitigation by denoting the boundaries of authority in decision-making.

The institutional scale denotes the hierarchy of rules at different levels from constitutions all the way down to operating rules. Institutional scale is the legal framework that steers climate policy-making. In relation to climate policy, this scale encompasses institutional arrangements, ranging from intergovernmental and national interactions, constitutions, laws and norms to operating rules and regulations for actions. These actions can be steered from top-down, but often also bottom-up, and governed horizontally or vertically, as also observed previously (Bulkeley 2010). Examples of these can be international agreements, such as of the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, the Paris Agreement and the directives of the European Union that function as external “driving forces” for climate actions in cities. Cities also plan and implement local initiatives and innovations for climate action, which are supported by global platforms and networks such as C40 Cities and many others (Reckien et al. 2014, Hughes et al. 2018, Bulkeley and Betsill 2013).

According to Cash et al. (2006), there are a number of different ways that these scales can interact. Interactions can take place across multiple levels within a scale (cross-level) and also across different scales (cross-scale), indicating the significant complexity within the dynamics of the social system. Cross-level interaction is referred to interactions taking place within a single-scale, while cross-scale refers to interaction between two or more scales, and this can further mean multiple levels on the two scales. In this study, we focus mainly on cross-scale interactions. Because there is a plurality of views of how scale and scale interactions can be understood (cf. Cash et al. 2006), it is not feasible to analyze all possible scale interactions.

Based on this conceptualization, we hypothesize that scale interactions influence the implementation of both mitigation and adaptation along the management scale, affect the possibilities to integrate the two policies, and these scale interactions also create concrete examples of conflicts, trade-offs or synergies in the case cities. Based on this hypothesis, we set the following research questions that guide our analysis:

1) What are the scale interactions that mainly affect the integration of climate mitigation and adaptation along the management scale?

2) Whether and how do these cross-scale interactions become manifested on the ground so that they result in concrete examples of conflicts, trade-offs or synergies between climate adaptation and mitigation on the management scale?

3. Methodology

3.1. Description of case study

We chose Copenhagen and Helsinki as case cities because of their ambitious climate goals and activities in climate change mitigation and adaptation. The climate change trajectories for both cities point towards the same direction: higher temperatures, higher sea levels, and more precipitation (City of Copenhagen 2011; HSY 2010). Both are also located on the Baltic Sea coast, which makes them vulnerable to the impacts of the changing climate (IPCC 2014), in particular to sea level rise and storm surges (Meier 2006, McGranahan, Balk and Anderson 2007, Bosello et al. 2012). Also, in terms of their population the cities are similar with about 585,000 inhabitants in Copenhagen and 613,000 in Helsinki (City of Helsinki Urban Facts 2014; Statistics Denmark 2015). Both cities are the capitals of their countries and both countries are Nordic welfare states (Greve 2007). This means that cities have (compared with many other cities globally) high administrative and financial capacity, and have their own tax revenues, but are at the same time well integrated into the country's governance structure (Sellers & Lidström, 2007).

Copenhagen aims a carbon neutral status by 2025 (City of Copenhagen 2012) and Helsinki by 2050 (Huuska, Lounasheimo, Jarkko, Viinanen and Ignatius 2017). Climate change adaptation has also been on the agenda in these cities and capital regions for many years (Leonardsen 2009, Pelin 2001). They have published adaptation strategies and continue to work on adaptation (e.g. City of Copenhagen 2011, HSY 2012; Yrjölä and Viinanen 2012, City of Copenhagen 2012, City of Copenhagen 2014, City of Helsinki 2017). Thus, the two case cities are fairly similar with respect to climate risks, size of the cities, and institutional settings. This provides us a broader empirical basis to test our hypothesis and answer our research questions (Seawright and Gerring 2008) rather than focusing on only one city.

While there is a growing number of studies on urban climate adaptation in the Nordic countries (e.g. Naess et al. 2005, Storbjörk 2007, 2010, Juhola, Haanpää and Peltonen 2012, Hjerpe and Glaas

2012, Tuusa et al. 2013, Cashmore and Wejs 2013, Hjerpe, Storbjörk and Alberth 2015, Rauken, Mydske and Winsvold 2014, Klein, Mäntysalo and Juhola 2016b), empirical studies of the inter-relationships between the two climate policy areas, adaptation and mitigation, in urban context have not received much research attention so far.

In both Copenhagen and Helsinki, the climate objectives and motivation are not solely the result of national or international requirements (top-down), but these cities have been very active in initiating and developing their own climate agendas, and are part of some climate networks (bottom-up), such as many other cities (see Bulkeley 2005, Bulkeley and Betsill 2005, Betsill and Bulkeley 2006, Bulkeley 2010). Although mitigation is still quite often better institutionalized than adaptation (cf. Anguelowski and Carmen 2011), especially Copenhagen is investing heavily in adaptation actions, partially due to the past flood events, such as a cloudburst event in 2011. In both cities, adaptation and/or mitigation are to some extent mainstreamed to other urban policies, such as in transportation policy, sustainable development, and land use planning[1].

We examine the management scale of the cities in detail, because it is the scale within which climate policies are implemented in cities. The levels of this management scale are strategies, projects and tasks. For example, within the management scale of a city, the implementation of climate policy by means of mitigation actions takes places through a climate strategy that outlines the broader targets for emissions reductions, which are then set as targets in energy efficiency projects that undertake specific tasks in specific locations. Implementation of climate adaptation in the management scale of the city follows the same logic, and in both cities the implementation is mainly the responsibility of local public authorities, but to some extent also of citizens and private actors (Klein et al. 2016a). In this study, we would like to see whether and how, for example, the jurisdictional and institutional scales affect adaptation and mitigation implementation on the ground, i.e. interplay with the management scale, and what challenges the limited urban space (i.e. spatial scale) brings along. In the two empirical contexts - how mitigation affects adaptation and how adaptation affects adaptation, the scale framework helps considering whether the implementation of adaptation and mitigation should be done separately or in an integrated manner.

