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Barriers in municipal climate change adaptation: Results from case studies using backcasting

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ABSTRACT

An experimental case study approach using backcasting methodology with the involvement of stakeholders was applied to develop visions of two ideally climate-adapted Swedish municipalities 20–30 years ahead in time. The five visions created were examined as regards measures that decision makers at other levels in society need to take in order to make local adaptation possible. Dependencies on other levels in society are strong regarding supply of water and treatment of sewage, energy supply and cooling, the built environment and care for the elderly, showing the strong integration of organisations at various levels in Swedish society. Barriers to adaptation relate not only to how global companies, government agencies and regional authorities act, but also to the degree of privatisation in municipalities, where poor skills in public procurement pose a barrier to adaptation.

1. Background and aim of the study

Adaptation to climate change on the local level is a new challenge that will call for considerable efforts by many municipal authorities [1]. When planning for the next 20–30 years, measures to cope with more extreme weather events such as heatwaves, intense precipitation and rising sea levels are of special importance as regards securing provision of services such as drinking water, sanitation, energy, care and education [2]. Adaptation to climate change involves planning and crisis preparedness work and many of the issues raised by climate change demand a long-term perspective and challenge traditional values and priorities in local planning. As an example, rising sea levels challenge plans for new housing along the coast in municipalities, but for various reasons such housing is still highly valued and this generates conflicting goals and values within the domain of local decision-making, which may delay climate adaptation work. However, there are also other barriers to smooth local adaptation, e.g. lack of support in terms of financial resources, information, legislation, guidelines, etc. from decision makers in other organisations than the municipality itself [3,4]. The way in which such "external" decision makers act influences whether climate change adaptation will succeed or fail at the local level. Relevant external decision makers for local adaptation in Sweden include the authorities at the national and regional levels, private companies at the regional, national and international levels and neighbouring municipalities.

In Sweden, efforts for mitigation at the local level date back to the early 1990s, inspired by Agenda 21 [5]. However, local adaptation work is of more recent origin and can be said to begin in 2007, when the Swedish Commission on Climate and Vulnerability presented its report *Sweden facing climate change – threats and opportunities* [6]. This included a comprehensive, sectoral evaluation at the regional level of how Sweden will be affected by climate change up to 2100.

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The Commission stressed the important role of municipalities in adaptation and suggested a range of proposals that would support adaptation at all levels, such as changes in legislation, more resources for research and mapping and coordination at the national level [6]. Some of these proposals, but far from all, have been implemented [7]. An example of implementation is the increase in resources allocated to the County Administration Boards[1] in Sweden in order to support municipal adaptation work, a measure taken in 2009 [8]. Municipalities in Sweden have responded to the adaptation challenge and to a certain extent have initiated work, according to surveys from the Swedish Association of Local Authorities and Regions (SKL) [9]. Today, about 30% of Swedish municipalities are working with climate change adaptation to a large extent in comprehensive planning and about 25% include it to a large extent in their risk and vulnerability assessments. Less than 10% do not work with adaptation at all in such processes. Although most municipalities have started their work, most say they lack important inputs such as planning tools and guidelines, which the Swedish Association of Local Authorities and Regions believes to be the responsibility of central government [9]. However, in our experience there is still poor understanding of the kind of support municipalities need in order to adapt and there is perhaps too much hope vested in municipal capability, with too little understanding of the need for support from external decision makers.[2]

With the above in mind, the aim of the present study was to *investigate* barriers to successful local climate change adaptation due to lack of support from decision makers in other organisations than the municipality itself. To this end we used a methodology involving backcasting and, together with civil servants from two municipalities, developed visions of the ideally adapted local society. These visions showed what local civil servants saw as preferred solutions in order for the municipality to be fully adapted to climate change within 20–30 years. Based on these visions, on material from the discussions that followed as they were presented and on back-office work, we were able to identify a range of external decision makers upon whose input these municipalities depend for achieving their goals. The results of the study will hopefully help local decision makers to articulate what kind of support they need from e.g. national and regional governmental agencies, and to develop strategies for negotiating with neighbouring municipalities or private actors at the local level. Although the results cannot be generalised to all municipalities, they may still raise the level of awareness of local needs at Governmental Agencies with a stake in climate change adaptation.

The paper is organised as follows. Section 2 provides an overview of the backcasting methodology and describes the extent to which it has been used for studying climate-related issues and/or with involvement of stakeholders. Section 3 describes the methods and materials used when working with the municipalities and section 4 provides a summary of the five visions and an analysis of barriers for adaptation related to inaction by external decision makers. The findings are discussed in Section 5.

2. The use of backcasting in climate change research

Backcasting is an approach to futures studies [10–13] especially designed for planning situations where existing trends or strong inertia seem to preclude the attainment of important societal goals or the resolution of a growing societal problem, such as environmental degradation or the potentially negative impacts of climate change. The methodology emerged in the 1970s in the area of energy conservation after the oil crisis [14–16]. The idea is to start by looking some 20 years or more into the future and trying to envisage a society where radical goals are realised or a pervasive problem is solved, or at least dealt with in an efficient way. Then one or several paths may be sought that link the present state to the future vision(s) in terms of policy measures. The aim of this approach is not to suggest a rigid 20-year plan, but to widen the conception of what is possible to achieve in the long-term as an input to planning and discussions in society. It may suggest new perspectives on a problem where we seem to be entrenched by the present framing of the problem. In recent years a version of backcasting presented under the label of participative backcasting has gained ground [10,17–19]. Here he involvement of stakeholders in the process of scenario development is a key feature. Examples of how stakeholders are defined varies but generally the term means ‘‘persons, groups or organisations that must somehow be taken into account by leaders, managers and front line groups’’ [75,22] and several studies have shown that lack of considerations for key stakeholders can explain failures in implementing decisions [76,77] With time various methodologies for stakeholder analysis have evolved [78] as well as various definitions of stakeholder types [79].

