State of preparedness for climate change adaptation in operations and maintenance of transport infrastructure in eight Swedish municipalities

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Abstract

This study analysed the preparedness for climate change adaptation (CCA) of transport infrastructure in eight municipalities in Sweden. The study focused on municipal officials’ role in organizing and implementing CCA measures. The interviews were done in 2011. Many respondents confused CCA with climate change mitigation. Three of the municipalities had performed vulnerability analyses but apart from that, well-documented decision support in long-term adaptation was largely lacking. Adaptation measures were often based on day-to-day problems and recently experienced weather incidents. Strategic work with long-term CCA seemed to be largely lacking. The placing of the responsibility for CCA in the municipal organization was often unclear. Six of the respondents found there were no actual hindrances to their work with CCA and no conflicts with other municipal aims. However, several responses indicated budgetary competition with environmental aims or other societal strivings. The planning and implementation of CCA measures seemed to be highly dependent on individual officials, their engagement, their passivity/activity regarding this issue, their defined responsibility and the boundaries for their current position in the municipality organization.

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Föreliggande studie utgör en del av TEMA-projektet ”Kompetenscentrum för klimatanpassning av vägkonstruktion, drift och underhåll” och har genomförts på initiativ av Annika K. Jägerbrand och med finansiering av VTI (Statens väg- och transportforskningsinstitut).

Syftet med TEMA-projektet har varit att bygga upp ett kompetenscentrum med VTI-forskare inom det tvärvetenskapliga området klimatanpassningar av vägkonstruktion, drift och underhåll. Projektet om klimatanpassning har bestått av två delar: kunskapsuppbyggnad och fördjupning.

Kunskapsuppbyggnaden hade som mål att gemensamt författa VTI rapport 771 ”Klimatanpassning av vägkonstruktion, drift och underhåll: Ett temaprojekt” (2012) och fördjupningsdelen har bestått av tre oberoende delprojekt: Klimatets inverkan på vägdimensionering, Vinterindex samt Planering och beslutsprocesser för klimatanpassning av drift och underhåll. Föreliggande rapport omfattar delprojektet ”Planering och beslutsprocesser för klimatanpassning av drift och underhåll” (projektnummer 12250).


Stockholm i december 2016

Annika Jägerbrand
Projektledare
Quality review

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Kvalitetsgranskning

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Summary

State of Preparedness for Climate Change Adaptation in Operations and Maintenance of Transport Infrastructure in Eight Swedish Municipalities

by Lennart Folkeson (VTI), Annika K. Jägerbrand (VTI) and Anders Genell (VTI)

Municipalities play an important role in adaptation of the transport system to climate change. This study analysed the preparedness for climate change adaptation (CCA) of transport infrastructure in eight municipalities in Sweden and examined municipal officials’ role in organizing and implementing adaptation. Semi-structured telephone interviews were performed in 2011 with municipal civil servants responsible for operations and maintenance of the municipal transport infrastructure. The study focused on the respondents’ level of knowledge concerning CCA, planning tools and decision support, state of CCA development, balance between planned and emergency measures, responsibility for the CCA development, the role of procurement, co-operation between municipal administrative units, co-operation with external actors, and conflicts of aims and hindrances to adaptation work. Many respondents confused CCA with climate change mitigation.

The respondents showed great interest in climate change and CCA but shortage of time limited their ability to keep up-dated with the state of the art and state of the practice. One municipality purchased good (and expensive) meteorological services in order to be prepared for events demanding special measures. Three of the municipalities had performed vulnerability analyses but apart from that, well-documented decision support in long-term adaptation was largely lacking. Adaptation measures were often based on day-to-day problems and recently experienced weather incidents. There was often no clear distinction between planning and measures. CCA measures were primarily directed towards coping with flooding and heavy snowfall.

The placing of the responsibility for CCA in the municipal organization differed between municipalities. Only one of the respondents reported that he was the person responsible (as head of department) for planning, decision making, implementation and follow-up of CCA of transport infrastructure in the municipality, but he had delegated this work to a unit belonging to his organization. Half the respondents indicated that demands concerning CCA were lacking in the procurement of operation and maintenance of the municipal transport infrastructure. One respondent mentioned co-operation on CCA with neighbouring municipalities. Apart from this, the only external co-operative partner mentioned was the Swedish Transport Administration. Co-operation on CCA between municipal units existed but the way this was organized varied between municipalities. Six of the respondents held the opinion that there were no actual hindrances to their work with CCA and no conflicts with other municipal aims. However, several responses indicated budgetary competition with environmental aims or other societal strivings. Overall, strategic work with long-term CCA seemed to be largely lacking. The planning and implementation of CCA measures seemed to be highly dependent on individual officials, their engagement, their passivity/activity regarding this issue, their defined responsibility and the boundaries for their current position in the municipality organization.
Sammanfattning

Ätta svenska kommuners beredskap för att anpassa drift och underhåll av transportinfrastruktur till klimatförändringarna

av Lennart Folkeson (VTI), Annika K. Jägerbrand (VTI) och Anders Genell (VTI)


Hälften av de intervjuade angav att klimatanpassningsrelaterade krav saknades i upphandlingen av drift och underhåll av transportinfrastruktur i kommunen. I fråga om samverkan inom och utom organisationen angav ett svar att kommunen samverkade med grannkommuner och ett annat att kommunen samverkade med Trafikverket. Svaren visade på en splittrad bild av samverkan inom den egna kommunala organisationen. Sex av de intervjuade angav att det inte fanns några egentliga hinder för deras arbete med klimatanpassning eller konflikter med andra kommunala intressen. Flera svar angav dock budgetkonkurrens med kommunala prioriteringar inriktade mot miljö eller andra samhällsintressen. Sammanfattningsvis verkade strategiskt arbete för långsiktig klimatanpassning i hög grad saknas. Planering och genomförande av klimatanpassningsåtgärder var starkt beroende av enskilda tjänstemän och deras engagemang samt definition och avgränsning av deras ansvarsområden inom organisationen.
1. Introduction

Transport infrastructure is highly dependent on climate and environmental conditions in order to sustain its function. The transport sector will therefore be significantly affected by climate change (TRB 2008) and seems to be particularly vulnerable to the effects of climate change (Love et al. 2010). Actual and anticipated climate change impacts (CCI) affecting transport systems include rising sea levels, heat waves and hydrological changes that will result in increased ground water fluctuation between long rain and drought periods, flooding, storm surges and increased frequency of extreme weather events such as storms and intense precipitation (Koetse and Rietveld 2008, TRB 2008, Royal Academy of Engineering 2011, IPCC 2013, Andersson-Sköld et al. 2014a, SMHI 2016). The hydrological changes will result also in secondary impacts such as increased erosion and landslides (e.g. SOU 2007). Disturbances in the transport system can have serious economic and social consequences. Already today, the costs related to flooding and climate related events such as landslides can be severe (e.g. Ekström et al. 2012, Grahn et al. 2016) and the costs are expected to increase due to CCI (SOU 2007).