3.2. Data collection methods and analysis

Semi-structured in-depth interviews (Longhurst 2010) were conducted face-to-face with 28 stakeholders and one interview was conducted via Skype™ (N=29), either one stakeholder at a time or by interviewing two stakeholders from the same organization simultaneously. The duration of an interview was approximately one hour. We invited key stakeholders, i.e. those who have actively taken part in designing, implementing or evaluating adaptation and mitigation strategies in the case cities, to participate the study. The interviews took place in Helsinki, Finland in May, June and September 2013 (16 organizations) and in Copenhagen, Denmark in September and October 2013 (10 organizations). A list of participating organizations can be found in Table 1. The interviewees were from public sector organizations (city administrations, regional organizations, research institutes and universities), and private sector organizations (one local NGO and two consulting companies). The names of the interviewees remain anonymous, only organizations are presented.

1 City of Helsinki has recently published a brochure on recent actions that show adaptation can be mainstreamed into urban planning: https://www.hel.fi/hel2/ksv/julkaisut/esitteet/esite-2017-4-en.pdf. Examples from Copenhagen can be found on State of Green's website: https://stateofgreen.com/en/news.

The interview question format was open-ended and an interview guide helped the interviewers to focus on the key topics, to maintain consistency, and to "stay on track". The responses were audio-recorded with the permission of interviewees, and complemented with written notes by the researchers. The audio-recordings were transcribed and responses verified (following Guion, Diehl, and McDonald 2011, 2). The interviews were identical in both cities except for the language: they were conducted in English in Copenhagen, and in Finnish in Helsinki. Thereafter, the material was coded and analyzed with ATLAS.ti 7 qualitative analysis software (ATLAS.ti™ Scientific Software Development GmbH), which helps coding the interview data systematically and time-efficiently. The coding structure was developed a priori.

We also analyzed a selection of climate adaptation and mitigation policy documents from the case cities. The policy documents consist mainly of official strategies and project descriptions of implemented projects in the case cities. From Helsinki, these include Helsinki Metropolitan Area Climate Strategy to the Year 2030" and "Helsinki Metropolitan Area Climate Change Adaptation Strategy". The strategies analyzed in Copenhagen are "CPH 2025 Climate Plan", and "CPH Climate Adaptation Plan". The projects are "Kalasatama" district in Helsinki and "Skt. Kjeld's" district in Copenhagen. These strategies and projects with specific tasks constitute the management scale in this study (see Appendix 1 for detailed descriptions of the documents).

3.3. Empirical analysis

We took the following steps in analyzing the data. First, we pre-screened scientific literature, policy documents and websites from both case cities in order to learn how climate adaptation and mitigation has been taking place in the case cities and who has been responsible for planning and implementation of climate policy, in order to invite relevant stakeholders to be interviewed. Once the interview data collection was done, we examined the interview responses with regards to the relevant strategies, projects and tasks in these (management scale). We examined how and in what kinds of situations these strategies and projects were mentioned the interview responses. Then, we analyzed the content of the documents written about the strategies and projects. These levels of the management scale are thus the main units of our analysis (Appendix 1). This data triangulation helped us finding out what kinds of scale interactions emerge from the jurisdictional and institutional scale that could affect the implementation of adaptation and mitigation "on the ground". Finally, we examined whether these interactions lead to conflicts, trade-offs or synergies between adaptation and mitigation in the case cities. We chose the approach and methods because they enable us to study the implementation process of the cities in detail. The convergence of data collected from different sources (data triangulation), in this study by means of stakeholder interviews and analysis of policy documents, determines the consistency of our findings (see Yin 2014). In this study, we present the results of adaptation and mitigation inter-relationships and scale interactions in the case cities in two empirical contexts in the case cities: (1) mitigation affecting adaptation (2) adaptation affecting mitigation.

<<Insert Table 1>>

4. Results

In this section, we show examples of the types of scale interactions that affect the implementation of strategies and projects in the case cities' management scale. The results show that the origins of conflicts and trade-offs, as well as synergies between adaptation and mitigation can be explained by these scale interactions. The challenges and potential of integration become manifested in the implementation of measures in practice at the local level in the form of synergies, trade-offs and conflicts (i.e. inter-relationships between adaptation and mitigation) in the management scale.

Based on the content analysis of the stakeholder interviews and the policy documents, we focus on two empirical contexts to illustrate, how scale interactions take place and what kind of inter-relationships between adaptation and mitigation can be found: 1) management of urban densification and energy efficiency of buildings (mitigation), and 2) surface runoff and urban heat management (adaptation). Our empirical material (interviews, documents) reveals 11 examples of conflicts, synergies and trade-offs in the two empirical contexts caused by cross-scale interactions that can help explain the inter-relationships between adaptation and mitigation and reasons why integration of the policies succeed or fail. Eight of these were identified in Copenhagen and three in Helsinki. In addition, further analysis reveals "drivers" of conflicts, synergies and trade-offs that can help explain why certain factors along different scales cause challenges for integration of adaptation and mitigation.

By means of all of these examples that are represented in this study, we can show how cross-scale interactions influence the management scale. The scale interactions appear, for example, when a specific regulation affects the way in which a strategy for management is formulated, or identify situations, where specific drivers at the institutional and jurisdictional scale could help urban planners and decision-makers detect potential for synergies, reasons for conflicts, and to negotiate potential trade-offs, before climate adaptation and mitigation are being implemented along the management scale through strategies, projects and tasks (see Figs. 2-7).

4.1. Scale interactions: Copenhagen

4.1.1. Mitigation actions affecting adaptation: Examples of managing urban densification and energy efficiency of buildings

First, one synergy in Copenhagen was identified in the building sector. The Copenhagen Adaptation Plan (City of Copenhagen 2011) denotes that buildings should be designed in an energy efficient way to support mitigation, and, at the same time, reduce risk of flooding by flood protection techniques such as sealed basements that function as adaptation measures to protect buildings (Fig. 2, example 1). Taking into account both these legal requirements (institutional scale) in construction, synergies to better tackle both climate adaptation and mitigation in Copenhagen could be enhanced. Thus, the Copenhagen's adaptation strategy ties together the two otherwise unrelated legal requirements for energy efficiency and flood protection and reveals how synergies can be created.