Forerunners to backcasting with stakeholders were Elise Boulding and Warren Ziegler [20, pp. 93–116], who in the early 1980s developed visions of a future without weapons with participants from the peace movement. In contrast to other influential futures studies approaches, e.g. the intuitive logics approach [21–24] and predictive approaches, backcasting is explicitly normative with its focus on desirable futures rather than likely or possible futures.

Typical areas where backcasting is applied today are sustainable development in general [19] or within sectors such as transport [25–27] or urban development [28,29]. Sustainable energy use is also a frequent area of application [30–32]. Backcasting has also been applied in the area of climate change, a prominent example being the IPCC report *Climate Change* 2001*: Mitigation* [33]. The mitigation scenarios add mitigating measures to the emissions scenarios compiled by IPCC [34],

[1] The County Administration Board is the representative of the Government in the region and the co-ordinating body for state activities in the region.

[2] This conclusion was derived from developing adaptation tools in a five-year research programme called Climatools. The tools were developed in collaboration with stakeholders from a number of municipalities.

which are based on the storylines A1, A2, B1 and B2. These measures are chosen and dimensioned in such a way that desirable climate goals are reached by the end of 2100. A number of scientific papers describe backcasting applied to the problem of climate change mitigation, often focusing on a decrease in carbon dioxide emissions from a specific sector [27,30,35–37]. Åkerman & Höjer [38] attempt to show what it would take to achieve a transport system in Sweden that is compatible with no more than a 2° increase in global average temperature by the year 2100.

In a literature survey of backcasting and climate change in scientific papers published in peer-reviewed journals, we could only find one clear case where backcasting was used to analyse *adaptation* to climate change. Van der Voorn et al. [39] propose a methodology for how backcasting in combination with adaptive management could be used for implementing adaptation strategies and policies, with an example from South Africa.

3. Methods and materials

3.1. Methodological approach

The rationale for using *backcasting* in the present study is that according to experience (see Section 1), present trends as regards adaptation to climate change in Sweden will not lead to the attainment of society's goal of well-adapted municipalities. Backcasting can be useful to help planners free their mind of present entrenchments in order to find novel solutions for the long term and thus to overcome factors such as goal conflicts, lack of resources, uncertainty and preoccupation with short-term problems.

In this study we took the perspective of the local administration in charge of climate change adaptation planning and used a *participative approach* [18], which meant that we involved stakeholders such as civil servants from municipalities in the envisioning. The rationale for this is that without such involvement the visions created and the work that followed involving identification of stakeholders such as decision makers outside the municipality upon which the municipality depend for successful adaptation, would not be credible. By identifying these key external stakeholders (decision makers outside the municipality) we made a prospective kind of stakeholder analysis [78].

A *case study*, as it is normally conceived, is carried out by researchers who study a group of people (the practitioners) involved in an ongoing or historical activity or process (see Yin [40]). The focus of interest (or unit of analysis) could be the process, the actors or the final result of the process. The researchers do not set up or interfere in the process and try to disturb it as little as possible while making observations and gathering data. It is not possible to generalise from the results, but it may be possible to generate hypotheses. In a *field experiment*, the framing of a process is designed by the researchers in order to make some aspects of the behaviour of participants explicit. Normally the experiment can be repeated with others. A sequence of repeated experiments may allow conclusions of a general character. The present study focuses on two instances of municipal visioning, which makes it similar to a case study. However, the visioning process was designed by the research team in order to shed light on an issue which was also specified by the research team, which makes the approach a form of experiment. Hence the present study can be labelled an *experimental case study*, which means we designed an artificial process for municipal civil servants.

3.2. Selection of municipalities

In total Sweden has 290 municipalities, with the number of inhabitants ranging from 2500 to more than 800,000. The municipalities are responsible for providing a significant proportion of all public services, e.g. basic schooling, childcare amenities, care services for the elderly and recreational and cultural activities. In addition, they are responsible for planning for the built environment and for a variety of technical systems, e.g. freshwater supply and sewerage, and refuse disposal. The municipalities of Sweden have the right to levy taxes.

For the present experimental case study we selected two municipalities in the greater Stockholm area: Salem and Danderyd. The criteria for selection were that both municipalities should be facing challenges in connection with climate change and that the two municipalities should be characterised by different socio-economic conditions, as this could result in differences in the capability to adapt and in the kind of solutions preferred. The reason for participation on the part of both municipalities was that they felt they were behind in their adaptation work and wanted to advance that process.

Regarding challenges, Salem, with 15,000 inhabitants and located south-west of Stockholm, borders Lake Mälaren and several smaller lakes and streams are located within the municipality, thus making flooding risks a priority. In contrast, Danderyd, with 31,000 inhabitants and located north of Stockholm, has a long coastline along the Baltic sea but few lakes and streams, and here sea level rise is a major concern. Concerning vulnerability to heatwaves, no apparent difference was anticipated. Regarding socio-economic conditions, there are some differences between the municipalities. Danderyd has the most high-earning and well-educated population in Sweden, while incomes and education levels in Salem are closer to the Swedish average. In Danderyd, the largest conservative party in Sweden (*Moderaterna*) holds approximately 40% of the seats in the local authority and has had an outright majority for many years, and the municipality has a lower taxation rate than Salem, which is run by a coalition of liberal and conservative parties. Another important difference is that Danderyd is an integral part of the urban area of greater Stockholm, while Salem is situated on the periphery.