Due to the interlinkages between the transport system and other systems, transport interruptions may cause a cascade of failures in other critical infrastructure functions, e.g. energy or water services (Royal Academy of Engineering 2011). Moreover, complex systems of interconnections between transport modes make the whole transport matrix sensitive to interruptions. Officials responsible for transport infrastructure have an important role in planning for adaptation to climate change in order to prevent damage and system failure, reduce effects on society and minimize future costs. Hitherto, however, attention regarding transport and climate change has largely been on climate change mitigation (CCM), e.g. reducing greenhouse gas emissions and increasing the energy efficiency of transport (Michaelis and Davidson 1996, Ribeiro et al. 2007, Banister et al. 2011, Schwanen et al. 2011). In comparison, there has been little research on climate change adaptation (CCA) in the transport sector (Eisenack et al. 2012, Andersson-Sköld et al. 2015). There is, however, a rapidly increasing volume of research into CCA which, according to the International Panel on Climate Change (McCarthy et al. 2001), is “the processes, practices, or structures to moderate potential damage or to take advantage of opportunities associated with climate change”.

In Sweden, one of the barriers for robust CCA management is the complex legislation and responsibilities involving the sectoral authorities, county councils, emergency services, local authorities and private landowners (Andersson-Sköld et al. 2014b). In Sweden, the Swedish Transport Administration (STA) is responsible for the national road network, whereas municipalities are responsible for most of the roads and streets in cities. The municipalities also have a responsibility concerning crises, accident prevention and consequences and the local overall risk management including flooding and other climate related risks (e.g. SKL 2009, Norén 2016). Further, STA has its own set of rules and processes for the planning and operation of road and rail networks. STA often anchor its planning in provincial governments, and as a result, there is a lack of interface between STA and the municipalities (Andersson-Sköld 2014b).

The STA has developed tools for risk analysis (Löflying, 2005a, Löflying, 2005b) and has participated in a national inventory of critical and vulnerable road infrastructure (Nordlander et al. 2007). Compared with the STA, which can mobilise resources to cope with e.g. weather hazards, municipalities have fewer economic resources. While CCI occur at all scales (global, national, regional, local), it is often at the local scale that the need for CCA emerges, and municipalities may therefore play a critical role in CCA in society (Smit et al. 1999, Næs et al. 2005, Urwin and Jordan 2008, Measham et al. 2011, Norén 2016). In recent years, Swedish municipalities have been increasingly active in their preparations for CCA, using spatial planning as an instrument. However, even highly CCA-motivated municipal decision makers are faced with the strong municipal trend of increasing occupancy of attractive coastal areas susceptible to sea level rise. Intentions expressed in spatial planning guidelines and action plans about limiting urban development in risky waterfront areas have had to be
compromised in the face of strong demand for flexibility in spatial planning, which is an example of CCA being viewed as a challenge for the future (Storbjörk and Ugla 2015).

The planning and implementation of municipal CCA activities in Sweden have to take a range of regulations into consideration. Among these are the Environmental Code (2000), the Planning and Building Act (SFS 2010) and the Act on Local and County Actions Before and During Extraordinary Events in Peacetime and National Emergency (SFS 2006). The former requires municipal planning of buildings and infrastructure to consider CCI, e.g. risks of flooding, landslides and erosion, and the latter requires municipalities to make regular risk and vulnerability analyses. Municipalities are required to have a plan for their measures to cope with disasters requiring municipal rescue action (SFS 2003), but the extent of CCA inclusion in the transport sector varies greatly, from good to not at all.

The overall situation concerning aspects other than transportation in municipal planning and CCA has been described previously (Viehhauser et al. 2007, SKL 2009, 2011, Amundsen et al. 2010, Roth and Thörn 2015). Furthermore, specific studies have been devoted to central–local government relations (Granberg and Elander 2007, Dannevig et al. 2012), adaptive capacity of cities, countries and regions (Jonsson et al. 2012, Juhola et al. 2012.), external actors’ engagement in urban CCA strategy development (den Exter et al. 2015), management of flood and other climate related risks (Næss et al. 2005, Storbjörk 2007, Andersson-Sköld and Nyberg, submitted), incentives for local politicians to engage in CCA (Hjerpe et al. 2015), barriers and challenges (Measham et al. 2011), barriers to organizational learning (Glaas et al. 2010, Storbjörk 2010) and the role of CCA guidelines in municipal spatial planning (Storbjörk and Ugla 2015). In addition, several reports, guiding material and recommendations are compiled at the national web portal on CCA (http://www.klimatanpassning). However, the role of individual officials in municipal preparedness for CCI, their current CCA actions and how individual knowledge and perceptions of responsibility affect municipal preparation for adapting to climate change in the transportation sector have been little examined. Therefore, this study investigated whether Swedish municipalities are aware of and have planned for CCA in their transport systems.

Due to the long lifetime of transport infrastructure, it may take several decades before CCA measures in the planning process are actually implemented. Efforts concerning CCA often focus on ensuring that future infrastructure is resilient enough to cope with the changing climate and seldom deal with CCA of operations and maintenance (O&M) of existing infrastructure. Moreover, municipal measures for the protection, adaptation and updating of current transport infrastructure often rely solely on voluntary initiatives by local politicians or municipal officials responsible for O&M. This makes it highly important for these specific individuals to have up-to-date and comprehensive knowledge about CCI in the geographical area of the municipality or region, since when taking local decisions on CCA measures, it is essential to have the correct information (Storbjörk 2010). If a municipality has the information and is aware of future CCI, it is likely to identify important measures that will make the transport system more resilient. Failure to do so means that it will lack preparedness for effective handling of more frequently occurring transport failures and emergency situations such as flooding of roads or collapse of bridges. For example, extreme events with intense precipitation may cause interruptions of transports on roads or railways which can be forecasted by the municipality and therefore handled or the risk for occurrence may be reduced by CCA mitigation measures. Another example concerns storms and wind-fallen trees that cause obstacles to the road traffic and need to be removed urgently. Such hindrance to emergency work by the O&M personnel may cause crucial delays in the actions needed to reduce the risk of jeopardizing damage.