The second synergy was identified as part of the city administration's climate work in Copenhagen, namely the mitigation strategy (City of Copenhagen 2012), which provides an analysis, demonstration and implementation roadmap for energy efficient buildings. The strategy states that new buildings should be constructed so that they cover both climate adaptation and low energy use requirements (Fig. 2, example 2). The synergy appears when an energy efficient building design is, for example, also flood or heat resistant so it supports both climate policies simultaneously, which can save time and resources while increasing the life span of the building. So, the combined effect of adaptation and mitigation is greater than if adaptation or mitigation were implemented separately.

The third synergy was identified in the Sankt Kjeld's project district, related to "future-proofing" of dwellings. A number of energy improvements and green developments, such as such as solar power cells, passive sun heating and local drainage of rainwater are being promoted but further improvements are needed (The Integrated Urban Renewal in Skt. Kjeld's 2011). According to the Copenhagen mitigation strategy (City of Copenhagen 2012), innovative, "out of the box" thinking, such as in terms of designing and implementing large construction projects, referred to as "spearheading projects and working as a lab" are useful because they take into account not only energy retrofitting, and low-energy construction (mitigation) but also climate adaptation. This means that strategic guidelines and the framing of projects at the management scale can enhance synergies at the city administration (local level, jurisdictional scale) that is in charge of implementation (Fig. 2, example 3).

<<Insert Fig. 2>>

4.1.2. Adaptation actions affecting mitigation: Examples of surface runoff and urban heat management

The first synergy of adaptation actions affecting mitigation can be seen in the building sector in energy efficiency guidelines (institutional scale). The purpose of the Act on Municipal Cooling Systems (No. 465 of 2008) is to increase the energy efficiency of buildings and reduce the use of conventional air-conditioning, due to the urban heat island effect (Fig. 3, example 1). The increased use of air-conditioning as adaptation to higher temperature would be in conflict with the mitigation aim to reduce energy consumption and greenhouse gas emissions. In Copenhagen, the Act on Municipal Cooling Systems (No. 465 of 2008) tries to alleviate this conflict by increasing energy efficiency of buildings and alternative air-conditioning (e.g. district cooling). This means a law (at the institutional scale) reduces the conflict between mitigation and adaptation goals that can be identified in the task to reduce indoor temperature of buildings in the city (management scale).

Second, the Copenhagen Adaptation Plan (City of Copenhagen 2011, 58) mentions the potential of green spaces in both surface runoff management and regulating indoor temperatures of buildings. It also mentions that building regulations (institutional scale) can be applied to keep storm water away from buildings and assure good indoor temperature conditions in buildings (City of Copenhagen 2011, 77). Also, the "mitigation" strategy of Copenhagen (City of Copenhagen 2012, 10) denotes that when renovating homes, materials such as green roofs, can help manage rainwater and provide more comfortable indoor climate at the same time. This reduces the need to use electricity-based conventional cooling systems. The project Sankt Kjeld's presents examples of the synergies of green roofs and green walls that delay the water's passage to the sewer system during heavy rainfalls and also reduce the need for energy-consuming air-conditioning in the example of the urban heat island effect (The Integrated Urban Renewal in Skt. Kjeld's 2011, City of Copenhagen 2013). (Fig. 3, example 2)

The third synergy is identified in the jurisdictional scale's influence on the Copenhagen adaptation strategy that appears to be the cooperation of energy and water sectors: the merger of Copenhagen's formerly separate energy service and water service organizations to HOFOR allows for the cooperation of the energy and the water sector, as HOFOR represents both adaptation and mitigation jurisdictions, creating a synergy at the strategic level at the management scale (Fig. 3, example 3).

<<Insert Fig. 3>>

We identified two conflicts in the water sector, where the Copenhagen adaptation strategy (City of Copenhagen 2011) indicates that in practice, the increasing use of groundwater pumps by the water sector to avoid flood damage can be in conflict with mitigation efforts due to increasing demand for energy (Fig. 4, example 1). Therefore, to avoid this conflict but still increase adaptive capacity it is important to increase energy efficiency by investing in energy efficient pumps and other technical innovations that enable to handle larger amounts of water in a shorter period of time. This is to be considered in wastewater treatment, runoff management, and water supply by the water sector jurisdictions. Furthermore, an evaluation of measures would be important but here the land-ownership (property ownership) appears again problematic, leading to difficulties in measuring the impacts of adaptation on mitigation, and vice versa (jurisdictional scale) (Fig. 4, example 2):

> "So, it's very difficult to… for us to say, 'Okay how much can what we are doing in adaptation contribute to the mitigation process?' For instance, green roofs they have a cooling effect yes, on the city, but they might also have an interrelating effect with reducing heat costs and so on. But it's, it's very difficult to actually say how much the effect is of all this because how do you measure … if you build a green roof…I mean you can measure how much water a green roof can retain, you can pour a bucket over and see how much comes out from the drain…and you can compare that with pour a bucket of water on an equally flat surface, but many of these houses are built by private, so if you want to measure the energy efficiency and so on it's very difficult." (Interviewee, Technical and Environmental Administration - Parks and Nature Department, Copenhagen)

<<Insert Fig. 4>>

4.2. *Scale interactions: Helsinki*

4.2.1. Mitigation actions affecting adaptation: Examples of managing urban densification and energy efficiency of buildings

In Helsinki we identified one conflict in the context of urban densification and energy efficiency of buildings. There is a conflict caused by energy efficiency requirements (institutional scale) to reduce emissions that have to be re-considered at the jurisdictional scale since emission reduction and energy efficiency regulations for building design have been stricter so far or have had higher priority than material durability requirements to protect buildings from floods:

> " …for example, material durability in construction: when it comes to houses, road surfaces or other structures, less attention has been paid to it than to energy efficiency for example…" (Interviewee, Public Works Department, Helsinki)

Therefore, a solution for the building sector but also for urban planning as a whole could be an evaluation requirement of the impacts of both adaptation and mitigation measures. In this case, the institutional scale, by means of operating rules for evaluation, can influence the attempts to integrate adaptation and mitigation in practice. This kind of evaluation was done on a voluntary basis as part of the development of Kalasatama district in Helsinki and it took the form of a report (Wahlgren, Kuismanen and Makkonen 2007). The Technical Research Centre of Finland (VTT) together with the City Planning Department of Helsinki prepared it. Based on a draft master plan for the district, the report includes an assessment and evaluation of potential climate change impacts, suggestions for adaptation measures and calculations of greenhouse gas emissions for the district (Wahlgren, Kuismanen and Makkonen 2007) (Fig. 5, example 1). An example of the current situation is that the Kalasatama smart grid system allows a testing ground for smart future energy solutions, and at the same time the district takes into account sea level rise and potential floods in all of its planning and construction, including the smart grid system (SITRA, Tekes and VTT 2011).