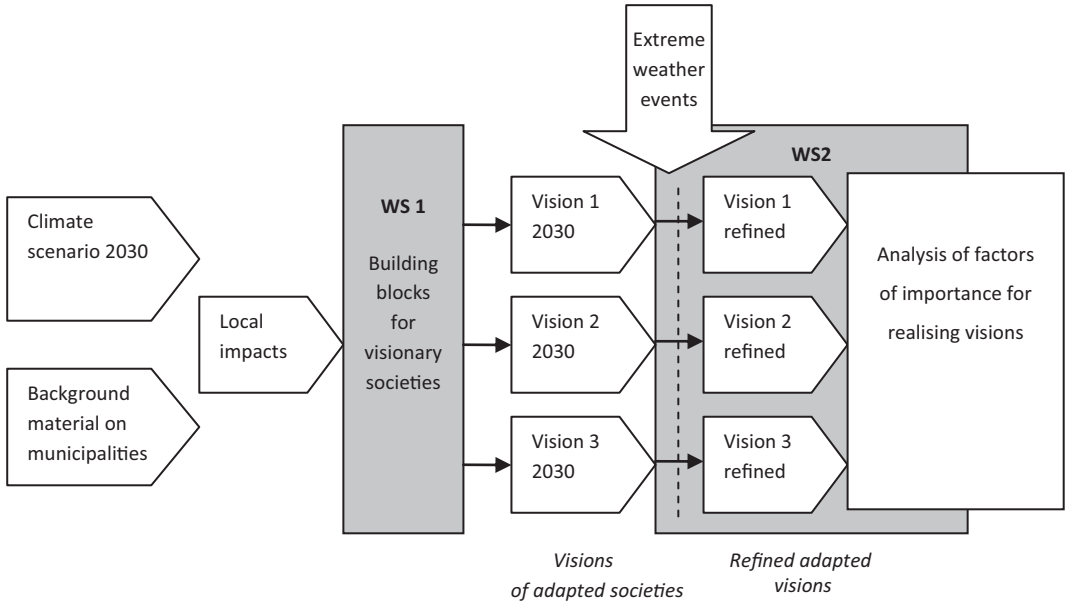

Fig. 1. Flowchart showing the participatory working process used when creating visions of ideally adapted municipalities.

3.3. The participatory working process

The intention was to use the same participatory working process in both municipalities (Fig. 1). However, the whole process was completed in one municipality before starting in the other municipality and some minor adjustments were made in the second round. This is further discussed below.

3.3.1. A climate scenario for 2030 and estimation of impacts

Due to the considerable inertia of the climate system, the uncertainty with regard to anthropogenic climate change is relatively small in the short-term perspective [41]. Hence for shorter time scales such as the coming decade or so, the climate outcome is insensitive to the choice of emissions scenario [34], and it suffices to consider climate projections contingent on one emissions scenario. The climate scenario for 2030 was based on climate modelling by the Swedish Meteorological and Hydrological Institute (SMHI) [42]. SMHI uses two emissions scenarios, A2 and B2, but for reasons discussed above we did not need to consider differences between these two scenarios for the shorter time-scale. In brief, the future climate in the Stockholm region is projected to be warmer. The mean temperature during spring and winter is projected to be 2.5 °C above the average in the reference period (1961–1990). Compared with the reference period, the number of months with average temperature below zero will decrease from four to two. The increase in mean temperature during the summer will be somewhat lower, but the number of very hot days will increase. Precipitation is projected to increase during winter (by approx. +20%), while it decrease in summer (by approx. −10%). According to current climate models, average sea level rise will not be an issue in the Stockholm region up to 2030 due to post-glacial land rebound, but will be of concern later on. In order to describe possible sea level rise up to 2100, we presented scenarios that ranged from below 1 m up to 2 m of average rise [43,44].

Background material such as comprehensive plans, risk and vulnerability analyses and documents with local visions were studied in order to roughly assess possible local impacts of a changing climate. This analysis was carried out as desk-based research. For each municipality, the most relevant impacts from climate change were then identified within three categories: human health, built environment and tourism including leisure time.

3.3.2. First workshop: generating building blocks for visionary societies

The purpose of the first workshop was to generate ideas – building blocks – for the construction of visions of future well-adapted local societies. This exercise was performed as a structured brainstorming facilitated by the research team. The participants included personnel from different municipal departments, primarily from social services, city planning, health and environment and crisis management. After presenting the material about projected climate change and possible impacts, the participants were asked the following focal question:

> What will our municipality look like in the year 2030, when the climate and the society have changed, but the services for residents are equally good/better than today?

Each participant came up with proposals that were not criticised at this stage. After the proposals had been clustered, the participants assigned votes to the different clusters of proposals (=variables) according to the criterion: How important is the variable for the focal question? The variables were prioritised according to the results of the voting.

3.3.3. Constructing visionary societies and extreme weather events

With the results from the first workshop, the research team constructed three visions of an adapted future society for Danderyd and Salem, respectively. As a first step in the construction of visionary societies, each of the prioritised variables was assigned between two and three states describing possible future outcomes of that variable. In this terminology, a vision is a set where each variable has been assigned one and only one state. In the back-office work, numerous combinations of states, i.e. different visions, were assessed with regard to plausibility and relevance. For each vision a narrative storyline was developed and distributed to the workshop participants before the second workshop. The storylines contained a description of the ideally adapted local societies in 2030, structured under different headings such as built environment, water and sanitation, transportation and care. A more thorough description of the methodology for constructing visions of the future is provided in Baard et al. [45] and [46].