Municipalities with a history of natural emergencies, e.g. flooding or extreme climate events, usually have procedures in place to create and implement adaptation plans for future CCI. However, predicting future implications and appropriate adaptations is still difficult, e.g. due to difficulties with
accuracy in forecasts and also competition for finances with other departments in the municipality (e.g. SKL 2011, Andersson-Sköld et al. 2013).

Furthermore, there is currently a lack of national directives and other national guidance regarding CCI on the transport sector, so municipalities must devise their own CCA measures. Personal efforts and initiatives have been shown to be of great importance to the progress of CCA work in municipalities in Norway, where there is limited pressure and guidance from the state on CCA (Dannevig et al. 2012). Recent studies show similar results for Swedish conditions (Andersson-Sköld et al. 2013, 2014b, Andersson-Sköld and Nyberg, submitted). This indicates that individual officials’ attitudes, knowledge and perceptions of responsibilities concerning CCA may significantly affect municipal preparedness for CCA. Thus, awareness of the importance of CCA for system O&M is important in order to safeguard the resilience of transport systems.

The aim of the present study was to analyse the state of preparedness for CCA among municipal officials responsible for O&M of the transport infrastructure. This was addressed by researching whether municipal officials have adequate information for making decisions on CCA, e.g. in anticipating CCI on transport infrastructure, or by using decision-based tools and/or risk and vulnerability analyses; and whether these officials feel responsible for planning and implementing CCA measures to mitigate CCI and any hindrances or conflicts stopping such measures or actions.

Using interviews, we investigated various aspects of the preparedness for CCA and how CCA work is organized in eight Swedish municipalities. To increase the probability of the municipalities being acquainted with CCA of O&M in the transport sector, they were selected on the basis of having transport infrastructure that has suffered varying degrees of damage caused by extreme weather events or CCI, or are at risk doing so due to geographical location. In the following, the eight municipalities are given code names (Applebay, Flingtown, Keycastle, Kingshill, Palmbeach, Shoreton, Tidewall, Tollbridge) to protect their anonymity.
2. Materials and Methods

To identify the responsibility for CCA of operation and maintenance of transport infrastructure in municipalities in Sweden, we investigated the views held by municipal civil servants about their roles, responsibilities and resources, their knowledge of climate change and how they perceive the status of their CCA work in eight municipalities. We identified eight research areas (R1-R8) addressing:

R1: Municipal officials’ knowledge of climate change and CCA
R2: Decision support and planning tools used in their decision making and daily work on CCA
R3: The state of development of CCA of transport infrastructure in their municipality
R4: The seat of responsibility for CCA in their municipal organization
R5: The role of procurement in safeguarding the incorporation of CCA intentions in the O&M of transport infrastructure
R6: The balance between ventures concerning preventive measures (long-term CCA) and emergency measures pertaining to extreme weather situations
R7: The presence of co-operation between municipal administrative units and co-operation with external actors
R8: Hindrances and goal conflicts influencing their work with CCA.

These research areas were addressed by twelve interview questions (Q1-Q12 in Table 1) to be presented during telephone interviews with civil servants in the selected municipalities.
Table 1. Research areas (R1-R8) and interview questions (Q1-Q12).

Research questions and related interview questions

R1: State of knowledge (on climate change and CCA)
Q1: What comes into your mind when you hear the term “climate change adaptation”?
Q2: How will the transport infrastructure in your municipality be influenced by future climate change?
Q3: When it comes to your work with climate change adaptation: how do you keep yourself up-to-date with new findings concerning climate change adaptation? Do you experience any hindrances to keeping yourself up-dated?

R2: Decision support and planning tools (knowledge, decision support and planning tools at hand for CCA)
Q4: Do you have sufficiently good decision support and planning tools for your work with climate change adaptation of transport infrastructure?

R3: State of CCA development (how far the municipality has advanced in its work with CCA of infrastructure)
Q5: Has any risk and vulnerability analysis for the municipality dealt with transport infrastructure?
Q6: What climate change adaptation measures have been planned concerning operations and maintenance? Which of these have been implemented?

R4: Responsibility (where responsibility for CCA rests in the municipality)
Q7: Who in your municipality is responsible, in theory and practice, for planning, decisions, implementation and follow-up of climate change adaptation of transport infrastructure operations and maintenance?

R5: The role of procurement
Q8: Is the procurement instrument used to safeguard inclusion of climate change adaptation issues in the operations and maintenance of transport infrastructure?
Q9: To what extent are there requirements related to climate change adaptation in the procurement of operation and maintenance measures?

R6: Balance between preventive and emergency measures
Q10: What is the resource share between preventive and emergency measures, in theory and practice?

R7: Co-operation between municipal administrative units and co-operation with external actors
Q11: In the work with climate change adaptation, what co-operation exists within and outside the municipality?

R8: Hindrances and conflict of aims (hindrances or goal conflicts in work with CCA)
Q12: Have you experienced any hindrances in your work with climate change adaptation? With what other issues or interests does your work with climate change adaptation compete?
The criteria applied when selecting municipalities to be included in the study were that the municipalities should:

- have a population between 26,000 and 62,000
- be geographically spread across different parts of Sweden
- have transport infrastructure that has suffered varying degrees of damage by extreme weather events or CCI, or risks such damage.

Four of the municipalities were known for having already suffered well-documented damage. Other municipalities were identified by knowledge of known transport system vulnerabilities, combined with predictions of CCI in various geographical parts of Sweden. In addition, the selection was based on the inclusion of municipalities:

- located on the coast
- located in the inland
- bordering a large lake
- located by a river or canal
- comprising densely or sparsely populated areas
- with major socio-economic investment in nationally important transport infrastructure (road, rail, air, inland-water and sea transport)
- with extensive or limited commuting.

