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Article

Planning for Climatic Extremes and Variability: A Review of Swedish Municipalities' Adaptation Responses

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Abstract: Climate change poses a serious challenge to sustainable urban development worldwide. In Sweden, climate change work at the city level emerged in 1996 and has long had a focus on mitigating greenhouse gas emissions. City planners' "adaptation turn" is recent and still ongoing. This paper presents a meta-evaluation of Swedish municipal adaptation approaches, and how they relate to institutional structures at different levels. The results show that although increasing efforts are being put into the identification of barriers to adaptation planning, in contrast, there is little assessment or systematization of the actual adaptation measures and mainstreaming strategies taken. On this basis, opportunities for advancing a more comprehensive approach to sustainable adaptation planning at both the local and institutional level are discussed.

Keywords: Sweden; adaptation; climate change; climate resilience; institutional transformation; sustainability; sustainable urban development

1. Introduction

Climate change poses a serious challenge to sustainable urban development worldwide, and Sweden is no exception. According to the Swedish Committee on Climate and Vulnerability, Sweden will face an increasing number of hazards due to changes in both climate means and variability [1]. Climate models project significant changes in (extreme and average) precipitation, windstorms and temperature, which are expected to result in an increased frequency or severity of floods, landslides,

fires, energy outages, water scarcity and diseases [1–5]. These will ultimately create unusual conditions that are outside societies' past experience. Developing ways to build resilience to such conditions is an urgent task.

In Sweden, climate change work at the city level began in 1996 in a tangible way as part of initial moves to implement Local Agenda 21 (LA21). In 1997, stimulated by the Kyoto Protocol and subsequent national grants, climate change started to become a more explicit part of municipal policies, but with a focus on mitigating greenhouse gas emissions [6]. During 2005–2006, the "adaptation turn" slowly emerged, triggered by extreme weather events and changing international perceptions [1,6–11]. Adaptation received further impetus in 2007 with the publication of a national government report on expected climate change impacts [1].

It is only in recent years, however, that Swedish municipalities have started to translate the "adaptation turn" into practice by developing actual adaptation measures and strategies. While they have the main responsibility for implementing risk reduction and adaptation actions, municipalities are faced with different conditions in terms of size, budget, staff, knowledge and past experience of hazards. Some municipalities are working to become pioneering cities in adaptation planning, others have remained inactive and have yet to make a start [12,13].

Against this background, the purpose of this study is to contribute to knowledge development and organizational learning for municipal adaptation planning. More specifically, this paper critically reviews current municipal adaptation approaches in Sweden and how they relate to past developments and institutional structures at different levels. It presents critical insights into the comprehensiveness of both the adaptation measures and mainstreaming strategies taken, and discusses opportunities for promoting a (more) comprehensive approach to adaptation planning.

The following sections describe the methodology (Section 2) and analytical framework (Section 3) on which the study is based. The results are divided into an analysis of current adaptation measures implemented "on the ground" (presented in Section 4) and of the mainstreaming strategies taken at institutional levels (Section 5). The findings are then summarized and discussed (Section 6), and conclusions are drawn regarding ways in which a more sustainable and adaptive transformation of cities can be fostered (Section 7).

2. Methodology

This study formed part of a broader research project funded by the Swedish Research Council Formas and was carried out in different methodological steps. The first step was to assess current adaptation approaches using a meta-evaluation of existing single and cross-case studies published between 2008 and 2013 [13–32]. These studies were identified through searching databases of scientific articles using the following search string: *adaptation AND (Sweden OR Swedish) AND (urban OR city OR cities OR municipa*)*. Scopus returned 48 initial hits, and Web of Knowledge 25. To make sure that the search did not miss relevant studies that did not contain the term adaptation, it was replaced by erosion, heat, heatwave, flood, sea-level rise, storm and windstorm, respectively. Irrelevant studies were then removed, while other significant studies were identified using the snowball effect (reference lists), resulting in a total of 20 scientific articles for review. The identified case studies focused on the municipalities of Arvika, Botkyrka. Danderyd, Falun, Gothenburg,

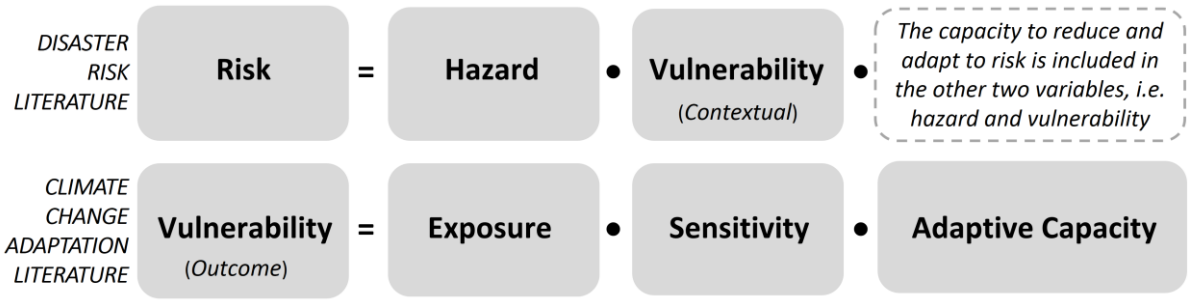
Helsingborg, Kristianstad, Lilla Edet, Lund, Malmö, Salem and Ystad, including the greater urban regions of Stockholm and Gothenburg. The reason why the analysis was limited to studies from 2008 onwards was that only then did Swedish municipalities begin putting adaptation concepts into actual practice (see Section 1). In a second step, initial outcomes were scrutinized and complemented by focus group discussions with municipal staff from nine different municipalities (Båstad, Eslöv, Helsingborg, Hässleholm, Höör, Kristianstad, Lomma, Simrishamn, Östra Göinge). These discussions were held in the context of a research circle on "planning under increased uncertainty" established by the Association of Local Authorities of the Skåne region (Kommunförbundet Skåne). Additional input from municipal staff included (i) primary data on municipalities' adaptation approaches, and (ii) relevant secondary data sources. The latter came mainly from the Web portal Klimatanpassningsportalen, which was included in the analysis of the current measures and strategies taken. In a third step, the data analysis was carried out on the basis of the analytical framework presented in the following section.

3. Analytical Framework

The escalating number of disasters worldwide is closely related to changing climatic conditions. According to disaster risk literature, disaster risk, and consequently disasters, results from an interaction between climatic and non-climatic hazards (*H*) and conditions of vulnerability (*V*) [33] (p. 9); [34] (p. 49). Climatic hazards include floods, windstorms, droughts, fires, heat and cold waves, sea-level rise (water surges) and landslides [35]. Vulnerability is the degree to which communities or societies are "susceptible to the damaging effects of a hazard" [33] (p. 30). It describes the existing conditions, characteristics and circumstances of an area exposed to one or several hazards, where a highly vulnerable area is understood as being incapable of resisting their impacts [33]. Risk is thus influenced by both climatic and societal change.

In contrast to disaster risk literature, climate change adaptation literature typically presents vulnerability as a function of exposure, sensitivity, and adaptive capacity [10,36–38], which can be likened to the understanding of risk described above. In so doing, exposure can be conceptualized in terms of hazard, while sensitivity and adaptive capacity are mainly captured by what the disaster risk literature denotes as vulnerability [39] (Figure 1).

Figure 1. Making sense of seemingly contradictory concepts used in disaster risk literature (top) and climate change adaptation literature (bottom).



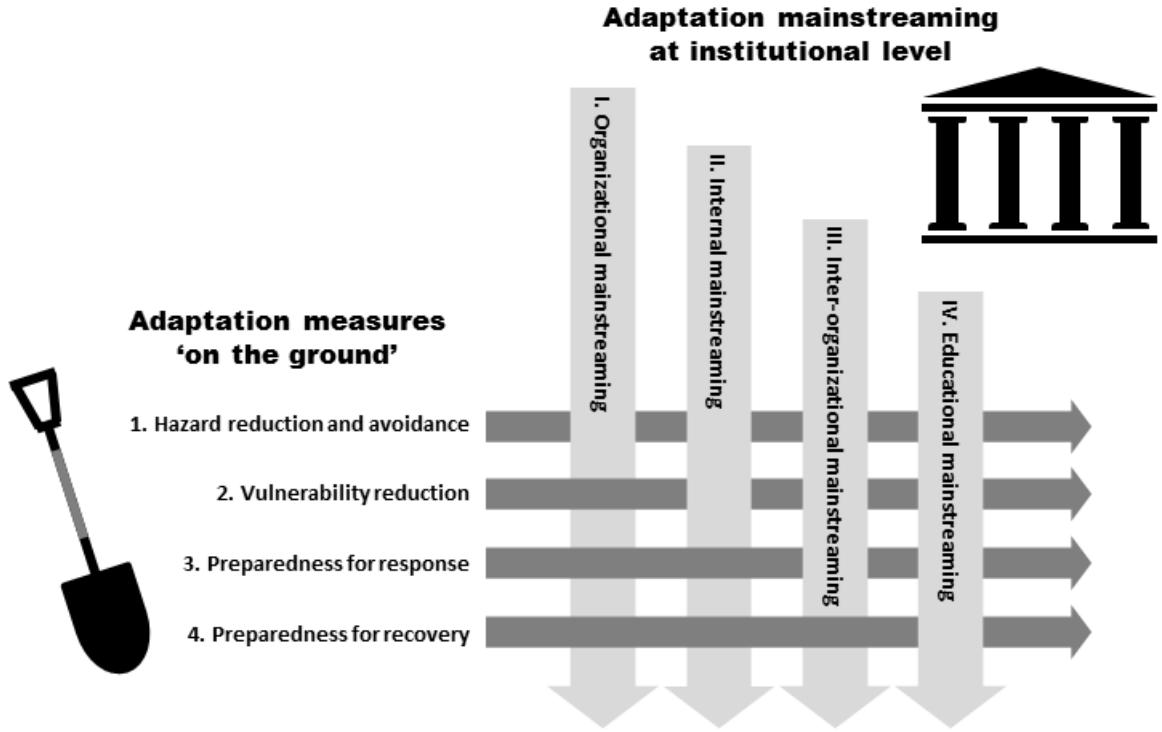
Disaster risk reduction and climate change adaptation, which have the common aim of reducing the occurrence and impacts of climate-related disasters and associated risk (arising from both climatic