Before the second workshop, two extreme weather events were also constructed in order to be used as inspiration in the second workshop (see below). The same heatwave was used in both Danderyd and Salem, as vulnerability to such events was considered equal, while two different extremes were constructed for inundation due to differences in local conditions, e.g. proximity to the Baltic Sea (Danderyd) or major freshwater lakes (Salem). In order to model a heatwave over the Stockholm region, we constructed a meteorological replicate of the European heatwave in 2003 [47,48]. Daily minimum and maximum temperatures and the corresponding standard deviations for 15 consecutive days in Paris during the 2003 heatwave were used in the model. The standard deviations were transferred to Stockholm: if for example the minimum temperature in Paris on 2 August was 3 standard deviations above the average, then the minimum temperature in Stockholm on 2 August was set at 3 standard deviations above the average for Stockholm during the period 1961–1990. During the modelled heatwave, the daily minimum temperature peaked close to 21 °C and the daily maximum temperature reached more than 37 °C. For this heatwave, we calculated the expected excess heat-related mortality for greater Stockholm in the year 2030 using a method where regression models were fitted to mortality and temperature data from Stockholm from the period 1998–2003, controlling for influenza, season, time trends, week day, and holidays [49]. The number of excess heat-related deaths was calculated to be approximately 150, of which two-thirds were among the elderly, aged 80 years or older. An excess mortality of 150 might seem relatively modest compared with that experienced in Europe in August 2003. However, compared with other weather-related deaths in the Scandinavian region, this is a large number and suggests that heat-related mortality should be considered seriously. This will be further exacerbated by demographic changes leading to a larger proportion of elderly people in the population.

The other weather event, which was a winter storm and very deep low pressure, was based on a historical case in Stockholm 1983 that contained a very large increase in sea level in Stockholm and considerable quantities of rain. The weather event developed for the case studies was made in two variants, each with a different focus. In the case of Danderyd, with its long coastline, the sea level rise was emphasised. In the case of Salem, the sea level was not an issue because Salem is not situated at the coast and instead the focus was on the large quantities of rain.

3.3.4. Second Workshop: refining and realising visions

The second workshop had two objectives. The first of these was to refine the proposed visions constructed based on the results from the first workshop. The second objective was to use the visions as a means of investigating barriers to successful local climate change adaptation and identifying what actors outside the municipalities need to do in order to become adapted as in the visions. During the first part of the second workshop, the two extreme weather events (see above) were introduced, after which the participants complemented the visions with more 'elements' of adaptation. In Salem all three visions were used in the analysis. In Danderyd, however, the participants rejected one vision as implausible because of the local political culture, with its reluctance to expand the municipal administration.

4. Local visions of climate-adapted societies and barriers to adaptation due to inaction by external decision makers

4.1. Local visions of climate-adapted municipalities

A summary of the local visions of climate-adapted societies is given here, while full descriptions of the visions were 2–3 pages long. An important difference between the municipalities was that Salem was open to rather large changes in land use patterns, while Danderyd was strongly opposed to exploitation of current green areas. Otherwise, there were a lot of similarities, such as the challenge of caring for increasing numbers of elderly people and being an attractive location for white-collar business enterprises.

4.1.1. Salem Vision 1: sustainable transformation of Hallsta area in 2030

The formerly forested area called Hallsta is now built up, with a mixture of multi-storey houses, detached houses and a science park, which makes it attractive and popular. That area is well-adapted to a warmer climate with numerous shaded areas and many public and private buildings in the rest of the municipality are now connected to a district cooling network, using water from one of the lakes. An artificial lake has been constructed and is cleansed biologically. This lake is popular among the inhabitants as other lakes in the vicinity are becoming increasingly polluted due to climate change and increased runoff of nutrients. Local stormwater disposal is very common and sewage water treatment as well as freshwater supply and electricity are taken care of in a satisfactory manner. There is a strong belief in the capacities of individuals to care for

themselves – it is common for elderly people to have insurance that give extra care during heatwaves for example. The expectations for climate change are moderate, meaning that emissions appear to be under control but there is still a worry about the unexpected, such as rapid ice sheet melt in Greenland or Antarctica.

4.1.2. Salem Vision 2. Denser centre and well-developed recreation areas in 2030

The centre called Salem now has several high-rise buildings and a denser structure than in 2012 and the green areas in the municipalities are untouched and preserved for recreation. Salem centre is protected from inundation through a well-developed system for local stormwater disposal and the centre is livelier than in 2012, with more business and cafes where people can meet. In fact, in all the municipality, systems for local stormwater disposal are very common and there are strong local restrictions on paving surfaces in a way that inhibits infiltration. Some newly built houses are constructed without a cellar. The water quality in streams and lakes has been improved as more dwellings are now connected to the sewage system, which is running smoothly. All green areas that were protected in 2012 due to their proximity to Lake Mälaren, which supplies drinking water, are still protected and freshwater supply is taken care of in a satisfactory manner. There is district cooling in many parts of Salem centre and in homes for the elderly. For those elderly people who do not have district cooling or air conditioning, there is a system whereby they get more frequent visits from carers during heatwaves. There is optimism about the future, as emissions of greenhouse gases are lower than in many years.

4.1.3. Salem Vision 3. Population increase and waterfront living in Högantorp in 2030

The formerly protected area of Högantorp, located close to Lake Mälaren, is now developed, with numerous dwellings of different character and size. It has now become clear that other sources of freshwater than Lake Mälaren have to be sought and there is an expectation that this will be taken care of in a smooth way. In the newly built-up area of Högantorp, there is a system for district cooling using the lake water, and the wind from the lake further cools this area during hot days. Many people who live in Högantorp are elderly, with a good pension, and they demand high comfort, which they can get in this more or less gated community. Some dwellings have green roofs to protect from heat and in this area systems for taking care of stormwater locally are well developed, so that no uncleansed water pollutes Lake Mälaren, where newly constructed beaches draw crowds during hot days. In the rest of the municipality development has been moderate, but in all new buildings district cooling is the norm and local stormwater is no longer disposed of in the sewage treatment facility. Elderly care is privatised and the older generation is now very demanding, requiring comfort even during heatwaves. As a result, they constitute an important lobbying group in the municipality and the mortality during heatwaves is low. Climate change is expected to go on, but there is a strong anticipation that challenges can be dealt with successfully and the opportunities will be exploited.