The population criterion was included so that medium-sized municipalities were represented and to avoid large municipalities which could be expected to have comparatively large resources for CCA work. Some important characteristics of the eight municipalities selected are given in Table 2.
Table 2. Characteristics of the eight municipalities selected (fictitious names), identified risks and vulnerabilities that might affect transport infrastructure systems in these municipalities and number of inhabitants per km² and total population in 2010. CCI: climate change impact.

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Location</th>
<th>Inhabitants/km²</th>
<th>Nationally important transport infrastructure</th>
<th>Population in 2010</th>
<th>Identified vulnerability to extreme weather or CCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applebay</td>
<td>City bordering large lake</td>
<td>16</td>
<td>Railway through city centre</td>
<td>26,000</td>
<td>Has experienced severe floods from large lake</td>
</tr>
<tr>
<td>Flingtown</td>
<td>Inland</td>
<td>30</td>
<td>Railway junction point in city centre. Dry port near the city</td>
<td>32,000</td>
<td></td>
</tr>
<tr>
<td>Keycastle</td>
<td>City bordering sea</td>
<td>65</td>
<td>Sea port. Highway bridge to large island in sea</td>
<td>63,000</td>
<td></td>
</tr>
<tr>
<td>Kingshill</td>
<td>Inland</td>
<td>32</td>
<td>Railway junction point in city centre. Dry port near the city</td>
<td>32,000</td>
<td></td>
</tr>
<tr>
<td>Palmbeach</td>
<td>City bordering sea</td>
<td>13</td>
<td>Railway station in city centre. Motorway and large sea port outside city centre</td>
<td>41,000</td>
<td></td>
</tr>
<tr>
<td>Shoreton</td>
<td>City bordering large lake</td>
<td>122</td>
<td>Large national airport</td>
<td>40,000</td>
<td>Has experienced floods from large lake</td>
</tr>
<tr>
<td>Tidewall</td>
<td>City bordering sea</td>
<td>123</td>
<td>Highway, railway and large sea port in city centre</td>
<td>42,000</td>
<td>Has experienced severe floods and snow storms</td>
</tr>
<tr>
<td>Tollbridge</td>
<td>Inland</td>
<td>134</td>
<td>Highway, railway and important canal in city centre</td>
<td>55,000</td>
<td>Has experienced floods. Canal/river shores prone to land slides</td>
</tr>
</tbody>
</table>

With the help of the internet and municipal switchboards, we identified the municipal official responsible for O&M of transport infrastructure in the municipalities. Contact was made with one interviewee per municipality. However, one municipality was represented by two interviewees, since the first interviewee was found to be responsible for only a limited part of the target issues. For another municipality, the interviewee was marginally supported by a staff member present during the interview.

Interviewees were:

- a chief officer of the traffic department
- a chief officer of the department of planning and community development
- a chief officer of the services department
- a chief officer of the transport and workshop unit of the services department
- a chief officer of the service and technical department
- a chief officer of the technical services and traffic department
- a chief officer of the traffic and park unit of the urban planning department
- two chief officers of the technical services department.

The interviewees, five women and four men, had held their posts for periods between half a year and at least 13 years. To safeguard anonymity, interviewees (also called respondents) are referred to as ‘they/them/their’ throughout the text and fictitious names are used for the municipalities. The semi-structured telephone interviews were performed by the authors, with 1-6 interviews each. The interviews, performed between 9 and 20 December 2011, lasted for about 30 (13-31) minutes. During the interviews, extensive notes were taken by the interviewer. The interviews were audio-recorded and (all except one) transcribed, partly word by word, partly in condensed form, summarising the main messages for each of the interview questions. The transcripts were transformed in extenso into a working table to facilitate the content analysis.
3. Results

3.1. State of Knowledge

Question 1: What comes into your mind when you hear the term “climate change adaptation”?

When asked about their interpretation of the term “climate change adaptation”, only three interviewees (Applebay, Tidewall, Tollbridge) stated the “established” meaning of the term. One answered: “We are moving towards a new climate and have to adapt our activities accordingly.” Another answered: “We are living in a period of change, which will influence us and has influenced us to a great extent here in the municipality of Tidewall.” The answer from the third revealed that climate change activities were greatly based on weather extremes experienced by the municipality during the last few years; “And therefore, we started working with climate issues—you have floods, you have storms and extreme heat waves—you have many different perspectives that you have to take into account.” (Tollbridge). This municipality now has an action plan addressing extreme weather events. However, most of the interviewees seemed to interpret CCA as CCM. Typically, reference was made to CO₂ emissions, low-emission cars, goods logistics, energy efficiency, resource-saving measures, future social welfare and unspecified environmental concerns at large.

Question 2: How will the transport infrastructure in your municipality be influenced by future climate change?

When asked about anticipated CCI on transport infrastructure, three municipalities (Flingtown, Palmbeach, Tidewall) mentioned issues related to higher precipitation amounts (rain and/or snow), typically concerning stormwater volumes and capacity to handle these.

One respondent expected larger weather variability (Palmbeach) and mentioned efforts to communicate adaptation needs with municipality politicians. Another respondent mentioned more efficient use of snow-clearing machinery and preparedness for de-icing needs (Applebay). Representing a municipality (Shoreton) facing the risk of flooding from a lake, another respondent mentioned the vulnerability of the road network and the need to eliminate physical bottlenecks. A municipality situated on the coast (Tidewall) was greatly occupied with problems related to frequent flooding events due to heavy rainfalls and to the future sea-level rise. In this city, the port will be relocated from the current position in the city centre to a new location—the main reason being demands on capacity to receive longer ships, however. Measures to handle large storm-water volumes in the future port area are being planned.

The spontaneous answers from four other respondents did not concern CCI but other transport-related issues. Typically, they mentioned issues such as cargo terminals (Tollbridge), location and characteristics of traffic flows, car-sharing, street tolls, “green” cars, public transport, cycle roads and pedestrian lanes, and train-freight volumes allowed through the city. The respondents from two municipalities (Keycastle, Kingshill) said they could not know the extent of future CCI on transport infrastructure in their municipality. “If I knew that, I’d be a millionaire!” answered an official who was in charge of O&M and then added that someone else within the municipality was probably more familiar with the question.

Question 3: When it comes to your work with climate change adaptation: how do you keep yourself up-dated with new findings concerning climate change adaptation? Do you experience any hindrances to keeping yourself up-dated?