extremes and variability), need to be mainstreamed into all kinds of urban sector work [10,36,40,41]. Mainstreaming refers to the incorporation of the challenges posed by climate change into the work of city authorities by formulating effective responses to it, which—to become sustainable—then need to be anchored in existing institutional structures, mechanisms and policy across sectors and levels [42–45]. The level of mainstreaming of these responses not only influences the adaptive capacity of city authorities but also whether, and what type of, adaptive "on-the-ground" measures they prioritize [42,46]. It is often said that adaptive capacity is influenced by six general aspects which can be related to mainstreaming (*i.e.*, the anchoring of adaptation at the institutional level): robust institutional setup, useful knowledge systems, functioning infrastructure, economic resources, access to technology and equity [10,38,47–49].

In the theory of institutional change developed by scholars such as Ostrom, North and Williamson [50–52], institutions are made up of the formal and informal constraints (rules and norms, respectively) that structure human interaction. On this basis, institutional change can result from change in the formal rules, the informal norms, or the enforcement of either of these [51]. Rules and norms should here be differentiated from strategies, which are the plans of actions that individuals or organizations adopt primarily for prudential reasons to achieve preferred outcomes [50]. Ostrom showed that for rule configuration and related learning to evolve towards more productive outcomes, there must be processes that lead to: (1) the generation of variety, (2) the selection of rules based on relatively accurate information about comparative performance in a particular environment, and (3) the retention of rules that perform better in regard to criteria such as efficiency, equity, accountability, and sustainability [50]. Applied to adaptation, this could for instance entail the involvement of a variety of stakeholders (including citizens) who have a voice and/or autonomy in changing rules, norms and/or adaptive behavior, which generates a diversity of approaches that need to be evaluated and communicated through multi-level collaborations.

On the basis of the theoretical understanding of disaster risk reduction and adaptation described above, an analytical and operational framework has been developed that encompasses city authorities' adaptive practice on the ground, as well as related horizontal (cross-sectoral) and vertical (cross-level) integration of adaptation at (inter-)institutional levels. More specifically, this framework allows the adaptive capacity of city authorities to be assessed through analysis of (a) their measures for (improving local capacities for) reducing and adapting to current and future risk (Figure 2, adaptation measures), and (b) the degree to which they have succeeded in mainstreaming adaptation at institutional levels (Figure 2, mainstreaming strategies). This framework was elaborated from 2006–2013 on the basis of the analysis and systematization of existing mainstreaming tools and studies, and it has been further validated in practice [42,53].

Figure 2. Analytical framework including measures and mainstreaming strategies for climate change adaptation.



Adaptive practices (to improve capacities) for reducing current and future risk include the following types of adaptation measures, which can have a physical, environmental, social and economic focus (risk assessment is an inherent part of the four measures listed [54]):

(1) Measures to reduce or avoid current and future hazard exposure (*i.e.*, hazard reduction and avoidance);
(2) Measures to reduce current and future susceptibility of the affected location so that it can withstand hazards (*i.e.*, vulnerability reduction);
(3) Measures to establish or improve mechanisms and structures for disaster response (*i.e.*, preparedness for response);
(4) Measures to establish or improve mechanisms and structures for disaster recovery (*i.e.*, preparedness for recovery) (Figure 2).

Such measures can be anchored across disciplines and scales by using a set of different mainstreaming strategies that are aimed at:

(a) Institutionalizing adaptation so that adaptation mainstreaming at program level becomes a standard procedure (*Strategy I*)
(b) Ensuring local authorities' own functioning during times of disasters and climate change (*Strategy II*);
(c) Collaborating with others to create a functioning multi-level system of urban risk governance (*Strategy III*);
(d) Promoting better science-policy integration and improved education on urban adaptation and sustainability (*Strategy IV*) (Figure 2).

In this context, both the inclusiveness and flexibility of adaptation approaches are crucial attributes in view of climate change and uncertainty. Inclusiveness relates to the use of all four types of adaptation measures (*i.e.*, hazard reduction and avoidance, vulnerability reduction, preparedness for response and preparedness for recovery; see list above) to ensure that all types of risk factors are addressed. Flexibility relates to the number and diversity of measures used in each of these four categories, and thus, to redundancy in the coping system. Simply put, the more redundant and diverse the back-up measures that a system provides for addressing a specific risk factor are, then the more flexible that system is. Flexible and inclusive systems translate into the ability to change in response to altered circumstances and to carry on functioning even when individual parts fail [42,55].

The framework described can be used for both analytical and operational purposes. It captures adaptation actions that are incremental or transformative, that is, improvements in existing risk reduction and adaptation approaches to maintain systems functions as well as the promotion of systems change for long-term sustainability [36,56]. The combination of the different aspects of the framework ultimately results in the delivery of adaptation actions on the one hand, and the building of adaptive capacity on the other [42]. Related efforts translate in urban actors that are able to create disaster-resilient and sustainable cities, which can adapt to evolving and changing risk in a flexible, dynamic and effective manner.

4. Municipal Adaptation Measures

This study shows that there is neither systematic support for, nor assessment of, the adaptation measures taken by Swedish city authorities. In the studies analyzed, "on-the-ground" measures are mentioned only randomly in order to illustrate the implications of other aspects (such as adaptation barriers and mainstreaming strategies at institutional levels). Related discourses are dominated by physically oriented measures (presented in Section 4.1), which account for around 60 per cent of the measures identified. Environmental measures are the second most frequently mentioned measures (described in Section 4.2). Hardly any social and economic measures (presented in Section 4.3) were found.

4.1. Physical Measures: Technological and Structural Approaches for Physical Vulnerability Reduction

The majority of the physical measures identified are aimed at hazard and vulnerability reduction to riverine and coastal flooding (Table 1). Many studies highlight the importance of physical measures for protecting settlements and individual homes from rising water levels (sea and lakes). Examples include the building of dams and other structures for regulating water flow, as well as the construction of walls, embankments, breakwaters, groins, harbors and other permanent structures which can interrupt water flow and limit the movement of sediment to prevent erosion and safeguard the coastline.

Other issues mentioned in relation to riverine and coastal flooding concern response preparedness, for instance regulation of building in low-lying areas in such a way that people can respond adequately during emergencies (e.g., having a second floor) [57]. Temporary embankments are also mentioned as a regular response strategy, for instance in Falun, and in Kristianstad where during the 2002 floods 50,000 truckloads of gravel had to be shuttled out to strengthen the existing embankments [57]. Climate change puts increasing pressure on existing embankments to keep water out of the city, making the inadequacy of former urban planning decisions very obvious. In the case of Kristianstad, land with a

historic tendency to flooding was drained for agricultural use and later used for settlements [25]. Today, various pump stations are installed to (continuously) pump water away [25].

Table 1. Physical adaptation measures.

Measure	Hazard	Type of measure	Sector
Breakwaters and groins to prevent erosion	Erosion	Hazard reduction	Environment and natural resource management
Building of harbors and solid constructions to protect the coastline	Erosion	Hazard reduction	Transportation/ Infrastructure
Testing the effectiveness and relevance of various technical measures for erosion	Erosion	All; Risk assessment	Environment and natural resource management
Having embankments to lakes to keep historically flooded land drained	Flood	Hazard reduction	Environment and natural resource management
Having various pump stations installed to (continuously) pump water away	Flood	Hazard reduction	Water and sanitation/infrastructure
Temporary stopping city planning in the flood-prone area until the new embankment is built	Flood; SLR	Hazard avoidance	Planning/Housing and infrastructure
Various types of water barriers/embankments	Flood; SLR	Hazard reduction	Environment and natural resource management/ Infrastructure
Water regulations and damming	Flood	Hazard reduction; Vulnerability reduction	Water and sanitation
Adapting land use	Flood	Hazard reduction; Vulnerability reduction	Planning/Housing and infrastructure
Changing regulations/recommendations for lowest level above the sea for new constructions (e.g., +3 m) (*i.e.*, not allowing construction at all under a certain ground level, or only allowing construction if the lowest floor level is above a certain margin)	Flood	Hazard avoidance; Vulnerability reduction	Planning/Housing and infrastructure
Requiring the waterproofing or elevation of critical technical supply systems on low-lying land	Flood	Vulnerability reduction	Housing and infrastructure
Inclusion of adaptation in the urban fabric (e.g., escape routes, flood proofing cellars, retention areas, adapting storm water systems and urban drainage)	Flood; SLR	Vulnerability reduction; Preparedness for response	Housing and infrastructure
Allowing waterfront homes on the condition of basements being floodable	Flood	Vulnerability reduction	Housing
Making building permits in low-lying areas conditional on structures that allow people to save themselves and others (e.g., access to a second floor)	Flood; SLR	Preparedness for response	Housing and infrastructure
Putting up temporary embankments	Flood	Response	Infrastructure