4.1.4. Danderyd Vision A. Command over climate change adaptation in 2030

The municipality is now very active in climate change adaptation and carries out its tasks both through its own administration and as a procurement body. The character of the municipality as a garden city has been maintained and numerous white-collar job opportunities and new multi-storey houses are available in the centre. There is an action plan for climate change adaptation in the region, which is translated into a local plan in each municipality, of which Danderyd is one. Along the coast to the Baltic Sea, the municipality has experienced flooding at times and there are plans to deal with this, such as building a barrier along the coastline to protect buildings, roads and walking trails. Many buildings now have access to district cooling and estate owners sometimes install their own bedrock heat pump that can cool the house in the summers. Stormwater is taken care of locally, as it is no longer allowed to be disposed of through the sewage plant, which functions well. Ditches for stormwater have been constructed and some land has been reserved for infiltration, resulting in better water quality in the numerous bays used for swimming along the coast. Green roofs are encouraged on new buildings by the municipality, which also tries to influence electricity grid companies to consider the risks of sea level intrusion when installing new cables and stations. There is an anticipation of considerable upcoming impacts of climate change, not least when it comes to sea level rise, but also a recognition that the change can be dealt with.

4.1.5. Danderyd Vision B. The unique approach

The municipality carries out its tasks in climate change adaptation mainly as a procurement body and strongly encourages private solutions for coping with issues such as inundation and heatwaves. The character of the municipality as a garden city has been maintained and white-collar job opportunities and some new multi-storey houses are available in the centre, but much of the population comprises elderly and well-off people who appreciate recreation and have high demands for safety and comfort. The municipality has helped neighbourhoods in constructing local cooling networks, as well as in taking care of stormwater locally. Some inhabitants rent their land to their neighbours for infiltration of stormwater, while freshwater and electricity supply and sewage water treatment are still issues for public bodies. There is a heatwave plan in the municipality, with alerts when certain thresholds are crossed and when commissioning home help for the elderly there are demands for more frequent visits during heatwaves, as well as for certain temperatures to not be exceeded in care homes. Information is given to property owners about the coming sea level rise and the municipality facilitates negotiations with insurance companies and other partners for financing e.g. barriers along the sea. A ski tunnel has been constructed by private enterprise to allow the inhabitants to ski even during snow-free winters. The anticipation is that climate change impacts will be considerable but manageable, and that studying successful adaptation in other parts of the world will be a good help to Danderyd.

4.2. Barriers for adaptation due to lack of support from external decision makers

Many barriers for realising the visions of the climate-adapted local communities due to lack of support from external decision makers were identified during the second workshop and through back-office work. The presentation below is structured thematically with examples from the visions in order to highlight the material used for the analysis. The themes that emerged in the two municipalities were very much the same and included: Supply of drinking water, sewage treatment and stormwater disposal; energy supply including cooling; protection of the built environment; and care of the elderly. Quotes from the visions are given in italics.

4.2.1. Supply of drinking water, sewage treatment and stormwater disposal

Concerning supply of drinking water and sewage water treatment, it was apparent in all the visions that the outcome of ongoing regional cooperation is decisive for successful local adaptation. Neither of the two municipalities is directly responsible for its own supply of drinking water, which is handled through the regionally based Stockholm Water Company, a municipally owned body that distributes water to 1 million people [50]. From this company, both municipalities receive drinking water originating from Lake Mälaren, but this lake will eventually have to be abandoned as a source of freshwater supply as the sea level rises and salt water intrudes [50]. One of the alternatives discussed is using new sources of freshwater that would entail building pipelines of 150–200 km, but no decisions have been taken so far, or raising the level of the lake, thus inundating large areas [51]. Continued inaction from the Stockholm Water Company is a barrier to adapting the freshwater supply in both municipalities. Regarding sewage water treatment, both municipalities are connected to a regional sewage water treatment plant, with the municipalities as co-owners. Both these plants are located by the Baltic Sea, thus making them vulnerable to rising sea levels. It was evident during the workshops that the municipalities trust that the regional companies supplying water and dealing with sewage water treatment have sufficient expertise and foresight to adapt to climate change. However, our contacts with the two companies treating sewage water revealed that their adaptation planning is still in its infancy, yet another barrier to successful adaptation in the municipalities.[3]

Stormwater disposal is perceived as an issue which the municipalities can influence, and the issue is high on the agenda, as sewage treatment plants are increasingly refusing stormwater at their facilities for fear of overflow during intense precipitation. In both municipalities, all the visions contained different solutions for local stormwater disposal, focusing on attractive and innovative solutions would that enhance the beauty of the built environment, while maintaining the recreational opportunities by safeguarding water quality:

> *Today there are no combined sewage systems in Danderyd and in order to maintain good water quality in the many bays where people swim. The municipality has demanded that all real estate owners ensure that stormwater is infiltrated and not discharged without cleaning (Danderyd, Image B).*

> *In the area of Högantorp there are many picturesque facilities that dispose of stormwater in open systems in an artful way, for example water staircases. The stormwater is also used in public facilities for cleaning, cooling and sewage transport (Salem, Image 3).*

