Planners' information need in adaptation to climate-induced floods

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Abstract

This study investigates urban planners' need for information to adapt to climate change. Interviews with planners in Trondheim and Stavanger disclose gaps in the provision of data and needed tools.

Climate change is increasingly seen as a major challenge within the field of urban planning. Many places will need to adapt to new climatic conditions, resulting in more severe droughts; rising sea levels; increasing precipitation; air pollution; water scarcity and increasing risk of landslides. Despite the growing awareness of the potential consequences of climate change, the process of climate change adaptation remains slow. In Norway, the central role of the local municipalities in the climate change adaptation process was underlined in the White Paper on climate change adaptation and urban planning has been given a central role in the adaptation process.

One of several reasons for the passive approach to climate change adaptation is the lack of relevant information. Although there is an abundance of research about climate change and its consequences, local officials report that the available data is often not relevant or applicable to the adaptation process on local level.

This study explores planners' information needs regarding climate change adaptation. More specifically, the focus is set on adaptation to climate-induced flood events, as a result of increasing precipitation and sea level rise. Two case studies of the Norwegian municipalities of Stavanger and Trondheim are used to shed light on the necessary data and tools to enhance adaptation to flood risk through planning. The study also considers to what extent the expressed information needs can be covered by existing information resources, as well as what data and tools that would be useful but are currently unavailable in the planning process.

1 Introduction

Climate change is a challenge gaining increasing interest and concern within the field of urban planning. Many places will experience more extreme climates with more severe droughts; increasing precipitation; rising sea levels; landslides; air pollution or water scarcity (Field *et al*., 2016). Despite the rising awareness of the potential consequences of climate change, the process of climate change adaptation remains slow. In Norway, the local municipalities were assigned the main responsibility for the adaptation process, with the White Paper [*Stortingsmelding*] on climate change adaptation (St.meld. 33, 2012-2013), nevertheless many municipalities remain passive actors in the adaptation process.

Previous research finds that one of the reasons for the slow adaptation process in local municipalities is the lack of relevant information. While there is a lot of information available about climate change and its potential effects, officials on municipal level report that they lack information that is locally relevant and useful in the local adaptation process (Aall *et al*.,

2015; Dannevig and Aall, 2015; Hanger *et a*l., 2013; Storbjörk, 2007; Tol *et al*., 2008). Guidance material specifically targeting adaptation in the municipalities is often dominated by general information about climate change and lacks descriptions of specific adaptation measures that could be implemented (Hauge *et a*l., 2016). A survey conducted among Norwegian municipalities showed that 9 out of 10 municipalities wish to have more information about the local effects of climate change (DSB, 2008). The mismatch between the existing information resources and the local planning practitioners' need for information represents therefore a substantial obstacle to incorporating climate change adaptation in municipal planning processes.

The main motivation for this study is to define which information resources are needed in planning for climate change adaptation within the specific scope of climate-induced floods in Norway. Climate-induced flood risk includes sea level rise and urban runoff.

The research question may be expressed as: What data, tools and guidance material are needed to improve flood adaptation in municipal planning processes?

The methodology is presented in Section 2, together with the chosen case studies. In Section 3, the findings are presented and discussed in relation to relevant planning theory, in order to assess the necessity of information resources for a pro-active approach to flood adaptation in planning. Section 4 summarizes the main findings of the study and gives some suggestions for implementation.

2 Material and Methods

2.1 Case study 1: Stavanger municipality

Stavanger is a coastal municipality in south-western Norway, incorporating the city of Stavanger and its immediate surroundings with a population of 130 000 inhabitant (SSB, 2018). Projections suggest that the region will see a 10 percent increase in the average annual precipitation until the end of the century (Miljødirektoratet, 2015). In addition, the number of days with extreme precipitation could more than double in the worst scenarios (Hanssen-Bauer *et al*., 2015). The risk for floods will thus increase, especially in urban areas in form of increasing urban runoff (Miljødirektoratet, 2015). Stavanger is also vulnerable to the effects of rising sea levels. Already today, central parts of the city are at flood risk during storm surge events (COWI, 2017) and the sea level is expected to rise by up to 80 centimetres by the end of the century (Simpson *et al.,* 2015). A recent cost-benefit analysis of future flood damage in Stavanger estimates the potential costs to 11 billion NOK by 2090, a cost that could be reduced to 3 billion if adaptive measures were implemented (COWI, 2017).

2.2 Case study 2: Trondheim municipality

Trondheim municipality is, with its 190 000 inhabitants the third biggest municipality in Norway based on population size (SSB, 2018). Historically, about 50 different flood events have been registered in Trondheim, primarily related to spring floods of the nearby rivers and streams, but more recently also due to extreme weather events. Climate projections suggest that the region will face both increasing precipitation and sea levels, resulting in higher flood risk. The total annual precipitation is expected to increase with 17 percent in the coming century in the worst scenario and the number of days with extreme precipitation could increase with up to 77 percent (Hanssen-Bauer *et al*., 2015). While sea level rise has so far been compensated for by the regional effects of land rise, it is expected a sea level rise of 53 centimetres by the end of the century (Simpson *et al*., 2015). This will increase the risk of flooding in the coastal areas especially when storm surges and wave effects are considered.

However, in opposition to Stavanger, the possible consequences of sea level rise are not yet seen in Trondheim today.