<<Insert Fig. 5>>

4.2.2. Adaptation actions affecting mitigation: Examples of surface runoff and urban heat management

We found two instances; one trade-off and one synergy, where adaptation affects mitigation the context of how surface runoff and urban heat management are carried out in Helsinki. A trade-off between adaptation and mitigation can become manifested in any city particularly in strategic urban planning, and in building and infrastructure sectors in particular, when mitigation and adaptation goals suggest competing types of land use (adaptation or mitigation management) for a specific geographical area (spatial scale) (see McEvoy et al. 2006). In Helsinki, the city administration (jurisdictional scale) has to carefully balance the use of space (spatial level) in its planning activities (projects and tasks for both adaptation and mitigation at the management level): how the space is used for adaptation in a way that it will not hinder mitigation (Fig. 6, example 1):

> ”…connected to urban density … when zoning and construction take place for example, as I mentioned, the planners want to use the area as efficiently as possible, and then the issues connected to street construction and public area construction, for example storm water issues, might need a different use of space. So at town planning level the compromises have to be found in the details…” (VTT Technical Research Centre, Helsinki)

<<Insert Fig. 6>>

Second, a synergy was identified in the energy sector with actions that require proactive planning (jurisdictional scale) and operational rules related to them (institutional scale). For instance, there is a possibility for the energy sector to integrate adaptation actions into their precautionary actions to protect energy supply from extreme weather events. This is a common practice of Helen Oy in Helsinki, a city-owned commercial energy provider (Fig. 7, example 1), which has been a worldwide pioneer in developing district heating and cooling (DHC) technologies (Riipinen 2013). The whole system of DHC plants in Helsinki has been built to increase energy efficiency of the city (mitigation) but at the same time assuring that this system keeps the city energy secure, which also means that the system is prepared for climate risks (adaptation, although not because of a specific adaptation objective but rather energy policy driven), such as from extreme weather events:

> "…so the difference between mitigation and adaptation is not big…we don't see a big difference and, on the other hand, there are some procedures that are linked to mitigation but are also part of environmental regulations since energy supply is a critical function and then certain precautionary provisions are in place. There needs to be a contingency plan for exceptional weather conditions, for example. So, in a way rising sea levels and precipitation and storms and preparing for these..." (Interviewee, Helen Oy, Helsinki)

<<Insert Fig. 7>>

4.3. Drivers of conflicts, synergies and trade-offs between adaptation and mitigation

Further analysis of the data allows us to examine possible explanations as to why cross-scale interactions result in conflicts or synergies, in other words, what the drivers of these interactions are. Based on our analysis, two issues emerge: first, differences in perceptions and priorities how policy implementation should take place, and second, limited institutional framework to integrate adaptation with mitigation.

4.3.1. Differences in perceptions and priorities

In Helsinki, the interview responses indicate that different goals of international climate policies, and different strategic goals of national and local governments at jurisdictional scale are particularly problematic, when considering the integration of adaptation and mitigation:

> "In a way, we are the "working horses" of the implementation of national goals and also the goals of the city. The city has its own energy goals. These are the ones we have reviewed with my colleagues. Since we are working for the city, we are bound to the goals the city is committed to. Even if we could not care less about such strategies, this does mean something in practice, indeed." (Interviewee, Public Works Department, Helsinki)

One problem is that different local jurisdictions have their own values, interests and preconceptions of what the policy priorities are (adaptation vs. mitigation), and what kinds of measures can be considered (jurisdictional scale). One example is when some authorities would like to support green solutions, such as green roofs that are beneficial for both adaptation and mitigation, whereas others do not perceive them beneficial due to concerns related to construction and maintenance of such solutions. These different perceptions "drive" a conflict on the ground, while hindering such an integrated action to be implemented, and instead, could support an alternative option to be realized, which is only beneficial for one of the two policy objectives. An interviewee from Helsinki admits that this is problematic:

> "Well, some think that green roofs are a good thing but then there are others who feel quite the opposite because the building process is so demanding… you might get water and mold damage also. So, these two schools of thought are quite far apart…" (Interviewee, Public Works Department, Helsinki)

Also in Copenhagen, possibilities to integrate adaptation and mitigation are challenging when the national government or local actors focus very narrowly on one policy only, such as in Copenhagen where disciplinary silos exist:

> ”… I think that this whole biased agenda towards the adaptation is wrong, basically, and I think the main reason is the message from the previous government, I think it was in 2007 or 2008 when they stated that we will not focus on mitigation; we will focus on adaptation.” (Interviewee, University of Copenhagen)

> ”I mean also for example climate adaptation is very much in Naturstyrelsen [Nature Agency, Ministry of Environment and Food] while mitigation is in Miljøstyrelsen [Environmental Protection Agency, Ministry of Environment and Food]. So, I mean also on top level there are big disciplinary silos going on.” (Interviewee, Aalborg University Copenhagen)

To address this challenge, the interviewees in Copenhagen stressed the importance of administrations' collaboration:

> ”And most of us are working for the same goals, but they all have different approaches. So, my approach is the quality of the urban space. My boss's focus is more on climate emissions and how we connect these two things. And Park and Nature [Technical and Environmental Administration – Parks and Nature Department], they're most connected with handling the rainwater on the surface. And the water company mostly cares about just … handling the problems with the water. So, we have common goals but all are different strategies and all have different perspectives on things. So, it's very important that we find ways to tie this together.” (Interviewee, Technical and Environmental Administration - Parks and Nature Department, Copenhagen)

> ”… at the moment what we are really, really working with is actually trying to align these different organizations, so that they can begin to co-operate. Because now they only, I mean… [have] a different understanding, different culture… So, you have to find a way of getting these systems to co-operate. Not easy.” (Interviewee, Technical and Environmental Administration - Parks and Nature Department, Copenhagen)