A factor that inhibits successful implementation of local stormwater disposal relates to the capabilities of the municipalities to include demands for this when issuing building permits and to impose sanctions on real estate owners that do not comply. According the Swedish National Board of Housing, Building and Planning, a government agency, the current legislation offers opportunities for municipalities to include such demands [52], but in practice this is not carried out, as knowledge about the techniques for local stormwater disposal and about how to implement the legislation are too poor at present [53]. According to the same informant, the agency needs to develop guidelines for municipalities if they are to succeed in implementing local stormwater disposal, thus eliminating a barrier to adaptation that exists today. Another factor that may inhibit efforts to cope with precipitation and flooding is lack of accurate local weather and climate forecasts that are cheap or free of charge. Both municipalities mentioned the role of the government agency SMHI as crucial for providing more downscaled climate data and improving the grid of weather stations for accurate local precipitation measurements. Today the cost of buying downscaled data is a barrier for adaptation in both municipalities.

4.2.2. Energy supply including cooling

Regarding supply of electricity, a barrier for adapting to climate change may be inaction from the companies managing the electricity grid in Sweden. In all the visions, the municipalities assumed that more or less the same companies as today would guarantee a supply of electricity tomorrow, despite impacts from climate change.

In Sweden, the management of the electricity grid was deregulated in 1990s and concessions for the regional and local grids are now given to various network companies on a long-term basis, usually 40 years (for grids) and 25 years (for areas). These network companies are responsible for ensuring an adequate network maintenance level in order to guarantee that security of supply is maintained within their own networks [54]. In Danderyd and Salem, the network is managed by several companies operating at local, European and global level, such as Telge energy, Fortum, Eon and Vattenfall [55], companies

[3] Contact with representatives from all relevant companies revealed that investigations have been initiated but not completed.

with so far little apparent climate adaptation on their agendas.[4] In Danderyd, several electricity stations are located along the coast and at low altitude, making them vulnerable to sea level rise and flooding. This concerned the stakeholders in that municipality, as they could see that they would be inundated and thus not function during future extreme weather events. An example of how this problem was solved comes from Danderyd:

> *The municipality tries to persuade the owner of the network to secure it from water intrusion. When the electricity infrastructure is renewed the aim is to locate lines, transformers and electricity stations high up, on poles or in some other ways, in order to protect them from rising water levels (Danderyd, Image A).*

Thus, the municipality sees its responsibility to try to convince those who manage the grid to take action, but cannot undertake the necessary actions itself and thus clearly encounters a barrier to adaptation.

The need for cooling in view of future heatwaves was recognised in both municipalities in all visions, as very few buildings are cooled today with the exception of shopping malls, some offices and a large hospital. Cooling when the outside air is too warm can be arranged by using cool water from lakes, streams and the ocean (free cooling), a solution considered environmentally friendly and preferred over traditional energy-demanding air conditioners by the municipalities. Both municipalities are located close to large water bodies. They envisaged their roles for adaptation in different ways: as facilitators when negotiating local solutions using free cooling (presumably between neighbours in a certain area wishing to establish a network for district cooling) or as informants about the various subsidies for investing in cooling technology and infrastructure that they expected to be provided by somebody else in the future:

> *The municipality has been proactive and facilitated local networks for cooling (Danderyd, Image B).*

> *The opportunity for discounting adaptation measures in the building sector has meant that a great part, but far from all, detached houses have been rebuilt for better cooling during prolonged heat (Salem, Image 1).*

There is as yet very limited funding available for adaptation measures in Sweden, which can be a serious barrier for adaptation. At present, only SEK 43 million per year are set aside for preventive measures against natural hazards, which can be regarded as a type of adaptation funding [56]. This can be compared with the amount estimated by the Swedish Commission on Climate and Vulnerability in 2007 to be the cost of coping with climate change in Sweden during the period 2011–2100, namely SEK 1900 billion SEK in their high-end scenario [6, p. 503]. Their high-end scenario today seems rather conservative given that climate change is occurring faster than expected a few years ago [57,58]. If the present level of SEK 43 million per year in adaptation funding is maintained, only 0.2% of the costs incurred between 2011 and 2100 will be met by government funding.

4.2.3. The built environment

The solutions for adapting the built environment also rested heavily upon the assumption of available funding for which the municipalities would successfully apply in several of the visions and, as we showed above, very little such funding is available at present. For Danderyd municipality, protection against rising sea level was seen as crucial, and the solutions proposed included building barriers along the shoreline with the help of funds from outside. The barriers would be needed to protect both private property (mansion-like houses with large gardens, currently with a sea view) and public land used for recreation and transportation. In this case too, Danderyd saw itself as a facilitator, bridging the gap between local needs and donors at the national level:

> *The threat of rising sea level in the Baltic Sea has prompted the municipality to apply for funds from a government fund for certain building projects motivated by climate change adaptation. Part of the money will be used for building a barrier along the shoreline. Today's beach footpath will be located on top of that barrier (Danderyd, image A).*

In contrast to Danderyd, Salem municipality envisaged itself more as an active performer when it comes to planning and managing. Thus Salem saw itself ensuring that school playgrounds and patios in old people's homes have natural shade (Visions 1–3). It was evident to Salem that such measures can easily be implemented by the local administration, as it owns and manages most of the facilities. The same municipality wanted to apply current legislation [59] in order to ban non-permeable surfaces and construction of basements in flood-prone areas. This Act was recently complemented with a clarification meaning that planning should be carried out with respect to climate change [60], a proposal by the Swedish Commission on Climate and Vulnerability [6]. However, Salem felt that the Act is still too weak and that it needs to be further improved in order for that adaptation barrier to be overcome.