Table 1. *Cont.*

Measure	Hazard	Type of measure	Sector
Acutely strengthening embankment during critical water levels	Flood; SLR	Response	Infrastructure
Consideration of rising temperatures, microclimates, insulation, etc. when planning (the location) of new buildings/settlements	Heat	Vulnerability reduction	Housing and infrastructure
Installing air-conditioning on buses	Heat	Vulnerability reduction	Transportation
Determining the appropriateness of different locations, among other things based on existing climate risk	Multi-hazard	Risk assessment and awareness raising	Planning

Restrictions on land use to avoid or reduce potential hazards are also commonly mentioned (Table 1). The most widespread measure seen here is the establishment of a minimum height above sea level for new buildings. Pressure on municipal planning departments to allow waterfront housing and other developments is however high, from both individual citizens and politicians who want to attract high-income taxpayers, leading to continued exploration of low-lying land [57]. Only one study mentions further ways of physical adapting urban planning to climate change, namely, the construction of escape routes, flood-proofed cellars, retention areas, improved storm water systems and urban drainage [25]. As regards extreme temperatures, the only measures found were the installation of air-conditioning on city buses and considering extreme temperatures when planning new buildings (e.g., through improved insulation) [21,57] (Table 1).

4.2. Environmental Measures: Win-Win and No-Regret Measures for Ecosystem-Based Adaptation

The environmental (green and blue) measures identified are principally aimed at managing excess runoff water by (a) directly reducing it where it falls, or (b) delaying its flow to the "traditional" stormwater system (Table 2). This is done, for instance, by green roofs, bio-swales and so-called rain gardens (shallow dents with suitable plants allowing runoff from impervious areas to soak into the ground), and the use of open and local stormwater systems or porous pavements in parking areas. So called "planned flooding" is part of several municipalities' adaptation portfolio, and it is gaining weight as a complement or alternative to the traditional "hard" measures designed to protect cities from floods and sea level rise. Such planning can include the protection of areas surrounding the city, such as wetlands and floodable meadows, to which water can be diverted. In Lomma and Vellinge, the municipalities have also made agreements with nearby golf clubs to allow the golf course to be temporarily flooded to protect the city [57]. Among the secondary benefits of green and blue adaptation measures are the fact that they can reduce the urban heat island effect, support biodiversity, and provide a pleasant and healthy urban environment.

Table 2. Environmental adaptation measures.

Measure	Hazard	Type of measure	Sector
Beach nourishment (artificial sand supply) to prevent erosion	Erosion; Flood	Hazard reduction	Environment and natural resource management
Using certain types of vegetation to reduce erosion and floods	Erosion; Flood	Hazard reduction	Environment and natural resource management
Strengthening of natural coastal defenses (such as dunes or bays between headlands)	Erosion; Flood	Hazard reduction	Environment and natural resource management
Making a combined erosion control barrier and beach promenade along the coastline	Erosion; Flood	Hazard reduction (multi-purpose)	Environment and natural resource management & Infrastructure & Recreation
Measures to prevent damages from runoff water from upland neighboring municipalities with help of national grant (because neighboring municipalities did not want to contribute to the financing)	Erosion	Hazard reduction; Vulnerability reduction	Environment and natural resource management
Monitoring erosion-related changes in the coastline	Erosion	Risk assessment and awareness raising	Environment and natural resource management
Open stormwater management [a]	Flood	Vulnerability reduction	Water and sanitation
Using the principle that stormwater should be handled locally, as close as possible to where it falls (green roofs are an example of this, see below)	Flood	Vulnerability reduction	Water and sanitation
Having an agreement with owner of a golf course to allow it to be temporarily flooded in case the city is threatened	Flood	Vulnerability reduction	Environment and natural resource management
Green roofs [a]	Flood; Heat	Vulnerability reduction	Housing and infrastructure
Using bio-swales, rain-gardens, porous pavement in car parks, open water channels and ponds[a] so that stormwater is treated separately from wastewater, and in an open system	Flood; Heat	Vulnerability reduction	Water and sanitation
Use of clean stormwater in green spaces—both as blue element or for irrigation	Flood; Heat	Vulnerability reduction	Water and sanitation & Recreation
Having an existing buffer in the form of wetlands and floodable meadows surrounding the city (and giving higher importance to these) [a]	Flood; SLR	Hazard reduction	Environment and natural resource management

[a] These strategies can also be considered as physical-environmental (*i.e.*, grey and blue infrastructure).

4.3. Socio-Economic Measures

The meta-evaluation resulted in the identification of only few social- or economic-oriented measures. Most of these are aimed at preparedness for response, such as the establishment of early warning systems or emergency traffic planning (e.g., keeping cars or trains away from thoroughfares that are exposed to floods) (Table 3). The provision of risk information and public awareness raising are further measures which are commonly mentioned. These, however, are controversial as they can have moral, ethical and financial implications. Information on (changed) risk levels might, for instance, make people's houses unsellable, while insurance cover does not apply to damage that has not (yet) occurred [1]. In view of this, some municipalities also take on more passive strategies, such as consciously avoiding the provision of maps of flood-prone areas to residents, to avoid being in the position of determining what is safe and what is not [31]. An economic measure is the creation of economic (or legal) incentives for the reduction of soil sealing on private property. This is one of the few measures identified that take into account individual citizens' potential for enhancing cities' adaptive capacity [57]. This is an important aspect since people's practices can both undermine, promote, and contribute to the transformation of institutional structures for adaptation—a discussion that is further developed and systematized in Wamsler and Brink [58].

Table 3. Socio-economic adaptation measures.

Measure	Hazard	Type of measure	Sector
Establishing an early warning system for floods	Flood; SLR	Preparedness for response	Risk management
Emergency traffic planning. E.g., for stopping railway traffic on waterfront embankments at certain water levels or closing the traffic on exposed roads	Flood; SLR	Preparedness for response	Transportation and tele-communication
Consciously avoiding showing citizens maps of flood prone areas upon which local guidelines are drawn in order not to end up in the role of determining what is safe or not (to not have to take responsibility)	Flood; Multi-hazard	Passive strategy	Planning/Housing and infrastructure
Provision of risk information and discussion of related ethical, moral and financial implications	Landslide	Risk assessment, awareness raising	Planning/Housing and infrastructure
Creation of incentives (economic or legal) for the reduction of soil sealing on private estates	Flood; Heat	Vulnerability reduction	Planning/Housing and infrastructure

5. Municipal Mainstreaming Strategies

5.1. Institutionalizing Adaptation in Municipalities' Day-to-Day Operations

Most of the mainstreaming strategies identified that are used by Swedish city authorities are part of organizational mainstreaming (Section 3 and Figure 2). Examples are the creation of specialized task groups or units for climate change adaptation, a revaluation of current staff members and subsequent

changes in their responsibilities, and the wider application of existing planning tools or the adoption of new ones (Table 4). As regards the specialized task groups or units, in Ystad a specialized group was formed under the technical unit to work exclusively with erosion-related issues, with one official being responsible for practical operations and maintenance of protective measures, and two others working with strategic communication and EU projects [32]. A similar group was established for floods in Kristianstad [25]. As regards the adoption of new planning tools, methods for intersectoral risk and vulnerability assessments and forecasting are widely promoted (Table 4). In the Göta Älv region, cost–benefit analysis (CBA) has also been increasingly used to choose between potential measures (and also indicate the economic cost of *not* taking action).

To improve adaptation financing, municipalities apply increasingly for national funding to finance large-scale risk-reducing measures [14,25]. Others take out insurance to be prepared for liability claims from disaster-affected citizens [24] (this measure is, however, a grey zone and could alternatively be classified as internal mainstreaming).

Table 4. Strategies for organizational mainstreaming (Strategy I).