Keeping up-dated in CCA issues commonly went through the internet, television, seminars, newsletters, networking and co-operation within and between authorities. Four respondents indicated multiple information pathways but three respondents mentioned a single pathway, e.g. news media. One of the respondents (Tidewall) said he did not actively search for information but got the necessary information from the environmental department. Five respondents expressed great interest in CCA.
issues. Three respondents saw no formal or practical hindrances to keeping up-to-date but five respondents said they were limited by shortage of time. One respondent admitted feeling “not so informed as one should be” [—being] responsible of a greatly diversified activity, [it is] difficult to keep track of everything.” Another respondent, using only media as an information pathway, said it was “a little tiresome to keep up-dated” and asked himself: “Who shall I listen to?” Instead of answering the question on retrieval of CCA information, one respondent talked about fiscal and environmental objectives of the municipality, such as a fossil-free municipality and procurement of locally and ecologically produced food. Another respondent did not know where to get information because he had only held his position for six months.

3.2. Decision Support and Planning Tools

Question 4: Do you have sufficiently good decision support and planning tools for your work with climate change adaptation of the transport infrastructure?

This question received only one clearly positive answer (Applebay). That municipality purchases good (and expensive) meteorological services in order to be prepared for events demanding special measures. The municipality regards this expense as justified, since it has already experienced severe problems with high precipitation volumes. The interviewee from Applebay did not explicitly mention decision support or planning tools, but the variety of planned municipal measures is clearly based on decision support of various kinds. Three of the municipalities (Keycastle, Palmbeach, Shoreton) responded that they do not have any substantial decision support. One example (Shoreton) illustrates this: “No, we do not have any decision support. I feel we fumble and glance over at how other municipalities are working.”

Another picture was: “Difficult question; for sure it can become better, I can say. Currently, it is much a question of ourselves having to chase after all this information. Even if there is so much information in society, one in some way has to sieve and grasp exactly the most important of all the important information, and that takes quite much time and effort.”

Three municipalities (Flingtown, Kingshill, Tollbridge) gave vague answers, e.g. “…difficult to see the depth of the problem” (Flingtown). One municipality (Keycastle) said the issue was not their responsibility and referred to higher levels in the municipal hierarchy. One respondent (the one employed six months earlier) said he had not had time to get acquainted with the question (Kingshill). The same municipality (Kingshill) thought that information on CCA issues should come from central authorities such as the STA or the Swedish Association of Local Authorities and Regions.

3.3. State of CCA Development

Question 5: Has any risk and vulnerability analysis for the municipality dealt with transport infrastructure?

This question usually received imprecise answers. None of the interviewees was directly involved in such analyses. One of them (Flingtown) said a three-year old analysis was currently being updated. The same respondent mentioned that an inventory of the bearing capacity and other characteristics of the surface layer of the road network had been performed covering the whole municipality. Another respondent (Keycastle) said that the security department had made an analysis in the current year comprising, among other issues, weather phenomena and floods. In one municipality (Tollbridge), such issues were also covered in the risk and vulnerability analysis, accompanied by action plans, to be performed prior to each four-year political term of office. That respondent referred to “the law on defence against disasters”. Analyses of CCI comprising transport issues were lacking in two municipalities (Applebay, Palmbeach), and in a third municipality (Shoreton) no analysis had been made for the last two years at least. Lack of a vulnerability analysis was also reported for a municipality with detailed action plans for emergency situations related to snowstorms (Tidewall).
Question 6: What climate change adaptation measures have been planned concerning operations and maintenance? Which of these have been implemented?

There were difficulties with distinguishing between plans and actions in the responses concerning CCA measures pertaining to infrastructure O&M. In the few cases where plans were explicitly mentioned, they typically concerned handling snow and flood water. One respondent (Palmbeach) mentioned on-going revision of snow clearance plans to increase the efficiency through, e.g., diversifying the technical performance patterns. Two other municipalities mentioned upgrading of snow clearance machinery (Applebay) and snow deposits (Tollbridge). As a response to the many floods experienced by one of the coastal municipalities (Tidewall), heavy terrain vehicles for extreme flooding and snowstorm situations had been purchased and rescue personnel had been trained in chainsaw handling to be prepared for clearing fallen trees blocking roads.

In one municipality (Flingtown), road upgrading measures to improve bearing capacity were to start in the following year, following earlier road mapping. One respondent (Shoreton) mentioned that CCA of transport infrastructure is an important aspect in the municipal comprehensive plan which has a 10-year perspective. The establishment of reserve power stations was mentioned by two municipalities (Tidewall, Tollbridge). However, one interviewee (Keycastle), responsible for CCA of transport infrastructure, did not actually answer the question but instead talked about (climate) smart buildings and environmental procurement requirements. Likewise, the respondent (Kingshill) having had his post for six months did not know if CCA measures had been planned or taken and instead talked about the traffic analysis being performed.

3.4. Responsibility

Question 7: Who in your municipality is responsible, in theory and practice, for planning, decisions, implementation and follow-up of climate change adaptation of transport infrastructure operations and maintenance?

Only one of the respondents (Palmbeach) reported that he was the person responsible (as head of department) for planning, decision making, implementation and follow-up of CCA of transport infrastructure in the municipality, but he had delegated this work to a unit belonging to his organization. Four municipalities (Kingshill, Palmbeach, Shoreton, Tollbridge) stated that the responsibility was distributed between various departments in the municipal hierarchy. In one municipality (Tidewall), no one person or post was said to have the overall responsibility, but the head of the Emergency and Rescue Services had partial responsibility. In another municipality (Keycastle), there was a disaster organization (together with the County Administration Board) that would act should an emergency situation occur. Municipal headquarters were indicated as having the crucial role in two municipalities (Applebay, Shoreton). Three respondents (Flingtown, Keycastle, Shoreton) mentioned politicians as having the ultimate responsibility: “The politicians! Nobody else than the politicians!” One municipality (Tollbridge) was in the state of administrative re-organization. The O&M activities were previously handled using in-house resources. A corporatization and outsourcing was planned but this transition was interrupted half-way. The organization was therefore split into two, with one principal who orders the services and one agent who owns the resources and performs much of the snow-clearance work. This situation had caused conflicts related to economy and planning. Since the economic resources are located with the customer administration, the respondent could only call attention to the need for CCA measures but not push through decisions without agreement from the customer administration. This leaves the impression of an organization which is far from optimal, causing frustration to the respondent: “We are a very confused organization, and we don’t want to have it like this but we have to accept the situation.” An indication of the detrimental influence of re-organization of the municipal administration on the CCA issue was also revealed from another municipality (Applebay).
3.5. The Role of Procurement

Question 8: Is the procurement instrument used to safeguard inclusion of climate change adaptation issues in the operations and maintenance of transport infrastructure?

and

Question 9: To what extent are there requirements related to climate change adaptation in the procurement of operation and maintenance measures?