In Danderyd, where two pre-schools are already inundated at times, the municipality envisaged that parents in the future would be alerted by text messaging when flooding occurs, so that they could plan for alternative childcare (Image B). Due to budget constraints, they could not imagine any other measure, such as relocation. As mentioned earlier, the majority of politicians in Danderyd are not in favour of increasing municipal taxes and as such there are also examples of barriers to adaptation in this study that are not external, but dependent on the politics in the municipality itself.

[4] The websites of these companies were searched with the keywords climate/climate change and climate adaptation in December 2011. Results related to mitigation mostly, with one mention from EON that the risks from climate change are now considered in risk mapping, http://www.eon.com/en/downloads/CR_Work_Program_en_.pdf.

4.2.4. Care of the elderly

Concerning adaptation in the care sector, mostly seen as adapting to heatwaves by the municipalities (all five visions), both municipalities wanted much more information about who is vulnerable to heat and why, and they also wanted to know about measures that can be taken to protect the most vulnerable during heatwaves. They identified a government agency, the National Board of Health and Welfare, as crucial for spreading such information and also for providing guidelines about measures. So far this agency has not been in the forefront of providing such information and guidelines, which was considered as a barrier to adaptation by both municipalities. The existing general guidelines and a handbook about indoor temperatures (where during summer the indoor temperature for vulnerable persons should not exceed 24 °C) [61,62] are not applicable during extreme events such as heatwaves. This makes it difficult for local authorities to use them in order to demand e.g. that managers of nursing homes take measures to lower temperatures during a heatwave. Both municipalities also wanted heatwave alerts from SMHI, something which that agency does not provide at present.

A striking difference between the two municipalities is the extent to which care of the elderly and disabled has been privatised, a measure that was made possible by legislation on choice in the public sector introduced in 2008 [62]. In Danderyd, 10 private companies provide a home help service attending more than half those in need, and four out of eight nursing homes are run by private companies [63]. The aim of the currently elected municipal authority is to increase the involvement of private operators. In contrast, Salem has only four private companies that provide home help services, while all three nursing homes are run by the municipality itself [64]. As a result of these differences, the possibilities for adapting to climate change, mostly perceived as adapting to heatwaves, are quite different and either entail formulating 'smart' requests for proposals in connection with tender invitations and procurement proposals or installing fans, thermometers, shades, free cooling, etc. in nursing homes run by the municipality and hiring the staff needed for this. In the former case, training in how to procure services in a smarter way than now is probably needed, as lack of such training and practice will form a barrier to adaptation:

> *Demands are made on those that provide home help services that the indoor temperatures should be tolerable even during heatwaves and this is monitored (by the municipality). Those who provide such services also state what extra help will be available during heatwaves. In that way everybody knows what they are getting in the event of a heat crisis and can plan according to defined assumptions. Furthermore, in procurement it is demanded that the premises have access to shaded areas where the elderly can stay when it is hot. . .(Danderyd, Image B).*

> *The municipal care administration has contracted newly retired employees who are prepared to do extra work in the event of heatwaves when there is a need to visit and help some elderly people who live in isolated places without air conditioning or district cooling (Salem, Image 2).*

5. Discussion

5.1. Barriers to climate change adaptation in this and other studies

As shown in Section 4, our study of two municipalities revealed numerous barriers to local climate change adaptation due to inaction by decision makers in organisations other than the municipality itself. Such barriers in Swedish municipalities are interesting because they are responsible for a larger share of public services in comparison with the situation in most other countries. Thus if barriers related to external decision makers are not dealt with, adaptation to climate change in society will not succeed. We encountered barriers caused by a wide array of decision makers: from those located at the local and regional level to those located at the national and international level. It seems that some of the developments in society, such an increasing degree of out-sourcing, privatisation, specialisation and conglomeration, have the effect that tasks formerly managed by the municipalities are now taken care of by external decision makers. This is a challenge to local climate change adaptation and demands new strategies and improved competence in municipal planning as regards procurement and negotiations. The question is to what extent the municipalities will have the capacity to deal with this new situation, and to what extent Swedish authorities at the national and regional levels grasp these dependencies. Our impression is that much needs to be done in this area in the coming years if adaptation to climate change in Sweden, which depends on success at the local level, will move forward at a reasonable speed.

The results from our study can also be put in the context of the climate change adaptation literature about barriers and limits. When the latest synthesis was produced by the IPCC in 2007, Working Group II concluded that much of the adaptation literature at that point emphasised the role of governments and that barriers to adaptation at that level consisted of (lack of) relevant climate information for development-related decisions and uncertainty about climate change information [65]. Working Group II also concluded that high adaptive capacity may not automatically translate into successful adaptation, that limits and barriers to adaptation are of a technological, financial, cultural, cognitive and informational nature, and that there are significant research challenges in understanding the processes by which adaptation occurs [65]. Since then, a number of case studies in municipalities have shed further light on limits and barriers to adaptation. For example, Groven et al. [66] explored why climate change adaptation was/was not integrated into civil protection in three municipalities in Norway, Sweden and the Netherlands and found a range of factors determining its integration, such as perceived vulnerabilities and a need for legitimacy. Van Aalst et al. [67] concluded that for successful use of community-based risk assessments for introducing adaptation, climate information must be better tailored to community needs, while Burch [68], who examined three municipalities in Canada for barriers and levers for successful adaptation, found that leadership that stimulates

innovation and collaboration was crucial. Burch [68] also noted that due to time constraints, few municipal employees have the time or inclination to add additional complex tasks.