4.3.2. Limited institutional framework for integrated solutions

In Helsinki, the interviewees mentioned that when considering the temporal scale of investments, there are trade-offs between adaptation and mitigation, which have to be negotiated at the jurisdictional scale. In other words, the temporal scale influence appears as a timeframe of investments on the jurisdictional scale:

> ”And then we need to decide where and when these investments are made, when our investment program is so huge with all these new residential areas and public transport investment and everything and it should all be unified. This is the problem in decision-making … not all investments can be made simultaneously and then we have to … decide how to schedule it all.” (Interviewee, City Executive Group, Helsinki)

In Copenhagen, the operational rules (institutional scale) of tendering cause difficulties to find integrated solutions of mitigation and adaptation. In terms of investments, calls for tenders are sometimes considered too narrow to invest in both:

> ”…it’s very difficult to come up with an integrated solution if the tender is too narrow, and you are then competing by price”. (Interviewee, NIRAS consulting company, Copenhagen).

From the institutional point of view, the legal framework is also not considered optimal for integrated solutions in Copenhagen, and there are legislative restrictions for integration (institutional scale) that affect the *jurisdictional* setting:

> “And then you have a legal framework, which is not optimal for doing the integrated solutions… So, we see the biggest challenge at the moment is actually from the legislative point of view, that we’re not allowed to do the integrated solutions. So, it’s not as much the problem that Copenhagen municipality and the water utility companies don’t want to, but they are actually not allowed to do it unless they bend the [national and international] rules and regulations.” (Interviewee, NIRAS consulting company, Copenhagen).

5. Discussion

We use a scale framework to study adaptation and mitigation inter-relationships, in other words, to see mitigation affects adaptation and how adaptation affects mitigation in two Nordic cities, Copenhagen and Helsinki. Based on empirical analysis of these cities, we present scale interactions in two types of urban contexts: managing urban densification and energy efficiency of buildings (mitigation) and surface runoff and urban heat management (adaptation). Previous literature has discussed dichotomy between the two climate policy objectives (Goklany 2007, Biesbroek et al. 2009) but has shown little empirical evidence on the reasons for this. Inter-relationships between adaptation and mitigation are considered complex, especially due to differences in scales these policies are developed and implemented in practice (Walsh et al. 2011).

This study contributes to informing local decision-makers and planners how scale interactions influence climate policy processes in cities. In this study, we mainly focused on the public sector because its role is still very prominent and has authority and power over climate policy implementation in the Nordic countries, as our results also indicate. This is in line with the literature: steering of Nordic climate policy takes place via regulatory frameworks of the state (e.g. Juhola and Westerhoff 2011, Dannevik et al. 2012, Juhola 2013, Klein et al. 2016b), although in general, climate policy in cities is increasingly implemented also via transnational networks and multi-level governance approaches, as discussed by Bulkeley (2010).

In Copenhagen, some examples of synergies between adaptation and mitigation are related to material and energy efficiency guidelines and roadmaps that encompass both energy efficiency and flood protection guidelines for building design, and indicate that especially energy policy has potential to simultaneously support both climate objectives. A legally binding act on municipal cooling systems to prepare for urban heat island effect and to reduce the use of conventional air-conditioning in an energy efficient way is being put into practice in Copenhagen. Furthermore, innovative integrated solutions to tackle climate change are being sought with exploratory projects planned by the city administrations and collaboration between energy and water sector jurisdictions. Although local actors in cities might be innovative in thinking, as also found in the literature (Bulkeley 2010), we found that both Nordic cities still follow the rules and regulations of national governments, which to some extent limit realization of integrated solutions. We also found that national climate policy priorities (adaptation vs. mitigation) can intensify the already existing “policy” silos among the local jurisdictions. Local actors have to balance between the two policy objectives even though they might have their own values, interests and preconceptions of what policy priorities should look like for the cities' local climate policy (McEvoy et al. 2006; Bulkeley 2010).

In Helsinki, national energy policy and mitigation, driven by strict regulations for energy efficiency of building design, lead to higher priority of local administrations for mitigation measures, such as insulation, rather than adaptation measures, such as material durability improvements to protect buildings from floods. Here, operating rules for evaluation of measures would be needed to be able to integrate adaptation with mitigation. So far, the evaluation has been done on voluntary basis at the jurisdictional scale. In Copenhagen, we found two instances where adaptation measures cause conflicts with mitigation measures. Adaptation strategy can cause increased energy use, due to need to increase in the capacity of groundwater pumps to handle floodwater more efficiently by the water sector, which should also be taken into account when implementing water sector and energy policies.

The results of our study show that in particular jurisdictional-management scale, and institutional-management scale interactions can cause trade-offs and conflicts between the two climate policy objectives and hinder integration of adaptation and mitigation. This is in line with previous studies stating that scale related differences in terms of how climate policies are steered and decisions on the policy objectives are made, can be a reason for the dichotomy between adaptation and mitigation (Goklany 2007, Biesbroek et al. 2009). However, our study also indicates that possibilities to avoid this dichotomy and enhance synergies by integrating adaptation with mitigation depend on how well these scale-interactions are understood.

Further empirical evidence shows that the spatial planners in Helsinki are aware of the challenges of integrating adaptation with mitigation. This is revealed by one trade-off that we identified: the adaptation and mitigation jurisdictions have to balance between adaptation measures that require physical space, such as some surface runoff management measures, and mitigation measures for urban densification, which reduce the possibility to increase energy efficiency. Strategic urban planning solutions that can help resolve competing goals have been pointed out by in the literature but were not visible in the two cities (Hamin and Gurran 2009). Although we found more occasions where synergies can be enhanced in Copenhagen, the example from Helsinki could be a part of Copenhagen's district heating and cooling plans as well. Helsinki implements proactive actions and has operating rules in place to protect energy supply (a critical function for energy efficiency) from extreme weather events, such as sea level rise or storm surges. For example, the district heating and cooling system operated by the energy company Helen Oy, supports climate risk resilient low emission energy production (cf. Sheppard et al. 2012).