Strategy	Hazard	Type of measure	Focus/issue
Establishing a team of professionals at the technical unit focused on building internal capacity for erosion management	Erosion	All	Working structures
Establishing an inter-departmental "embankment group" to coordinate internal learning and improve action taking	Flood; SLR	All/Awareness raising	Working structures
Forming a specialized group for adaptation within a municipal department (e.g., for Environment and Building)	Multi-hazard	All	Working structures
Ensuring that working groups (for climate change issues) are gender-balanced, taking into account that women and men can have different approaches to the issue of climate change	Multi-hazard	All	Working structures
Clarifying roles and responsibilities for adaptation within the municipality	Multi-hazard	All	Staff responsibilities
Use of consultants to investigate local aspects and impacts of climate change on the municipality	Multi-hazard	Risk assessment	Increase of staff/Staff capacity development for adaptation
Attending seminars on adaptation (e.g., of County Administrative Board)	Multi-hazard	Awareness raising	Staff capacity development for adaptation
Using ground stability/landslide susceptibility maps, provided by the Swedish Civil Contingencies Agency (MSB), as a tool to support planning	Landslide	Hazard avoidance	Tools (RA)
Using cost benefit analysis (CBA) to decide on which adaptation measures to take	Landslide; Multi-hazard	Risk assessment	Tools
Mapping of flood risks and analyses of sea-level rise and wave range for risk assessment and planning	Floods, Erosion	Risk assessment	Tools (RA)
Using GIS-technique to store and combine data in thematic maps, e.g., geographic and geological information about documented landslides, type of landslides and information about related planning	Landslide	Risk assessment and awareness raising	Tools (RA)
Analyzing stakeholder relevance and capacities for adaptation [a]	Multi-hazard	Risk and capacity assessment	Tools (RA)

Table 4. *Cont.*

Strategy	Hazard	Type of measure	Focus/issue
Commissioning a cross-sectoral investigation of vulnerability to extreme weather events and of related adaptation costs	Multi-hazard	Risk assessment	Tools (RA)/Staff capacity development for adaptation
Making a municipal climate change adaptation plan	Multi-hazard	All	Regulations and policies
Adopting a policy for Integrated Coastal Zone Management	Erosion	All	Regulations and policies
Establishing new regulations for lowest building level and related requirements (see Table 1)	Flood	Hazard avoidance, Vulnerability reduction, Preparedness for response	Regulations and policies
Revision of building norms: Making low-water use appliances such as dual-flush toilets and low-water use dishwashers a standard	Water scarcity; Flood/ Sewage overflow	Vulnerability reduction	Regulations and policies
Municipalities taking out insurance for (against liability claims)	Multi-hazard	Preparedness for recovery	Adaptation funding
Applying for external funding (from MSB) to be able to afford planning for the "worst case scenario" in building processes (flood walls)	Flood; SLR	Hazard reduction	Adaptation funding
Applying for national grants (e.g., for supporting landslide mitigation measures)	Landslide	Hazard reduction	Adaptation funding
Choosing to work with the type of floods that occur every other year instead of planning for more severe and unusually occurring floods; which makes the work more easy to motivate politically	Flood	All	Political agenda/Awareness raising
Putting adaptation higher on the municipality's political agenda—by using past flood events to raise awareness	Flood	Recovery	Political agenda/Awareness raising
Formally assigning the issue of adaptation to the water council formed in response to the EU Water Directive (knowing that in practice such issues are not considered to be included)	Multi-hazard	Passive strategy	Working structures
Awaiting further recommendations and guidelines by national actors (and meanwhile continuing with "business as usual")	Multi-hazard	Passive strategy	Regulations and policies
Using figures (e.g., for maximum flow; lowest building level) provided by national authorities (to not have to take responsibility for, finance and/or defend own figures)	Multi-hazard	Passive strategy	Regulations and policies
Deliberately waiting with making a new master plan although there is an urgent need for an update, since this presently requires the consideration of climate change, and the municipality does not have the resources	Multi-hazard	Passive strategy	Regulations and policies/Adaptation funding
Trying to justify new developments in waterfront areas (and related high-value adding activities) with the fact that they will generate more funds for adaptation	Flood; SLR	Passive strategy	Political agenda/Adaptation funding

[a] Can also be seen as part of inter-organizational mainstreaming (Section 5.3).

Apart from the proactive strategies identified to push forward the integration of adaptation at institutional level and thereby assure adaptive and disaster-resilient developments on the ground, a

range of opposite strategies was also found (Table 4). There are cases where municipalities actively delay adaptation-related actions, deliberately waiting to see what other municipalities do and what guidelines may come from national authorities [14,31,32]. This often relates to financial constraints, or avoiding taking responsibility for adaptation and thereby not having to defend decisions that may be unpopular (or even "political suicide" [57]). Others decide to interpret figures calculated by authorities as binding, which means that the "blame" for unpopular measures can be passed on to a higher level. Another strategy is to focus on improving protection against the kind of flood that occurs every year, rather than potential future floods [32], which is likely to be easier to justify politically. Such focus on incremental improvements may, however, impede transformative changes.

5.2. Reducing Risk Faced by the Municipalities Themselves

The meta-evaluation resulted in the identification of only one strategy for internal mainstreaming (see Section 3 and Figure 2). It originates from Gothenburg, where each municipal department has mapped out how its own technical system could be impacted by flooding in the future (Table 5). This assessment was motivated by their (physical) location in a flood-prone area [24].

Table 5. Strategies for internal mainstreaming (Strategy II).

Strategy	Hazard	Type of measure	Focus/issue
Each municipal department mapping how its technical system could be impacted by flooding in the future (mapping individual objects, technical systems and specific areas with high risk of flooding)	Flood	Risk assessment and awareness raising	All/Mainly social and public services; Housing and infrastructure

5.3. Horizontal and Vertical Cooperation on Adaptation

In the context of inter-organizational mainstreaming (see Section 3 and Figure 2), the strategy most frequently mentioned is the creation of, and participation in, different networks for adaptation. The next most frequently mentioned is the establishment of cooperation with neighboring municipalities (e.g., for the management of shared rivers or water catchment areas) (Table 6). Another strategy is the active involvement of different stakeholders in the adaptation process, including the private sector and non-governmental environmental protection groups. Some municipalities have also participated in adaptation projects at EU level. Nevertheless, according to Simonsson *et al*. [59], a lack of coordination and cooperation is still one of the key obstacles to achieving effective climate adaptation in Swedish local authorities. In addition, cooperation is often limited to information transfer as opposed to engaging in two-way collaborations [22]. This is especially true for the involvement of citizens.

This meta-evaluation indicates that bottom-up knowledge transfer and participative methods are generally non-existent in municipal and regional discussions about adaptation [20,22,60,61]. Exceptions are given in Johannesson and Hahn [25] and Storbjörk [31], who do mention the involvement of citizens. In the case of Kristianstad, flood risk levels were for instance publically announced to stimulate dialogue with citizens [25] and, in the case of Falun, concerned at-risk home owners were said to be included in the risk-reducing process [31] (Table 6). *How* this was achieved is not specified.

Another strategy identified is the use of an online platform for knowledge exchange established in 2011 [62] (see Tables 6 and 7). However, the links to current measures were at the time of this study (June 2013) limited to two reports, one on erosion prevention [63] and the other on thermal comfort [64], plus a general adaptation guide from the County Administrative Boards [5], all of which were dominated by potential (and not actually implemented) measures.

Table 6. Strategies for inter-organizational mainstreaming (Strategy III).

Strategy	Hazard	Type of measure	Focus/issue
Inter-municipal cooperation in municipal river catchment groups	Flood	All	Inter-municipal cooperation
Networking and exchanging experiences with other municipalities in networks such as Erosionsskadecentrum (EC) and/or through co-arranging conferences and annual coastal meetings	Erosion; Multi-hazard	All	Networking/ Inter-municipal cooperation
Changing from keeping the municipality's high flood risk unannounced to a more open approach to allow cooperation, including publically declaring to allow open dialogue with citizens	Flood; Multi-hazard	Risk assessment and awareness raising	Risk awareness
Making a combined Sea and Climate Adaptation Plan which connects environmental regulations and adaptation plans as well as related stakeholders at different levels (from municipal to EU level)	Flood; Erosion; SLR	All	Regulations and policies
Reorganizing the inter-municipal (crisis management) structure to become more interdisciplinary (based on past crises including floods)	Multi-hazard	All	Inter-municipal working structures
Actively involving concerned stakeholders in adaptation planning such as power companies, homeowners, fishermen and actors seeking to protect the environment and various recreational interests	Flood; Multi-hazard	All	Inter-sectoral cooperation
Cooperating with neighboring municipalities in a stormwater group	Flooding	All	Inter-municipal cooperation
Using informal or professional networks for adaptation knowledge transfer, such as newsletters or gatherings for engineers working with water (e.g., for defining standards such as for dimensioning stormwater pipes)	Multi-hazard	All	Networking/Inter-sectoral cooperation
Partaking at EU level in coastal projects	Erosion; Multi-hazard	All	International cooperation
Developing regional spatial plans which can help e.g., municipalities with shared watersheds to coordinate adaptation approaches	Multi-hazard	All	Inter-municipal cooperation/Tools
Exchanging knowledge on adaptation with other municipalities, and regional and national authorities, through the online platform "Klimatanpassningsportalen"	All	All	Knowledge exchange (through Internet platform)

Table 7. Strategies for educational mainstreaming (Strategy IV).