Four respondents (Flingtown, Keycastle, Kingshill, Tollbridge) considered CCA-related requirements to be included in procurements of O&M contracts concerning transport infrastructure. However, two of them (Flingtown, Keycastle) did not give examples related to CCA but to the over-all environmental policy of the municipality. One respondent referred to demands on street constructions and water supply and sewer systems to be serviceable for 100 years (Flingtown), and another (Tollbridge) referred to salt spreaders sustaining the climate of W Sweden (e.g. wet climate and large de-icing salt usage). Also these requirements seem to have little connection with true CCA. Though being in charge of the O&M of the municipality, one of the respondents (Keycastle) talking about the over-all environmental policy felt he was not the right person to give the view of the entire municipality. Therefore, he referred to the procurement unit, and to the politicians:

“I think you would have received completely different answers [if you had asked the politicians]; they live in quite another world. I live in the reality with the budget I have. They of course also have a budget that they have to keep to, but at the same time they have visions in a quite different way. “

Three municipalities (Applebay, Shoreton, Tidewall) admitted there are no requirements on CCA in the procurement. Another respondent (Palmbeach) informed that inclusion of CCA-related requirements was hindered by the lack of CCA- and environment-related measures in the so-called industry regulations.

3.6. Balance between Planned and Emergency Measures

Question 10: What is the resource share between preventive and emergency measures, in theory and practice?

The resource distribution between planned/preventive and emergency measures related to climate varied greatly between municipalities. The roughly estimated share of 80/20 (Flingtown) between preventive and emergency actions was the only quantified share stated. Another respondent indicated that the majority of resources was consumed by emergency actions (Tidewall). Three respondents (Applebay, Keycastle, Kingshill) indicated their municipalities have budgets for both planned and emergency actions. It was not clear from the interviews whether the other municipalities made this distinction in their budgets. Most answers dealt with snow clearance, and these activities were subject to detailed planning. In at least six municipalities (Applebay, Keycastle, Kingshill, Palmbeach, Shoreton, Tidewall), snow clearance was not economically restricted: “There is nobody who says that we must not clear snow because of lack of money.” In cases of unusually hard winter conditions, deficits may be transferred to the next fiscal year (Kingshill) or will be covered either by additional contributions from a higher administrative level or through redistribution of resources from other O&M activities which will then be given less priority—examples were bare-ground operations (Palmbeach) and upgrading of bridges (Keycastle). Such regularly occurring mis-dimensioning of the budget for snow clearance caused concern to an interviewee responsible for the winter-service machinery: “… an ostrich-like mentality from those who decide on the budget, […] those who in a way just neglect the reality, and then one can throw the budget to hell.”
3.7. Co-operation between Municipal Administrative Units and Co-operation with External Actors

Question 11: In the work with climate change adaptation, what co-operation exists within and outside the municipality?

The question on co-operation within and outside the municipality organization revealed a multitude of co-operative activities but most of the answers were imprecise and did not usually concern CCA. However, one respondent (Tidewall) admitted there was no co-operation specifically covering CCA issues. The nature and degree of co-operation with the various units was seldom revealed. The municipality headquarters office was the most frequently mentioned co-operation partner within the municipalities. Mentioned were also the city architect and municipality units responsible for water supply and sewer systems, urban planning, municipal development and the environment. Co-operation also existed with municipality-owned or private companies dealing with water supply and sewer systems, energy and O&M. One respondent (Tollbridge) mentioned co-operation with neighbouring municipalities, e.g. inventory of equipment to be used in flooding situations. Apart from this, the only external co-operative partner mentioned was the STA (Keycastle). One respondent indicated a need of learning from the experience of other municipalities (Shoreton).

3.8. Hindrances and Conflict of Aims

Question 12: Have you experienced any hindrances in your work with climate change adaptation? With what other issues or interests does your work with climate change adaptation compete?

In six municipalities (Applebay, Flingtowm, Keycastle, Kingshill, Palmbeach, Tidewall), no hindrances or conflicts with other interests were experienced in the CCA work, but there was some budgetary competition with other municipality issues and difficulties in prioritizing CCA work over other fields of the respondents’ duties in two municipalities (Flingtown, Keycastle). One respondent (Tollbridge) felt that environmental issues sometimes clash with CCA issues. Prioritization of CCA issues was sometimes hindered by this issue having limited weight compared with other societal issues (Kingshill). One interviewee (Shoreton) said that the CCA issue “does not feel very prioritized, no it doesn’t. The changes are rather long-term, at least as I view it.” Spontaneously, one interviewee said that “we need to sort of reach out and receive a bit more publicity for these issues. In times of cutbacks these fields may easily become reduced.” (Tollbridge). The same interviewee, though, stated that “this is a highly prioritized issue which poses challenges to us, or makes it extra challenging.”
4. Discussion

Many of the interviewees responsible for CCA issues had limited knowledge of CCA and were not able to clearly distinguish these issues from CCM or even general environmental issues. This is in contrast to other studies where the CCA awareness was found fairly high in Swedish municipalities (SKL 2011, Andersson-Sköld et al. 2013). One reason can be a different selection of respondents. For example, in the study by Andersson-Sköld et al. (2013), the rescue service, city planners and those responsible for risk management were involved in the interviews, whereas the current study involved respondents related to the transport sector. Here, many of the interviewees devoted relatively much interview time to general environmental measures. One explanation might be that these officials had multiple areas of responsibility and that the CCA questions were therefore given little priority.

Where adaptation actions did exist, in plans or in measures already being taken, the adaptation measures seemed to emerge as a step-by-step and single-issue response to harsh weather situations experienced during recent years. This agrees with previous studies where despite the high awareness, preventive work was found to be less well-functioning than crisis management (SKL 2011, Andersson-Sköld et al. 2013, Andersson-Sköld 2014b). Neither in the referred studies, nor in the current one were there any signs of strategies based on thorough evaluation involving a holistic view of possible aspects of longer-term future adaptation needs. Likewise, allocation of responsibility for these issues seemed to be unclear, and the focus for working with CCA seemed to be in conflict with other issues for both officials and the municipality. This is in line with a recent study by Roth and Thörn (2015). They found that less than half of the studied Swedish municipalities had decided on the location of responsibility for the planning or the implementation of the CCA work, and only half the municipalities had appropriated funds for systematic CCA.