Our analysis further reveals two types of "drivers" that can explain why cross-scale interaction results sometimes in synergies and sometimes leads to trade-offs or conflicts. One driver identified in both cities is the difference in perceptions and priorities of local jurisdictions considering adaptation and mitigation goals (cf. Wang 2013) and another one is the limited institutional framework, such as powerful national climate policy objectives, to allow integrated solutions to be realized and implement them in the way local actors would like to do it (cf. McEvoy et al. 2006). More understanding of these kinds of drivers that affect the possibilities to integrate the two climate policies have been considered important (Jordan 2009). Furthermore, legislation or guidelines on how to consider both policy areas simultaneously are lacking (McEvoy et al. 2006), as also our results show. Also, our findings indicate that adaptation has received less attention and is less institutionalized than mitigation in Helsinki, where the latter is still strongly driven by international agreements and steered by national government, as also found by Juhola (2013). However, comparing this to Copenhagen, it seems that overall, adaptation is becoming the main climate change related goal due to recent flash flood events in the capital region of Denmark, although Copenhagen's zero emission goal is far more demanding than in Helsinki.

Nevertheless, common conflicts in both cities originate from differing strategic goals and priorities of the administrations between adaptation and mitigation to varying relevance of a specific policy for decision-making (Hamin and Gurran 2009), as our results show. Evaluation of the impacts of adaptation measures on greenhouse gas emissions in different urban sectors and policies, and climate change evaluation tools and innovations, reconsideration of material and energy efficiency guidelines and regulations can help to negotiate trade-offs and conflicts, and achieve synergies. This is in line with Laukkonen et al. (2009), Dymén and Langlais (2013), Gupta and Gregg (2013) and Juhola et al. (2013). We also found that it is not necessary climate change driven policy that provides the solution here. Innovations can be driven by other policy objectives than climate change, as our findings indicate. The results also help identifying policies, such as water and energy related ones, which should take more responsibility and consider inter-relationships between adaptation and mitigation, and thus, fulfill climate policy objectives and become "climate-proof" as well (Thornbush et al. 2013).

These results show that the dichotomy between adaptation and mitigation (cf. Goklany 2007, Biesbroek et al. 2009) can be at least partially explained by scale interactions. Our findings support the hypothesis that the cross-scale interactions influence the implementation of adaptation and mitigation, and affect the possibilities to integrate the two policies in both cities in many different ways. In this study, we present multiple ways how cross-scale interactions directly influence the integration of adaptation and mitigation: they hinder the possibilities for integration, force to make trade-offs between adaptation and mitigation, but sometimes also enhance the integration of adaptation and mitigation by providing synergies. Furthermore, more awareness on inter-relationships between adaptation and mitigation would be needed for actors also dealing with "non-climate" policies, such as of urban mobility policy, to share responsibility and increase collaboration. Overall, urban policy-making and planning processes need to account for the inter-relationships between adaptation and mitigation better.

Application of this scale framework improves understanding of the inter-relationships between adaptation and mitigation. The examples of synergies in several occasions presented in this study provide solid argument that integration of adaptation and mitigation could be recommended in Nordic cities. Cities need to find ways to develop urban climate policies in a time and resource efficient manner and at the same time, find urban planning practices that help tackle climate change from both adaptation and mitigation perspectives (Laukkonen et al. 2009, Walsh et al. 2011).

We found the combination of interviews and policy document analysis useful in identifying scale interactions. While, this study is limited to Copenhagen and Helsinki, we consider that the research framework could also be applied to examine a larger sample of cities. An analysis based on a larger variation of cities, could reveal more differences between cities and allow meaningful comparisons to be made between cities that are significantly different, such as comparisons between cities in developing and developed countries.

6. Conclusion

As revealed by the several examples of conflicts, our study underlines that integration of adaptation and mitigation in urban areas is challenging. But because we were also able to identify a plenty of synergies, which show that adaptation and mitigation can be addressed in an integrated manner, it can be concluded that integration does make sense – at least in the case cities Copenhagen and Helsinki. We consider it more likely that the conflicts at the local level can be avoided or diminished and synergies strengthened, if the cross-scale interactions can be identified better and therefore be better understood. In attempts to develop proactive, synergetic climate responses in an integrated manner that are at the same time cost-efficient (Giordano 2012) and politically acceptable (Viguie and Hallegatte 2012), understanding of the cross-scale interactions and background drivers of these is advantageous. Based on the findings, we conclude that an empirical examination of linkages between adaptation and mitigation through the scale framework provides new knowledge for urban climate change planning and decision-making to better understand the scales at which the two climate policies overlap, interplay and influence the decisions and practices of adaptation and mitigation. In particular, attention needs to be paid to overcome the difference in thinking about the two polices and find integrative frameworks to support their joint implementation in cities to reduce the complexity that global climate change brings about.

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Table 1. Participating organizations.

Copenhagen, Denmark	Helsinki, Finland
City administration	
Technical and Environmental Administration - Parks and Nature Department	Administration Centre
Technical and Environmental Administration - Parks and Nature Department, Skt. Kjeld's project office	Helen Oy
Technical and Environmental Administration - Centre for Urban Design	Economic and Planning Centre
Finance Administration	Building Control Department
HOFOR water utilities	City Planning Department
	Procurement Centre
	Public Works Department
	Environment Centre
	Real Estate Department, Geotechnics
Regional	
Danish Portal for Adaptation to Climate Change / Ministry of the Environment	Helsinki Region Environmental Services Authority
	River Vantaa and Helsinki region water protection association (regional NGO)
	Helsinki Regional Transport Authority
Research	
Univ. of Copenhagen - Department of Geosciences and Natural Resource Management	VTT Technical Research Centre of Finland
Aalborg University-Copenhagen - Department of Development and Planning	Aalto University
The Danish Meteorological Institute (DMI) - The Information Centre for Climate Change Adaptation	
Consulting	
NIRAS	GAIA Group

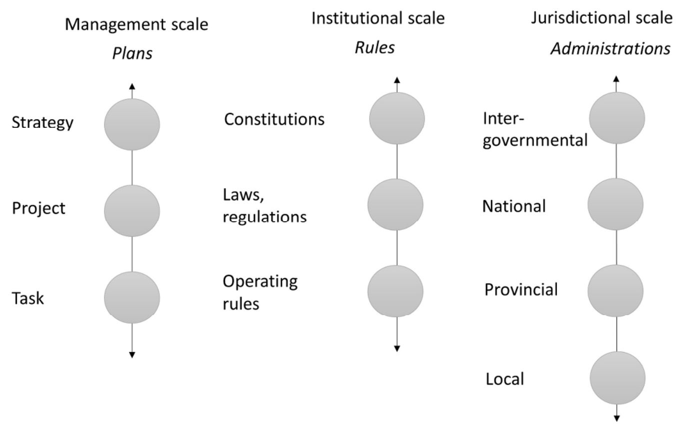

Fig. 1. Scales of social organizations, adapted from Cash et al. (2006).