Strategy	Hazard	Type of measure	Focus/issue
Using existing scenarios and forecasts from assessment reports, as well as reviewing more recent research, to test if security margins for vital societal establishments like bridges, tunnels, and power stations are appropriate	Flood; SLR	Risk assessment	Use of scientific knowledge for housing and infrastructure planning
Cooperating with universities to provide scientific input to municipal work, such as getting expert inventory on possible adaptation strategies, and hosting joint conferences for awareness-raising	Erosion	All	Cooperation with research institutions
Using decision tools developed by e.g., academic research programs	Multi-hazard	All	Use of scientific tools
Getting engaged in joint EU-level research projects e.g., EUROSION, SENCORE, MESSINA on coastal erosion (also as a result of a weak national concern)	Erosion	All	Taking part in joint research projects
Involving local universities in "on-the-ground" projects in the city	Multi-hazard	All	Inclusion of academics in municipal projects

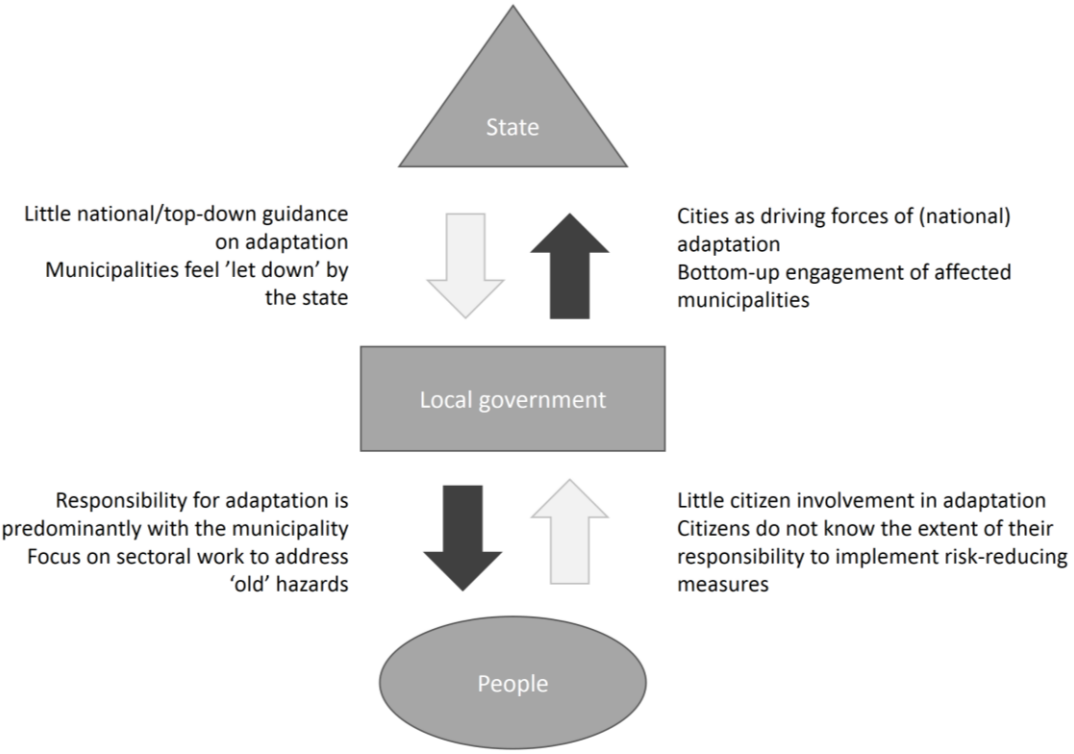
5.4. Science-Policy Integration for Adaptation

Strategies to promote better science-policy integration (cf. Section 3 and Figure 2) have mainly been identified in the context of erosion. For example, municipalities use researchers as consultants in order to keep up-to-date with relevant knowledge on adaptation. In Ystad, the close cooperation with a university professor has translated into actions such as expert inventories on possible adaptation measures, hosting joint conferences to raise awareness (at both the municipality and the university level), and getting involved in EU-level research projects [13,32]. Other municipalities use decision-support tools developed by research programs (such as Climatools at the Swedish Defense Research Agency) [65]. Another strategy is a traffic department's use of several available sources of research (e.g., IPCC reports, existing climate scenarios as well as more recent research) to determine security margins for vital societal establishments such as bridges, tunnels and power stations (identified in the context of Gothenburg [22]).

6. Discussion

This meta-evaluation was carried out to review current municipal adaptation approaches in Sweden by analyzing the discourses on both "on-the-ground" adaptation measures and the mainstreaming strategies used at institutional levels. The results (presented in Sections 4 and 5) show that there is so far no comprehensive approach to adaptation planning, either at local or institutional level. This situation was identified as being related to past developments, at national and international level, which have "formed" today's risk governance structure in Sweden. Related aspects are simplified in Figure 3 and are discussed below.

Figure 3. Interaction between adaptive approaches (or lack thereof) at different levels.



6.1. Municipalities' Responsibility for Local Adaptation

There is neither systematic support for, nor assessment of, the adaptation measures taken by city authorities. In the studies analyzed, adaptation measures are mentioned randomly and then only to illustrate the implications of other issues (such as adaptation barriers and strategies at institutional levels).

Municipalities in Sweden have been given great responsibility for adaptation, but this is typically managed in separate sectors with competing interests at stake and without inter-sectoral communication and co-learning [11,31]. This has occurred because of the lack of comprehensive adaptation mainstreaming across different sectors and levels (Section 5), which makes risk governance and adaptation planning the responsibility of a few (often technical) officials [22,32].

In the studies analyzed, discourses on adaptation "on the ground" are dominated by physically oriented measures (see Section 4.1), which reflects a biased focus on technological and structural measures. Vulnerability to climate change in Sweden thus still seems to be addressed as a technical, rather than a social issue [20,22,60]. This technical focus presents, in itself, a risk of maladaptation through, for instance, providing people with a false sense of security, leading to passivity, and trying to only "build away" floods instead of using a broader range of physical, environmental, social and economic strategies that also allow *living with* floods.

Within the physical measures identified, adaptation for reducing flood risk is predominant. This situation can be traced back to the beginning of the Swedish "adaptation turn" in 2005, when a government communication to the United Nations Framework Convention on Climate Change (UNFCCC) acknowledged the need for Sweden to engage in adaptation. This communication stated that some municipalities (e.g., Malmö, Halmstad and Gothenburg) had already started adaptation planning: by raising the minimum floor level and introducing safety margins for high-water levels, and

by reviewing the capacity of sewer systems [66] (p. 89). Until today, municipalities seem to have continued to work along these lines.

The focus on physical adaptation for reducing flood risk is further related to the fact that in Sweden (and worldwide) the reduction of risk from extreme weather events has traditionally been centered on water management [67,68]. In Sweden, "new" emerging hazards, such as heat and flash floods due to sewage overload receive less attention, although heatwaves are here much deadlier than floods [69,70].

The urban characteristic of these emerging hazards may also be a contributing factor to the comparatively little emphasis given to them, as disaster research and policy have traditionally been more focused on rural communities [59]. Furthermore, the lack of information on concrete adaptation measures relates to the fact that existing field-specific knowledge has not yet been sufficiently linked to adaptation and is consequently not easily available or intelligible to climate change practitioners and academics. For instance, architectonic or landscape features to improve outdoor thermal comfort are discussed in the literature, but these discussions do not necessarily consider *increasing* heat nor related adaptation and risk reduction in the context of climate change. Several of the adaptive measures which are (or could be) suggested in today's setting are, however, not new. Deak and Bucht [19] point for instance to the predominance of vegetated roofs in nineteenth-century Lund.

Environmental measures are the second most frequently mentioned measures (see Section 4.2). This is related to (i) the increasing trend to support ecosystem-based adaptation in Europe [71], and (ii) the growing body of research on the multiple benefits of green and blue infrastructure approaches and on the limitations of (non-)incremental physical measures [19,36]. Nevertheless, suggestions from expert committees for "working with nature" and removing settlements at risk still tend to be downplayed by politicians [13].

This situation can be related to historical gaps between the environmental and civil protection policy domains. According to Groven *et al*. [23], a fundamental conflict is apparent between the transformative agenda of environmentalists and the protective agenda of civil protection. Within the context of this study, this kind of division has also been observed within municipalities, and may be traceable all the way up to the national authority level, with organizations like the Swedish Meteorological and Hydrological Institute (SMHI) and the Swedish Civil Contingencies Agency (MSB) lacking harmonization of efforts [72]. While SMHI has been given the role of pushing forward adaptation knowledge in Sweden, MSB is the national focal point for the Hyogo Framework for Action and responsible for coordination and administration of the National Platform for Disaster Risk Reduction [73]. Such divisions at national level may rather reinforce (instead of transform) the current sectoral approach to adaptation planning at municipal level.

6.2. Cities as Driving Forces of (National) Adaptation

The situation described has led to a major call on the part of municipalities for stronger and more coordinated national engagement as well as improved guidance on adaptation planning at both the local and institutional level (see also under 6.3). The present study further suggests that of the "emerging" hazards, the ones that are (slowly) gaining more attention are those prevalent in cities that have had a strong bottom-up movement (on a national scale) and have reached a certain level of mainstreaming. For example, erosion was long seen as a localized problem of the Skåne region rather

than a national concern, to the frustration of municipal and technical staff of the region [13,57]. In Ystad, a small task group was formed under the technical unit to work on erosion-related issues (see Table 4). Their work included practical "on-the-ground" measures as well as lobbying for awareness raising, contacting politicians, cooperating with a nearby university (see Table 7), hosting conferences and networking events (see Table 6), and founding *Erosionsskadecentrum*, a cooperation body for coastal municipalities affected by erosion [13,32]. The successful combination of both adaptation measures and comprehensive adaptation mainstreaming not only made Ystad a pioneer in erosion management in Sweden, but has contributed to pushing erosion, and climate change adaptation in general, higher on the national agenda [13,72].

It is, however, evident that the forming of task groups is, on its own, not enough to ensure adaptation, let alone stimulate commitment at the regional and national levels. In one municipality in Skåne, an adaptation group was created within the department of Building and Environment. Because of unclear leadership and task specification, the meetings of this group were few and soon ceased to take place [57]. Even where groups for adaptation planning stay active, they might not have any operational power, as was found for Gothenburg's Extreme Weather Group, dedicated to proactive adaptation planning. In this case, the only operational unit managing extreme weather events was the Department for Crisis Management, which has a more reactive risk management function [22]. These examples illustrate the situation for most municipalities and the need for more top-down guidance on adaptation (see next sub-section).