4.1. State of Knowledge

Only a minority of the respondents spontaneously spotted the established interpretation of the term climate change adaptation. The majority thought either of climate change mitigation measures, such as emission limitations, or various kinds of environmentally friendly measures, such as energy efficiency in the transport sector or even in the construction sector. A large share of the interview time was thus devoted to traffic flows, public transport, transit stations, cycling and issues like that. Some interviewees recurrently spoke about CCM or environmental issues in general even after having repeatedly been re-allocated onto the CCA track by the interviewing researcher. For one respondent, the recurring emphasis on environmentally-friendly measures without coupling to CCA left the interviewer with the impression that it was important to this official to market his municipality as environmentally friendly. It should be borne in mind, however, that the established term (“klimatanpassning”) used in Swedish for “climate change adaptation” does not contain the word “change”.

In spite of the large share of interviewees obviously not grasping the core of the CCA term, six out of eight municipalities had ideas about how the infrastructure will be affected by CCI. Snow clearance, floods and storm-water handling dominated among the themes brought up. Obviously based on experience from recurring practical problems with these disturbances, the views on possible CCI were very limited when it came to the longer perspective, however. The over-all impression given was that the officials were occupied with day-to-day problems leaving little room for elaboration of strategies for CCA in a longer perspective. The respondents from two municipalities could not even imagine in what ways the transport infrastructure could become influenced by climate change. Perhaps, the emphasis on CCM rather than CCA in the interviews can be interpreted as mirroring the relative novelty of the CCA issue and the limited involvement of the transport sector in the issue. Similar novelty of CCA was seen in most sectors in investigations conducted before and around the time of the national climate adaptation inquiry (e.g. Viehhauser et al. 2007, SKL 2009). As a response to the national climate adaptation inquiry (SOU 2007), the EU Floods Directive (Directive 2007) and the
Hyogo Framework (2007), the knowledge has increased within many sectors and the general risk management has been strengthened at the municipal level. Possibly due to the complexity of regulations and responsibilities, the transport sector has, however, not been in focus and sometimes not even included (Andersson-Sköld et al. 2013, 2014b, Roth and Thörn 2015) although CCM needs have been subject to much information from the central authorities for many years (Löfling 2005a, 2005b, Nordlander et al. 2007 SOU 2007). Apart from time shortage, respondents generally saw little hindrance to keeping up-dated. The degree of interest varied from enthusiasm to tiredness. Obviously, attitude and degree of engagement are greatly person dependent.

The interviews were limited in extent and depth, making it difficult to really know how much knowledge on CCA issues the interviewees actually possess. Previous studies on CCA in municipal planning have shown that knowledge is highly important (Storbjörk 2007) and that lack of information (Measham et al. 2011) and limited organizational capacity (Glaas et al. 2010, Dannevig et al. 2012) are important constraints for CCA. However, historical experience of climatic events can spur local climate change actions for prevention measures (Næss et al. 2005), as also seen in this study. Thus, even though we only included eight municipalities, our results are in line with previous findings, indicating that knowledge or (personal) experience combined with municipal experience of climate disasters can explain many of the views revealed in interviews.

4.2. Decision Bases and Planning Tools

Despite the increasing availability of tools, methods and even examples for CCA management and planning, e.g. those collected at the CCA web-portal (http://www.klimatanpassning), the terms “decision support” and “planning tool” seemed unfamiliar to many interviewees. The great variety of climate-related actions continuously being performed or planned indicates that decisions are underpinned by information or factors that the respondents do not necessarily characterize as decision bases or tools. Some municipalities were said to lack decision support or to need better support. Only one respondent (Applebay) clearly stated that the municipality has planning tools, but what he thought of was meteorological service. Desires for better decision bases were expressed, and there was a call for national authorities to provide municipalities with co-ordinated information on CCA issues. Even a municipality having experienced troublesome recurrent climatic calamities (Tidewall) seems to have no clear overview of the presence or need of CCA actions for the transport infrastructure. This is also experienced in larger cities working systematically with CCA, and for example mentioned in a recent thematic extension to the master plan of Gothenburg (ranked third on CCA in Sweden; Roth and Thörn 2015). The over-all impression from the interviews is that the presence, quality and use of decision bases seem to be highly dependent on the personal knowledge and experience of the individual officer. It can therefore be questioned if municipalities’ reliance on individual officers for handling the CCA issues meets the legal requirements (SFS 2003) for municipal planning of emergency actions.

4.3. Risk and Vulnerability Analyses, Performed and Planned CCA Measures

The state of CCA work differs greatly between municipalities. No municipality had performed a specific risk analysis for the transport infrastructure. The degree to which CCA issues are in the foreground, plans have been made and actions taken seems to be greatly coupled with the degree, characteristics and severity of weather-related incidents having occurred in the municipality during the last few years. Similarly, experience from Norway shows that previous weather hazards are important.
to the progress of municipal CCA work (Dannevig et al. 2012). Swedish and Norwegian municipalities have been shown to be more active in developing local climate strategies than other Nordic countries and in fact Norway requires municipalities to develop a municipal climate strategy (Nordic Council of Ministers 2012, ADAPT 2016).

Much effort is devoted to coping with current problems and weather incidents reasonably foreseeable in the near future. In the interviews, it was difficult to distinguish between plans and actions, both seeming to be greatly steered by the problems present in the day-to-day work. However, many municipalities evidenced the presence of detailed plans for the municipal snow clearance. Snow and flooding were the weather phenomena most discussed during the interviews. Little attention seems to be paid to longer-term changes or to getting a picture covering also issues outside the limited responsibility of the individual officer. This clearly indicates that the municipalities are not prepared for CCI.