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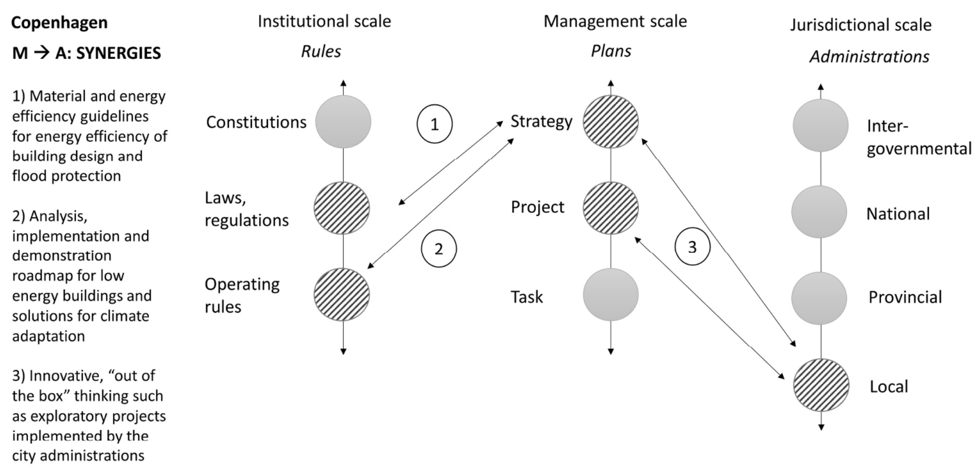

Fig. 2. Mitigation affecting adaptation: synergies in Copenhagen across scales (circles with lines inside).

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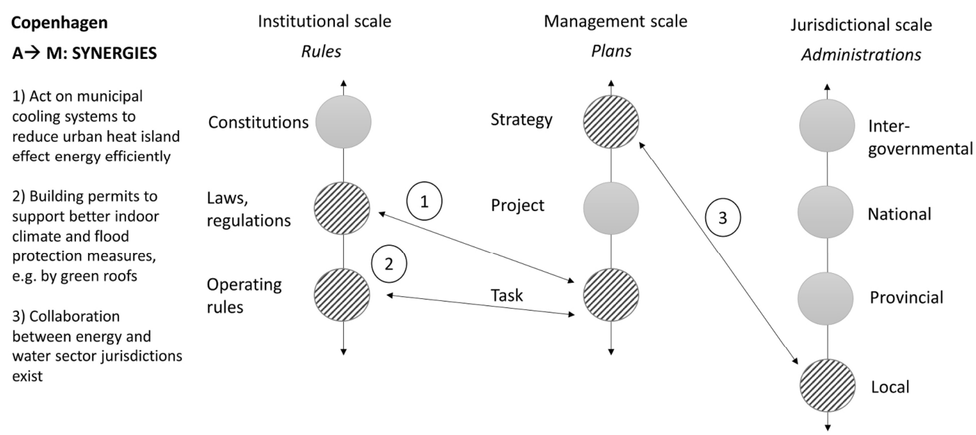

Fig. 3. Adaptation affecting mitigation: synergies in Copenhagen across scales (circles with lines inside).

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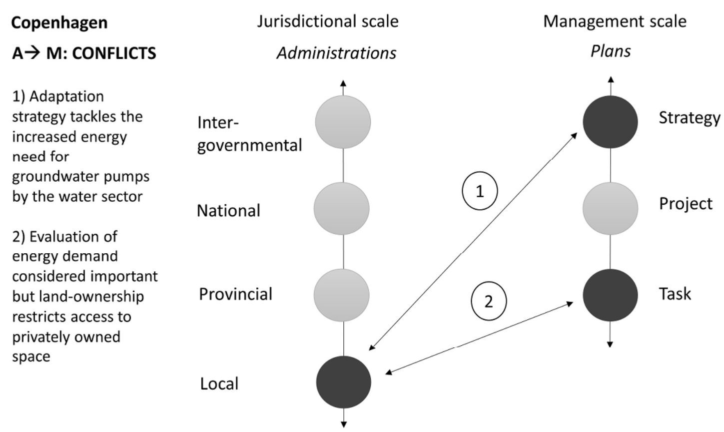

Fig. 4. Adaptation affecting mitigation: conflicts in Copenhagen across scales (black circles).

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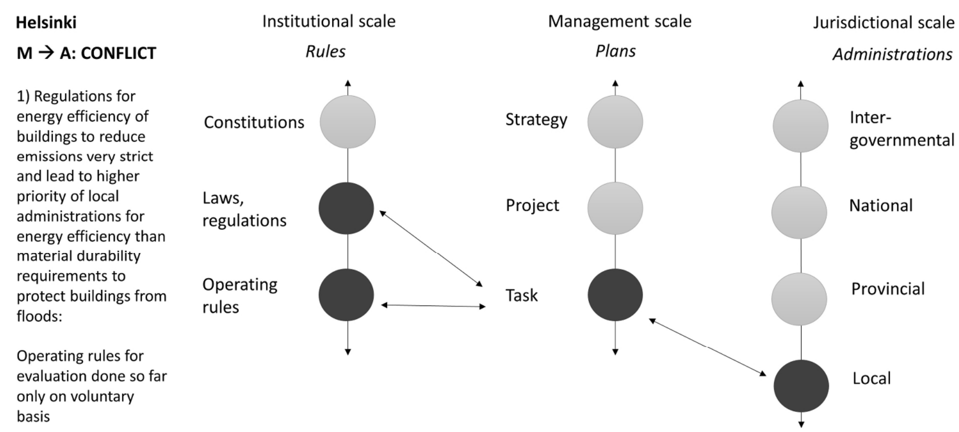

Fig. 5. Mitigation affecting adaptation: conflict in Helsinki across scales (black circles).