6.3. (Little) National Top-Down Guidance

Sweden has no national adaptation strategy, despite its top-down management of environmental issues in general [11]. Nevertheless, the national government has certainly influenced today's risk governance structure.

In 2005, a government team was appointed to investigate impacts, vulnerability and possible ways forward for Sweden in a changing climate. This resulted in the report "Sweden facing climate change—threats and opportunities" [1], whose suggestions for improving Sweden's robustness to future climate change covered regional coordination of adaptation issues, possible funding alternatives, and extended liability for physical planning [1,11]. The predominant strategies for adaptation mainstreaming are still along those lines, focusing on improved cooperation and the integration of risk assessment into physical planning. Since the report was published in 2007, there has been no formal feedback activities from the local to central level; in fact, such feedback is not scheduled until 2015, presenting a risk of delaying the learning process on municipal adaptation and related maladaptation [28].

The report had also proposed to establish a knowledge center on climate change adaptation. In 2011, the government decided to fund such a center at SMHI. In the same year, a statute sponsored by the Swedish Civil Contingencies Agency (MSB) was enacted, requiring Swedish municipalities and county councils to perform annual risk and vulnerability assessments [74]. This relates, in turn, to policy directives at the EU level, such as the European Strategic Environmental Assessment (SEA) Directive, which legally demands climate change effects to be considered in urban developing planning [75]. This is the reason why several advances in adaptation mainstreaming relate to municipal

risk assessments. Nevertheless, current risk assessment approaches have been criticized for being treated in isolation and being too limited in focus (e.g., [60]).

The identified focus on adaptation mainstreaming is further related to the increasing recognition that adaptation in Sweden (and worldwide) needs to move from single physical interventions and technical fixes to institutional change [10,60]. Within that context, the focus on barriers to adaptation planning at the institutional level was triggered by, among others, the IPCC's Fourth Assessment Report which emphasizes that the barriers and limits to adaptation are not fully understood [10]. This has motivated a large number of studies on barriers to adaptation, both in Sweden and internationally [13,17,20,28,32].

The situation described has led to a strong call on the part of municipalities for improved top-down guidance for adaptation planning at both the local and institutional level. Pioneering municipalities and other authorities facing increasing climatic challenges feel "let-down" by the state and have instead turned to private consultants (see Table 4) as well as to research programs and networks at the EU level (see Tables 6 and 7) [13,57]. The call for more top-down guidance is also related to the fact that local governments are (increasingly) dependent on decision-making externally and at higher levels to implement adaptation, for instance, because they depend on private and/or inter-municipal water, electricity and healthcare companies (which may not have adaptation high on their agenda) to provide vital services to their citizens [17]. Municipalities that are dependent on each other for adaptation, such as those sharing a common watershed or watercourse, today often cooperate on a voluntary basis (see Table 6), but many see the need for this coordination to be institutionalized at the regional level [57].

Meanwhile, several government agencies remain passive [17,20]. The need for more guidance is also evident in related municipal approaches identified by this study: their strategies include waiting for other municipalities to act, stalling the development of new spatial plans (which require consideration of adaptation aspects), and using different ways of avoiding responsibility for established security margins and risk assessments (see Table 4).

An attempt to address municipalities' call for more top-down guidance has been made through the creation of the Web portal *Klimatanpassningsportalen*. The Web site is a tool developed by the Swedish National Knowledge Centre for Climate Change Adaptation, located at SMHI, in cooperation with Swedish municipalities, county councils and 13 governmental agencies. It provides a great opportunity to address the identified lack of systematization and assessment of current measures and strategies for adaptation and mainstreaming. This is in line with the purpose of "Klimatanpassningsportalen", which is to collect and disseminate up-to-date knowledge about vulnerability and climate change adaptation in Sweden, for instance, by "providing good examples and thereby making it easier to practice adaptation at local and regional level". However, at the time of this study, the database did not incorporate a systematic compilation of adaptation measures and strategies (although related work is currently under discussion).

6.4. (Little) Citizen Involvement

While at the national level, there seems to be a lack of top-down guidance, at the municipal level top-down approaches are prevalent (Figure 3). Discourses on participative processes and the involvement of people's local knowledge and adaptive capacities are almost non-existent. The studies

reviewed do not provide any insights into people's adaptive practice and capacities. One exception is a brief mention of "private measures" taken by worried citizens in Ystad Municipality, who piled up rocks to prevent erosion (which, however, has only created new adaptation problems by moving erosion elsewhere) [13]. Another acknowledgement of citizens' influence on adaptation appears in the future scenarios constructed by Carlsson-Kanyama *et al*. [17], where the elderly have been given a powerful voice, letting them make demands and lobby so that they are well cared for and safe during heatwaves.

The low importance given to citizens' adaptive practice and capacity also relates to a problem of scale in adaptation planning. For example, Deak and Buch [19] describe how city authorities in Lund currently equate stormwater management with large-scale operations such as the construction of large dam areas, which in addition is seen as being in conflict with the creation of recreational space. This ignores the importance of the small green urban matrix (e.g., consisting of residential gardens and public green spaces) for creating a sustainable urban drainage system [19]. In contrast to climate change adaptation, small-scale measures for climate change mitigation that can be implemented by citizens are more widely supported [76] and discussed in literature [21].

7. Conclusions

Planning for adaptation to the adverse effects of a changing climate is a vital part of sustainable urban development. Based on a meta-evaluation of recent studies on adaptation planning in Sweden and focus group discussions with municipal officials, this paper presents critical insights into how adaptation planning "on the ground" has been shaped by the deficient institutional structures developed for anchoring related knowledge and learning.

The analysis of current adaptation measures and mainstreaming strategies (presented in Sections 4 and 5) shows that, to date, there has been no comprehensive approach to adaptation planning, either at local or institutional levels:

- Focus is on the assessment of barriers for adaptation mainstreaming, but there is no assessment and systematization of the mainstreaming strategies implemented.
- The mainstreaming strategies that have been identified across the municipalities analyzed are diverse, but not comprehensive. At the level of individual municipalities they consist only of single actions. There is a focus on policy issues, horizontal and vertical cooperation, organizational learning and the integration of risk assessment into physical planning. Other aspects of adaptation mainstreaming are seldom discussed (e.g., definition of adaptation responsibilities, adaptation financing, reduction of city authorities' own risk and better science-policy integration).
- Adaptation measures that are implemented on the ground are rarely discussed, let alone their assessment and systematization. This is despite municipalities' call for more (top-down) guidance on local adaptation.
- Similarly to the mainstreaming strategies, the adaptation measures identified are varied but lack comprehensiveness. They address mainly "old" (not newly emerging) hazards, and physical or technological measures for hazard and vulnerability reduction predominate.

- Both at local and institutional levels little consideration is given to the importance of (supporting) citizens' adaptive capacities. There are hardly any tools and structures for adaptation planning that actively involve citizens.

The situation identified is related to past developments, both at national and international level, which have "formed" today's risk governance structure in Sweden. Sweden was one of the first countries to begin implementing measures and strategies for climate change mitigation in 1990 and has generally been active in international climate change politics [7]. The advances in climate change adaptation have, however, been much slower.

The success of climate change mitigation through LA21 relates to several critical points, which differ from the institutionalization process of adaptation mainstreaming. In the case of mitigation and LA21, the Swedish government (i) provided considerable funding to municipalities; (ii) facilitated the sharing of experiences among local authorities through the Ministry of Environment's LA21 coordination unit; (iii) helped local politicians in prioritizing LA21 by showing high-level commitment to local initiatives; and (iv) strongly supported feedback and iteration through formal reporting procedures from local to national level [28]. A fifth success factor, we argue, was the strong bottom-up involvement of citizens, who were incentivized early on by local and national authorities and given guidance on changing their everyday behavior. People largely became engaged in social learning about the urgency of—and approaches to—reducing greenhouse gas emissions, and were, in turn, able to set new norm standards and put pressure on other actors, for example, in the role of consumers.

The current focus on adaptation mainstreaming relates to the growing consensus that Sweden needs to shift focus from physical measures and technical fixes to institutional ones [60], which, undeniably, can be seen as a prerequisite for achieving sustainable transformation of risk governance systems. However, the importance of continued assessment and evaluation of measures on the ground should not be ignored, and needs to transcend sectoral fragmentation.

In municipalities, the selection of practical, concrete measures is often obstructed by (i) uncertainty over future climate and socio-economic conditions, and (ii) the lack of agreement (e.g., across municipal sectors) on what is the best alternative [23,60]. While these obstacles may be contributing factors to the lack of (information about) locally implemented measures, they also strongly demonstrate the importance of improved assessment and systematization of current measures and the knowledge transfer of related "lessons learned". As stated by Jonsson *et al.* [60], without holistic assessments of the long-term effects of (physical) adaptive measures, they risk both aggravating old vulnerabilities and creating new ones.

The need for improved assessment and systematization also relates to the importance of the set of concrete adaptation approaches used being *inclusive* and *flexible*. This implies that a variety of not only physical, but also environmental, social and economic measures (see Tables 1–3) need to be implemented to address all contributing risk factors (see Section 3 and Figure 2). This goes hand-in-hand with "safe failure"; that is, for adaptation systems to carry on functioning even when individual parts fail. For instance, relying solely on a high flood wall does not present a flexible adaptation approach, as it only protects the city from tidal waves, flooding or sea-level rise up to a certain level, and in the worst case, it can have a reverse effect by shutting in rainwater on the inside or creating floods in other areas. Therefore, in order to increase flexibility and inclusiveness, complementary measures need to be

added. Flood walls could, for instance, be combined with green areas which can work as a flood "buffer" (vulnerability reduction, environmental measure), adaptive behavioral change such as not furnishing cellars (vulnerability reduction, socio-physical measure), a functional early warning system for storms/high tide which give people time to evacuate or move vulnerable and valuable property (response preparedness, social measure), and insurance policies the pricing of which incentivizes home owners to take other risk-reducing measures (recovery preparedness, economic measure).