Compared with other studies of barriers and limits to adaptation (of which those mentioned above are but a few examples), our study adds a vertical dimension to the analysis, i.e. it highlights the interdependence between organisations at various levels in society; local, regional, national and international. It stresses the need for a systems perspective on adaptation, where decision makers at different levels in society are recognised as important for adaptation but in different ways; some as legislators, some as informants or funders, some as researchers and some as procurement agents or providers of essential services. In fact, our study, which was carried out in a highly industrialised market economy, is an illustration of how dependent even municipalities with a high degree of autonomy are on decision makers at other levels and locations in society, a feature they presumably share with municipalities in similar societies around the world. An example of dependencies comes from Australia [80] where the reliance on policy makers such as ''context setters'' (stakeholders whose power and influence have a mediating role, but who may lack interest in the situation) at the local level was highlighted. Further studies on barriers and limits to climate change adaptation at the local level would perhaps be more useful if powers and interest of stakeholders/decision makers at various levels in society were better explored than now.

5.2. Possible improvements and usage of the methodology

Although the methodology applied was not systematically evaluated for its efficiency in inspiring civil servants to engage in adaptation planning, our overall impression was that it served at least part of that purpose. That conclusion was reached after conversing with the civil servants involved directly after the workshops and by interviewing them about 8 months later. However, some aspects of the methodology need to be improved/dealt with before 'envisioning ideally adapted municipalities' is considered as an adaptation tool. At the outset, substantial efforts were made by the researchers to explain the difference between climate change *adaptation* (''adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'' according to the glossary given in Parry et al. [69]), and *mitigation* (''an anthropogenic intervention to reduce the anthropogenic forcing of the climate system'', ibid.) and to explain that the study was about adaptation. Despite these efforts, for both municipalities the idea generation phase resulted in as many building blocks for mitigation as for adaptation. As an example, while envisioning district cooling in new houses (adaptation), these new houses were also equipped with solar cells in the same visions in order to produce electricity with low emissions of greenhouse gases (mitigation). This reluctance to focus on adaptation was probably partly because of the long tradition of associating climate change with mitigation, as mentioned in the Introduction, but also as a desire for wholesomeness when envisioning. If the method were to be used again, we believe that the adaptation perspective needs to be even further strengthened and emphasised in the introductory phase, as it is a new feature in Swedish society and possibly in other societies as well. A second aspect that needs much further improvement is the presentation of visions, which mainly took the form of narratives in our study. Previous studies have shown that climate change calls for more comprehensive and engaging science communication [70] and visual imagery elicits affective responses [71]. Provided that resources are available, one option could be to visualise the visions of ideally adapted local places in 3D views. This approach was tested by Shaw et al. [72] in a study where various futures of local places were portrayed, with and without adaptation to climate change. However, it has also been argued that in order to enhance climate change adaptation work at the local level, it is important to provide methodologies that are not too resource intensive [45].

We also believe that our methodology may be of use for revealing to stakeholders such as decision makers beyond the local level of their own importance for climate change adaptation. It is our impression that such revelation may be needed, at least in Sweden, where several government agencies remain passive to the needs for adaptation initiatives (see Section 4). One approach could be to create visions using our methodology with all/most municipalities in a region, in order to get a comprehensive picture of the support needed from decision makers beyond the local level. Another idea for how to apply the methodology could be to envision an ideally adapted government agency and then identify which decision makers in society that agency depends on for adaptation success.

As a final reflection on the methodology, we acknowledge that the use of scenarios (and visions of the future) in the climate change context is currently undergoing a transformation. In response to a request from the IPCC in its fifth assessment report (AR5), the climate and the impacts research communities have established a new process for developing scenarios for climate change research [73,74]. The aim is to generate a simultaneous analysis of mitigation, impacts and adaptation using a common scenario framework. When such a framework becomes available, exercises such as that presented in this paper can be carried out, allowing for more comparability with other studies.

5.3. Issues for further research

As mentioned earlier, based on these experimental case studies in Danderyd and Salem, we are unable to draw general conclusions about barriers encountered by Swedish municipalities. However, below are a few issues that we think are worthy of further research.

First, we can assume that some barriers are of great relevance to many municipalities:

- Municipalities need substantial financial support in order to carry out costly measures such as building barriers against rising sea levels, something which is lacking today;
- Regional cooperation is necessary for municipalities as regards e.g. drinking water supply and sewage water treatment
- A better developed legal and institutional framework is needed in order to facilitate effective local solutions as regards e.g. stormwater disposal, cooling of buildings, banning non-permeable surface around dwellings and making private entrepreneurs running e.g. schools or institutions for elderly care adapt their activities and services to climate change
- In general, there is a need for local climate forecasts as an input to vulnerability analysis in municipalities and also a need for local weather forecasts and alert systems to give early warnings to local emergency response services.

Second, we believe that the following differences between municipalities may have an impact on their dependence on external support and how they choose to adapt to climate change:

- There is a significant difference in planning situation between municipalities that are highly integrated into a major urban region (such as Danderyd) and small municipalities at the periphery of a large urban area (Salem).[5] In the first case the high degree of integration between the central municipalities of the urban area makes their dependence mutual in character, while the peripheral municipality is one-sidedly dependent on the urban core. The mutual dependences of the core municipalities make planning complex and prevent individual solutions in many cases. On the other hand, if the municipalities cooperate, they have the power to achieve effective solutions to climate adaptation. This is of relevance to infrastructure solutions, land use planning, drinking water solutions and sewage water treatment.
- Municipalities with a high degree of privatisation of schools, elderly care, etc. will have to find different solutions and need different skills for adaptation than municipalities that essentially run the schools and institutions for elderly care themselves. When care is privatised, good skills in public procurement become very important, including how to write specifications and how to evaluate tenders. If such skills are not sufficient, this is a barrier to adaptation.

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