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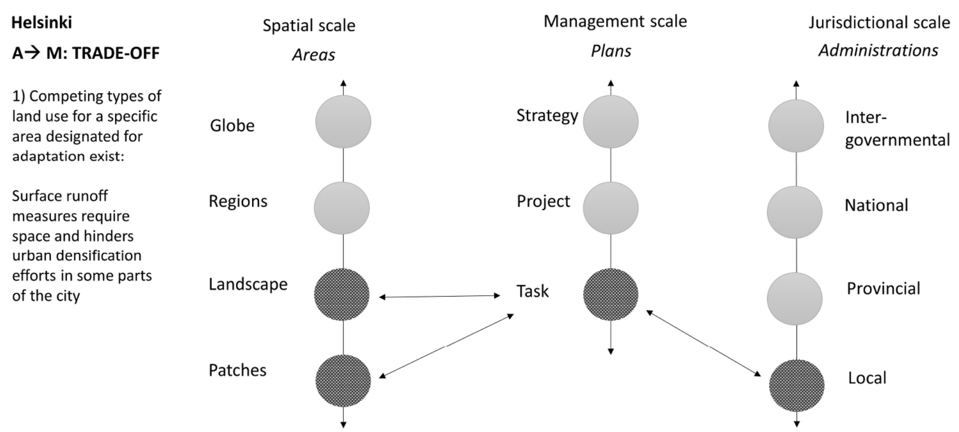

Fig. 6. Adaptation affecting mitigation: trade-off in Helsinki across scales (scattered circles).

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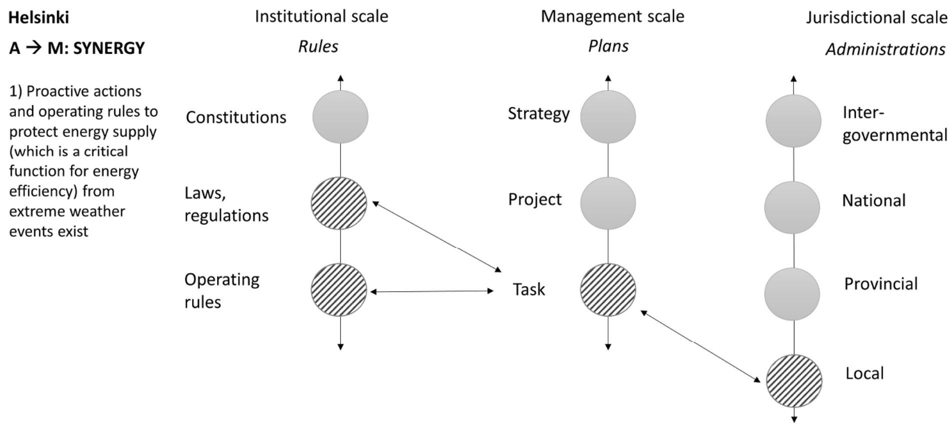

Fig. 7. Adaptation affecting mitigation: synergy in Helsinki across scales (circles with lines inside).

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Appendix 1. Examples of climate adaptation and mitigation strategies and projects selected to this study.

Copenhagen

Strategies

CPH 2025 Climate Plan. This mitigation strategy is a collection of specific goals and initiatives of four areas in the City of Copenhagen: energy consumption, energy production, green mobility, and city administration's own actions. The Plan calls for immediate action in order to become the world's first carbon neutral city. To achieve the mitigation goal Copenhagen has, among other things, made efforts to mainstream green mobility into urban planning, and improved energy efficiency of building practices. (City of Copenhagen 2012).

CPH Climate Adaptation Plan. This adaptation strategy outlines the challenges of adaptation for the city in the short, as well as medium term. By implementing adaptation measures the city wants to be prepared for storm water runoff and flash floods, sea-level rise and flooding, and assure water quality. Based on present-day knowledge, this strategy identifies options that are considered the most appropriate for adaptation in Copenhagen. (City of Copenhagen 2011).

Projects

Sankt Kjeld's district, Copenhagen. As part of the "Copenhagen Carbon Neutral by 2025" goal, the city of Copenhagen launched several climate change related initiatives, including the Copenhagen Climate Resilient Neighborhood project (The Integrated Urban Renewal in Skt. Kjeld's 2011, City of Copenhagen 2013). It consists of several urban renewal projects, including 'experimental' types of efforts to respond to climate change within the district of Sankt Kjeld's (2011-2016) such as urban greening. The district encompasses 105 ha of urban land with 24,000 inhabitants. The most important goal of this project is climate adaptation. Other goals consist of energy efficiency, green development and green growth.

Helsinki

Strategies

Helsinki Metropolitan Area Climate Strategy to the Year 2030. The aim of this mitigation strategy is to reduce greenhouse gas emissions. This should be achieved by more sustainable building and procurement, combined heat and electricity generation, defragmentation and densification of urban structure, promotion of public transport, cycling and walking, and more efficient use and reduced consumption of energy by private households. (YTV 2007).

Helsinki Metropolitan Area Climate Change Adaptation Strategy. This adaptation strategy is a regional adaptation strategy, focusing on the built environment and urban areas in the Helsinki metropolitan region that covers Helsinki, Espoo, Vantaa and Kauniainen. Among the important goals are the management of impacts of sea level rise and efficient surface runoff water management. (HSY 2012).

Projects

Kalasatama district, Helsinki. Kalasatama is an ongoing urban renewal project (2009-2030). Its aim is to transform an old harbor area into business and residential district of 175 ha for approximately 20,000 residents (http://en.uuttahelsinkia.fi/kalasatama; Helsingin kaupunkisuunnitteluviraston yleiskaavaosasto, 2007). The project contributes to mitigation via defragmentation and densification of urban structure and an energy grid that can facilitate local small-scale electricity production (http://en.uuttahelsinkia.fi/kalasatama/business; Wahlgren et al. 2007, YTV 2007) and to adaptation by lifting the ground level for infrastructure and buildings, as well as by offering an option for floating houses (Mees et al. 2014).