The need for improved assessment and systematization also applies to the strategies for adaptation mainstreaming. In the face of complex and uncertain predictions of climate change impacts, institutional and policy change at all levels must be able to learn from past experience. Not only is a careful pre-assessment and post-evaluation of risk reduction and adaption measures required, but also the development of indicators to monitor the effectiveness, equity, accountability and sustainability of related policies [46,50,77,78]. Current adaptation mainstreaming does not include such aspects.

In sum, the outcomes of this study stress the need for a more distributed risk governance system where top-down and bottom-up approach to adaptation planning are combined in which citizens, too, can take an active stake. This relates to all aspects, from risk assessment (e.g., combining top-down and bottom-up analysis, quantitative and qualitative datasets, and impact studies with policy and implementation analysis [60]) through to information sharing, the prioritization, implementation and monitoring of measures, and the institutionalization of adaptation planning. The latter includes aspects such as the definition of different actors' responsibilities; related working structures and processes to support continuity of the implementation processes; estimates and availability of required resources in terms of manpower, know-how and costs; the incorporation of risk reduction and adaptation into governmental and municipal budgeting; and the revision of all kinds of operational tools from risk assessment to planning and systematic monitoring and reporting. In this context, further research is needed on the measures and strategies that enable the mobilization of adaptive capacity both at municipal and individual levels. This is crucial to complement the current focus on adaptation barriers.

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Conflicts of Interest

The authors declare no conflict of interest.

References and Notes

1. Swedish Government Official Reports (SOU). *Sweden Facing Climate Change—Threats and Opportunities*; Final report from the Swedish Commission on Climate and Vulnerability. Edita Sverige AB: Stockholm, Sweden, 2007.
2. Carlsson-Kanyama, A. Värmeböljors Påverkan på Samhällets Säkerhet: En Kunskaps- och Forskningsöversikt med Fokus på Sverige och Konsekvenser utanför Hälso-området; Swedish Civil Contingency Agency: Karlstad, Sweden 2012. (In Swedish)
3. Rocklöv, J.; Hurtig, A.-K.; Forsberg, B. *Hälsopåverkan av ett Varmare Klimat—En Kunskapsöversikt*; FOI: Umeå, Sweden, 2008. (In Swedish)
4. Swedish Institute for Communicable Disease Control (SMI). Cryptosporidium i Östersund: Smittskyddsinstitutets Arbete Med Det Dricksvattenburna Utbrottet i Östersund 2010–2011; SMI: Stockholm, Sweden, 2011. (In Swedish)
5. Westlin, S.; Modigh, A.; Valen, C.; Frost, C.; Gauffin, J.; von Sydow, K.; Fröberg, L. *Klimatanpassning i Fysisk Planering—Vägledning från Länsstyrelserna*; County Administrative Boards of Sweden: Stockholm, 2012. (In Swedish)
6. Langlais, R. A climate of planning: Swedish municipal responses to climate change. In *Planning for Climate Change: Strategies for Mitigation and Adaptation for Spatial Planners*; Davoudi, S., Crawford, J., Mehmood, A., Eds.; Earthscan: London, UK, 2009.
7. Knaggård, Å. Vetenskaplig Osäkerhet i Policyprocessen: En Studie av Svensk Klimatpolitik; Lund University: Lund, Sweden, 2009. (In Swedish)
8. Pielke, R.; Prins, G.; Rayner, S.; Sarewitz, D. Climate change 2007: Lifting the taboo on adaptation. *Nature* **2007**, *445*, 597–598.
9. Stern, N. *The Economics of Climate Change*; Cambridge University Press: Cambridge, UK, 2006.
10. Parry, M., Canziani, O., Palutikof, J., van der Linden, P., Hanson, C., Eds. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK, 2007.
11. Glaas, E. Reconstructing Noah's Ark: Integration of Climate Change Adaptation into Swedish Public Policy. Ph.D Thesis, Linköping University, Linköping, Sweden, 2013.
12. Pettersson-Strömbäck, A.; Meister, K.; Mossberg Sonnek, K. *Hur Individen Uppfattar Negativa Effekter av Klimatförändringarna*; Umeå University and Swedish Defence Research Agency (FOI): Umeå, Sweden, 2012.
13. Storbjörk, S.; Hedrén, J. Institutional capacity-building for targeting sea-level rise in the climate adaptation of Swedish coastal zone management. Lessons from Coastby. *Ocean Coast. Manag.* **2011**, *54*, 265–273.
14. Andersson-Sköld, Y.; Bergman, R.; Johansson, M.; Persson, E.; Nyberg, L. Landslide risk management—A brief overview and example from Sweden of current situation and climate change. *Int. J. Disaster Risk Reduct.* **2013**, *3*, 44–61.
15. André, K.; Simonsson, L.; Swartling, Å.G.; Linnér, B.-O. Method development for identifying and analysing stakeholders in climate change adaptation processes. *J. Environ. Policy Plan.* **2012**, *14*, 243–261.

16. Baard, P.; Vredin Johansson, M.; Carlsen, H.; Edvardsson Björnberg, K. Scenarios and sustainability: Tools for alleviating the gap between municipal means and responsibilities in adaptation planning. *Local Environ.* **2012**, *17*, 641–662.
17. Carlsson-Kanyama, A.; Carlsen, H.; Dreborg, C.-H. Barriers in municipal climate change adaptation: Results from case studies using backcasting. *Future* **2013**, *49*, 9–21.
18. Juhola, S.; Peltonen, L.; Niemi, P. The ability of Nordic countries to adapt to climate change: Assessing adaptive capacity at the regional level. *Local Environ.* **2012**, *17*, 717–734.
19. Deak, J.; Bucht, E. Planning for climate change: The role of indigenous blue infrastructure, with a case study in Sweden. *Town Plan. Rev.* **2011**, *82*, 669–685.
20. Dymén, C.; Langlais, R. Adapting to climate change in Swedish planning practice. *J. Plan. Educ. Res.* **2013**, *33*, 108–119.
21. Dymén, C.; Andersson, M.; Langlais, R. Gendered dimensions of climate change response in Swedish municipalities. *Local Environ.* **2013**, *18*, 1066–1078.
22. Glaas, E.; Jonsson, A.; Hjerpe, M.; Andersson-Sköld, Y. Managing climate change vulnerabilities: Formal institutions and knowledge use as determinants of adaptive capacity at the local level in Sweden. *Local Environ.* **2010**, *15*, 525–539.
23. Groven, K.; Aall, C.; van den Berg, M.; Carlsson-Kanyama, A.; Coenen, F. Integrating climate change adaptation into civil protection: Comparative lessons from Norway, Sweden and the Netherlands. *Local Environ.* **2012**, *17*, 679–694.
24. Hjerpe, M.; Glaas, E. Evolving local climate adaptation strategies: Incorporating influences of socio–economic stress. *Mitig. Adapt. Strateg. Glob. Change* **2012**, *17*, 471–486.
25. Johannessen, Å.; Hahn, T. Social learning towards a more adaptive paradigm? Reducing flood risk in Kristianstad municipality, Sweden. *Glob. Environ. Change* **2013**, *23*, 372–381.
26. Johansson, M.; Nyberg, L.; Evers, M.; Hansson, M. Using education and social learning in capacity building—The IntECR concept. *Disaster Prev. Manag.* **2013**, *22*, 17–28.
27. Jonsson, A.C.; Hjerpe, M.; Andersson-Sköld, Y.; Glaas, E.; André, K.; Simonsson, L. Cities' capacity to manage climate vulnerability: Experiences from participatory vulnerability assessments in the lower Göta Älv Catchment, Sweden. *Local Environ.* **2012**, *17*, 735–750.
28. Nilsson, A.E.; Gerger Swartling, Å.; Eckerberg, K. Knowledge for local climate change adaptation in Sweden: Challenges of multilevel governance. *Local Environ.* **2012**, *17*, 751–767.
29. Olsson, J.; Amaguchi, H.; Alsterhag, E.; Dåverhög, M.; Adrian, P.-E.; Kawamura, A. Adaptation to climate change impacts on urban storm water: A case study in Arvika, Sweden. *Clim. Change* **2013**, *116*, 231–247.
30. Semadeni-Davies, A.; Hernebring, C.; Svensson, G.; Gustafsson, L.-G. The impacts of climate change and urbanisation on drainage in Helsingborg, Sweden: Combined sewer system. *J. Hydrol.* **2008**, *350*, 100–113.
31. Storbjörk, S. Governing climate adaptation in the local arena: Challenges of risk management and planning in Sweden. *Local Environ.* **2007**, *12*, 457–469.
32. Storbjörk, S. "It takes more to get a ship to change course": Barriers for organizational learning and local climate adaptation in Sweden. *J. Environ. Policy Plan.* **2010**, *12*, 235–254.
33. United Nations. *UNISDR Terminology on Disaster Risk Reduction*; United Nations: Geneva, Switzerland, 2009.