4.4. Responsibility

The interviewees were selected in their role of head of the department and therefore theoretically responsible for the municipal (road) transport system and associated O&M as well as the CCA thereof. Not all respondents were fully aware of themselves having the responsibility, however. Obviously influenced by the way the municipality is organized, the distribution of responsibility concerning CCA issues differed greatly between the municipalities. The interviews thus revealed a range of locations of the responsibility: the respondent himself, everybody in his respective position, the municipal leadership, the politicians and “no-one”. Some respondents seemed to be rather self-contained and in the position of governing their own working framework. Others gave the impression of being more dependent on higher levels in the organization. It is possible that the responsibility of CCA for the transport system could be situated somewhere else in the municipality, perhaps at a more strategical level. However, the interviewees mainly had the executive responsibility for the O&M of CCA. If someone else had the strategic or planning responsibility, it had not been communicated clearly enough to the interviewees or the interviewees did not reveal that information in the interviews.

The interrupted re-structuring of the organization of one of the municipalities (Tollbridge) was found to cause not only much frustration to the interviewee but also much administrative and budgetary trouble hindering efficient planning of actions and execution of duties. The efficiency in the CCA work seems to be at least partly dependent of the organizational location of the responsibility and the degree to which the individual officer can influence his work. Many officers displayed difficulties in developing perspectives beyond the day-to-day duties.

The interviews thus gave a picture of unclear responsibility for CCA, as found in other studied in Sweden (Andersson-Sköld et al. 2013, 2014b). This is comparable to results from a Canadian study, where local stakeholders saw little need for action to prepare for CCA even when they took the climate change issue seriously (Cloutier et al. 2015). It seems as though CCA, unlike CCM, has a low priority among local politicians in Sweden, which partly reflects their view of local CCA goals being defensive in nature (Hjerpe et al. 2015).

The lack of responsibility or unwillingness to take responsibility for CCA in planning has been reported previously (Storbjörk 2010). In our study, it is clear that there is often a lack of explicit delegation of the responsibility for CCA of the O&M. This may also mirror the limited guidance and the vagueness of duties on CCA placed with the municipalities by the state. Clearer signals from the central government have been called for, as reported in a Norwegian study (Dannevig et al. 2012). Likewise, the importance of institutionalization of feedback of local and regional CCA experience to the national level has been identified in a Swedish study (Nilsson et al. 2012). Limited connection between high-level adaptation principles and concrete technical adaptation measures has been found to hamper the planning of adaptation of special transport modes (Eisenack et al. 2012). At the municipal
level, there might also be other institutional limits (Measham et al. 2011) than those that were only vaguely revealed in our interviews.

4.5. Procurement

In half the municipalities, requirements concerning CCA issues were said not to be used in the procurement of infrastructure O&M. Also where such requirements occurred, the examples given were not related to climate change. Therefore, the overall impression is that CCA-related requirements are almost non-existing in the organizations. Besides, the presentation of examples well outside the field of CCA can be interpreted as limited acquaintance with, or status given to, the CCA issue.

4.6. Balance between Preventive/Planned Measures and Emergency Measures

Only one respondent could provide an estimation of the share of efforts between planned (preventive) and emergency actions. In most municipalities, snow clearance was given the resources needed, whether a specified budget was set or not. Economic resources were redistributed “from elsewhere”—examples of unplanned contributors being road maintenance and bare-ground operations. Interestingly, the only municipality that clearly answered that the major part of the budget was usually consumed by emergency actions was the municipality that had repeatedly experienced severe flooding as well as snow-storm calamities (Tidewall). The limited control of the share between planned and emergency actions can be interpreted as reflecting the state of preparedness for CCA in the municipalities. In any case, any possible CCA strivings seemed to be more dependent on experienced year-to-year weather characteristics than based in solid long-term forecasting of climate change. Thus, our findings support previous studies having shown that CCA at the local level is still to a large degree a reactive phenomenon (Næss et al. 2005, Penning-Rowsell et al. 2006, Amundsen et al. 2010, Roth and Thörn 2015).

4.7. Co-operation

Though frequently giving the picture of much co-operation within and outside the municipality organization, few respondents gave examples concerning CCA. Apart from the information on co-operation with a neighbouring municipality concerning flooding equipment and un-specified collaboration with the STA, little evidence was given of external co-operation. The municipalities therefore seem to be rather self-contained when it comes to CCA. Limited evidence was given for municipalities’ compliance with the law demanding municipalities to plan for co-operation with other municipalities “and others concerned” (SFS 2003). There was thus limited co-operation both within the municipal organizations and with external stakeholders. Very limited cross-sector collaboration on CCA has also been shown in Danish municipalities (Lund et al. 2012). A Canadian study has pointed out multi-sector collaboration as a crucial factor to overcome barriers to CCA (Cloutier et al. 2015). In a Dutch study, cities have been found to seek external actors for partnerships to develop climate strategies (Den Exter et al. 2015).

Municipalities currently look for knowledge and solutions that have already been developed and tested by other municipalities, instead of creating their own decision support and planning tools. This can be interpreted as constructive, since it is better to use proven knowledge or solutions, but it can also risk leading CCA in the wrong direction if the measures implemented do not fit the circumstances of the municipality, or if they are not scientifically sound.

4.8. Hindrances and Conflict of Aims

Regarding hindrances or conflict of aims, the interviews gave a split picture. The status given to the CCA work in municipalities seemed to be very person-dependent. The efforts of individuals have
previously been identified as a crucial factor for CCA progress in Norwegian municipalities (Dannevig et al. 2012). In addition, when climate change is considered as an environmental issue among other topics such as pollution and water quality, CCA has to compete at the local scale for priority (attention) and resources (funding) (Measham et al. 2011). One interviewee felt the CCA questions to be little prioritized but at the same time admitted climate change is a long-term process. Thus, the status of the CCA issues may be dependent on whether CCA is viewed as an issue of public safety, development or environmental protection.

4.9. Conclusions

In conclusion, the current state of knowledge, planning and actual CCA seems to be highly dependent on individual officials, their interest, passivity or activity regarding CCA, their position in the municipal organization and its defined responsibilities and boundaries. Our results were based on only eight municipalities but showed much similarity with previous findings in the Nordic literature.

The number, depth and extent of the interviews were admittedly limited. Also, the interview responses naturally reflected the organizational structure of the municipality, and the size of the municipalities was within a narrow span, though comprising 62 of Sweden’s 290 municipalities. Nevertheless, the interview material as a whole points to a limited appreciation of the threats from future climate change and much room for development of adaptation measures based on broader analyses of needs of long-term planning and action.
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