34. Wisner, B.; Blaikie, P.; Cannon, T.; Davis, I. *At Risk: Natural Hazards, People's Vulnerability and Disasters*; Routledge: London, UK, 2004.
35. Pachauri, R.K., Reisinger, A., Eds. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; IPCC: Geneva, Switzerland, 2007; Volume 446.
36. Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken, D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., *et al*., Eds. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX); A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK, and New York, NY, USA, 2012.
37. O'Brien, K.; Eriksen, S.; Nygaard, L.P.; Schjolden, A. Why different interpretations of vulnerability matter in climate change discourses. *Clim. Policy* **2007**, *7*, 73–88.
38. Smit, B.; Wandel, J. Adaptation, adaptive capacity and vulnerability. *Glob. Environ. Change* **2006**, *16*, 282–292.
39. The definition of vulnerability in the IPCC's Fourth Assessment Report, also applied widely in contemporary research, states that vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes [10]. Adaptive capacity is defined as "the ability or potential of a system to respond successfully to climate variability and change" [10] (p. 727). Note that in climate change adaptation literature the vulnerability concept is defined differently depending on its use (contextual or outcome vulnerability) (see [37]). In both disaster risk reduction and climate change literature vulnerability definitions are often vague and offer little concrete insight into how vulnerability should be interpreted [37].
40. United Nations. On Better Terms: A Glance at Key Climate Change and Disaster Risk Reduction Concepts; United Nations: Geneva, Switzerland, 2006.
41. United Nations. *Briefing Note 01: Climate Change and Disaster Risk Reduction*; United Nations: Geneva, Switzerland, 2008.
42. Wamsler, C. Cities, Disaster Risk and Adaptation (Routledge Critical Introductions to Urbanism and the City); Routledge: London, UK, 2014.
43. Moser, C.; Luers, A. Managing climate risks in California: The need to engage resource managers for successful adaptation to change. *Clim. Change* **2008**, *87*, 309–322.
44. Kok, M.T.J.; de Coninck, H.C. Widening the scope of policies to address climate change: Directions for mainstreaming. *Environ. Sci. Policy* **2007**, *10*, 587–599.
45. Climate Policy Integration, which is a common policymaking mechanism in the European Union, the United Nations, and also in Sweden, is often labelled "mainstreaming" [36,44]. The mainstreaming concept is, however, a more comprehensive concept (Figure 2).
46. Mickwitz, P.; Aix, F.; Beck, S.; Carss, D.; Ferrand, N.; Gorg, C.; Jensen, A.; Kivimaa, P.; Kuhlicke, C.; Kuindersma, W.; *et al*. *Climate Policy Integration, Coherence and Governance*; Partnership for European Environmental Research: Helsinki, Finland, 2009.
47. Keskitalo, E.C.H.; Dannevig, H.; Hovelsrud, G.K.; West, J.J.; Swartling, Å.G. Adaptive capacity determinants in developed states: Examples from the Nordic countries and Russia. *Reg. Environ. Change* **2011**, *11*, 579–592.

48. Engle, N.L.; Lemos, M.C. Unpacking governance: Building adaptive capacity to climate change of river basins in Brazil. *Glob. Environ. Change* **2010**, *20*, 4–13.
49. McCarthy, J., Canziani, O., Leary, N., Dokken, D., White, K., Eds. *Climate Change 2001: Impacts, Adaptation, and Vulnerability*; Cambridge University Press: Cambridge, UK, 2001.
50. Ostrom, E. *Developing a Method for Analyzing Institutional Change*; Social Science Research Network: Rochester, NY, USA, 2008.
51. North, D.C. *Understanding the Process of Economic Change*; Princeton University Press: Princeton, NJ, USA, 2010.
52. Williamson, O.E. The new institutional economics: Taking stock, looking ahead. *J. Econ. Lit.* **2000**, *38*, 595–613.
53. Wamsler, C. Operational Framework for Integrating Risk Reduction and Climate Change Adaptation into Urban Development; Brookes World Poverty Institute (BWPI): Manchester, UK, 2009.
54. Coppola, D.P. Introduction to International Disaster Management; Elsevier: London, UK, 2011.
55. Wamsler, C.; Brink, E. Moving beyond short-term coping and adaptation. *Environ. Urban.* **2014**, in press.
56. Pelling, M.; Manuel-Navarrete, D. From resilience to transformation: The adaptive cycle in two Mexican urban centers. *Ecol. Soc.* **2011**, *16*, Article 11.
57. Information obtained from municipal staff (see Section 2—Methodology).
58. Wamsler, C.; Brink, E. Interfacing citizens' and institutions' practice and responsibilities for climate change adaptation. *Urban Clim.* **2014**, in press.
59. Simonsson, L.; André, K.; Swartling, Å.G.; Wallgren, O.; Klein, R. Perceptions of risk and limits to climate change adaptation: Case studies of two Swedish urban regions. In *Climate Change Adaptation in Developed Nations: From Theory to Practice*; Ford, J., Berrang-Ford, L., Eds.; Springer: London, UK, 2011.
60. Jonsson, A.C.; Hjerpe, M.; Andersson-Sköld, Y.; Glaas, E.; André, K.; Simonsson, L. Cities' capacity to manage climate vulnerability: Experiences from participatory vulnerability assessments in the lower Göta Älv Catchment, Sweden. *Local Environ.* **2012**, *17*, 735–750.
61. Nilsson, A.E.; Gerger Swartling, Å. *Social Learning about Climate Adaptation: Global and Local Perspectives*; Stockholm Environmental Institute (SEI): Stockholm, Sweden, 2009.
62. Klimatanpassningsportalen. Available online: http://klimatanpassning.se (accessed on 14 June 2013). (In Swedish)
63. Rydell, B.; Persson, M.; Andersson, M.; Falemo, S. Hållbar Utveckling av Strandnära Områden: Planerings- och Beslutsunderlag för att Förebygga Naturolyckor i ett Förändrat klimat; Swedish Geotechnical Institute: Linköping, Sweden, 2011. (In Swedish)
64. Thorsson, S. *Stadsklimatet—Åtgärder för att Sänka Temperaturen i Bebyggda Områden*; Swedish Defence Research Agency (FOI): Stockholm, Sweden, 2012. (In Swedish)
65. Baard, P.; Vredin Johansson, M.; Carlsen, H.; Edvardsson Björnberg, K. Scenarios and sustainability: Tools for alleviating the gap between municipal means and responsibilities in adaptation planning. *Local Environ.* **2012**, *17*, 641–662.

66. Ministry of the Environment. Sweden's Fourth Communication on Climate Change under the United Nations Framework Convention on Climate Change; Ministry of the Environment: Stockholm, Sweden, 2005.
67. Easterling, W.E.; Hurd, B.; Smith, J.B. *Coping with Global Climate Change: The Role of Adaptation in the United States*; Pew Center on Global Climate Change: Arlington, VA, USA, 2004.
68. Johansson, B.; Mobjörk, M. *Climate Adaptation in Sweden: Organization and Experiences*; Swedish Defence Research Agency (FOI): Stockholm, Sweden, 2009.
69. Swedish Civil Contingencies Agency (MSB). *Översvämningar i Sverige 1901–2010*; MSB: Karlstad, Sweden, 2012. (In Swedish)
70. Forsberg, B. *Samhällets och Vårdens Möjligheter att inom Riskgrupper Förebygga Dödsfall under allt mer Extrema Värmeböljor*; Department of Public Health and Clinical Medicine, Umeå University: Umeå, Sweden, 2012. (In Swedish)
71. European Environment Agency (EEA). Urban Adaptation to Climate Change in Europe: Challenges and Opportunities for Cities together with Supportive National and European Policies; EEA: Copenhagen, Denmark, 2012.
72. Nilsson, C. Institutional, legal and financial frameworks for CCA in Sweden. Lecture for the course "MVEN18 Strategies for climate change adaptation and mitigation" at Lund University, Lund, Sweden, 13 May 2013.
73. Swedish Civil Contingencies Agency (MSB). Den Svenska plattformens organization. Available online: https://www.msb.se/sv/Forebyggande/Naturolyckor/Nationell-plattform/Organisation (accessed on 14 June 2013). (In Swedish)
74. Swedish Civil Contingencies Agency (MSB). Myndigheten för Samhällsskydd och Beredskaps Föreskrifter om Kommuners och Landstings Risk- och Sårbarhetsanalyser; MSB: Karlstad, Sweden, 2010. (In Swedish)
75. European Commission. Strategic Environmental Assessment (SEA). Available online http://ec.europa.eu/environment/eia/sea-legalcontext.htm (accessed on 14 June 2013).
76. Swedish Association of Local Authorities and Regions (SALAR). *Local Action on Climate Change—Swedish Experiences*; SALAR: Västerås, Sweden, 2009.
77. Ribeiro, M.; Losenno, C.; Dworak, T.; Massey, E.; Swart, R.; Benzie, M.; Laaser, C. *Design of Guidelines for the Elaboration of Regional Climate Change Adaptations Strategies*; Ecologic Institute: Berlin, Germany, 2009.
78. Swart, R.J.; Biesbroek, G.R.; Carter, T.R.; Cowan, C.; Henrichs, T.; Mela, H.; Morecroft, M.D.; Rey, D. *Europe Adapts to Climate Change: Comparing National Adaptation Strategies*; Helsinki, Finland, 2009; pp. 440–450.

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