2.3 Methodology

The study is primarily based on twelve in-depth interviews with public officials at administrative units involved in planning processes in Trondheim and Stavanger municipality. Considering the lack of previous research about the information needs in the planning process with regard to adaptation, the study is intrinsically exploratory in character. As a result, the interviews followed a semi-structured interview design. The interview included a selection of mandatory topics to ensure that key areas were covered, while allowing other (potentially new) topics to be addressed.

The mandatory main questions and topics that have been addressed are detailed in the following:

- Background?
  Topics: task, role, previous experiences.

- How is climate change adaptation to flood risk addressed in the municipal planning processes today?
  Topics: Previous flood events, cause, effect on the society, effect on the planning process, need for adaptation, factors for facilitating adoption, focus area for climate change adaptation, adaptative measures, success, failures.

- Are the available data/tools/knowledge sufficient for enabling climate change adaptation to flood in municipal planning?
  Topics: Accessibility, relevance, success, failures, user-friendliness, capacity building, responsibility, in-house developed tools, communication.

- How could one better accommodate the needs for data/tools/knowledge about climate change adaptation to flood in the municipal planning process?
  Topics: improvement, lack, communication, dissemination, format, capacity building, prospects.

The organisation of the adaption process varies among the municipalities, and it was therefore not clear from the start who the most relevant informants would be. The coordinator for climate change adaptation provided contacts with relevant interview objects. Priority was given to people who had experience of working with flood adaptation. Their input was therefore assumed to be more informative based on their previous experience. In addition, "*snowball sampling*" was used to identify other relevant interview objects.

3 Results and discussion

3.1 Knowledge-status on climate change adaptation in the municipal administration

The interviews suggest that there is a **general lack of knowledge** and competence within the field of climate change adaptation. The competence on flood adaptation, especially concerning sea level rise, is often very limited in the municipal administrations. Several of the interview participants claim that the competence on climate change adaptation varies a lot from person to person and is primarily based on individual engagement and interest in these issues. "Not all 50 people who work at the planning office are fully updated on these issues. Even though the aim is that they will be", says one of the interview participants. When asked to name the most important factor for strengthening climate change adaptation in planning, one of the planners brings up the need for a "general understanding of what climate change adaptation is", which suggests that even a basic understanding of the concept might in some

cases be missing. Awareness about the need to adapt, together with knowledge about available adaptive measures, are identified as two of the prerequisites for succeeding with planned adaptation (Füssel, 2007). Thus, the absence of these factors could explain why climate change adaptation often has not come further in the municipalities.

The competence gap is most likely even **larger in smaller municipalities** with fewer resources set aside for climate change adaptation. Trondheim municipality was reported to function as a mentor on climate change adaptation for smaller municipalities in the region of *Trøndelag*, none of them had addressed the need for adaptive measures before.

Although the competence level might not be sufficient, the focus on climate change and adaptation to flood risk was reported to have **increased dramatically** in both Stavanger and Trondheim municipalities. "I have worked here for 25 years now and in the past 5 years it has become a growing focus on these issues" said one respondent in Stavanger. At the same time, another respondent noted that flood adaptation was not a central issue on the planning agenda. "In most plans, this is not the main focus, because there are many other things we need to take into consideration as well".

The interviews also suggest that there have been some **internal competence-building initiatives** on climate change adaptation, such as seminars and thematic meetings. However, these have primarily been singular events. In addition, both Stavanger and Trondheim established an intersectoral working group on climate change adaptation, in order to improve the communication between different disciplines and to ensure a more holistic approach to adaptive measures. Interview participants from Stavanger municipality appeared to be satisfied with the intersectoral working group, especially since it includes not only technical service units but also the planning and building inspection units. "But we are not done yet. There is still some potential for improvement", one person says, pointing to the need for some organisational changes and to strengthen the mandate of the group. The intersectoral working group in Trondheim also showed potential for improvements, among other aspects to overcome lack of engagement and insufficient competence among the members. "We need some restructuring, otherwise we will not move forward", said one of the members of the group. "Not everyone has the time, they are not dedicated and competent enough" said another respondent. Lastly, both municipalities are also members of various cooperation networks on climate change adaptation that provide a platform for exchanging experiences and learning from others. However, for the exchange to be fruitful the knowledge must be brought into the local adaptation process. "The network is meant to provide competence and inspiration, but this has to be included in the documents back home, otherwise it makes no sense. It does not matter if you sit here [in the network] glowing with enthusiasm and interest if you do not bring it back home", said one of the respondents.

As a result of limited competence and capacity within the municipal administration, analyses related to flood adaptation in the planning process are usually conducted by **external consultants**. However, one planner underlined that there are not many experts in this field also among private consultants: “The amount might increase if more municipalities begin demanding these [analyses]” said the planner. While no further assessment of the knowledge status among private consultants has been conducted in this study, the interviews suggested that the competence on adaptation to climate-induced floods is rather limited both in the public and the private sector.

The type of mentioned information resources has also been observed to largely depend on the **type of flood risk**. As shown in Figure 1, the interview references to data and knowledge predominantly address adaptation to sea level rise, whereas references to tools are slightly more directed to adaptation to urban runoff. Two hypotheses might explain this tendency: a) reliable data on urban runoff might be difficult to acquire due to the unpredictable nature of

the intensive precipitation; or b) a relative lack of information resources on sea level rise would result in a higher demand.

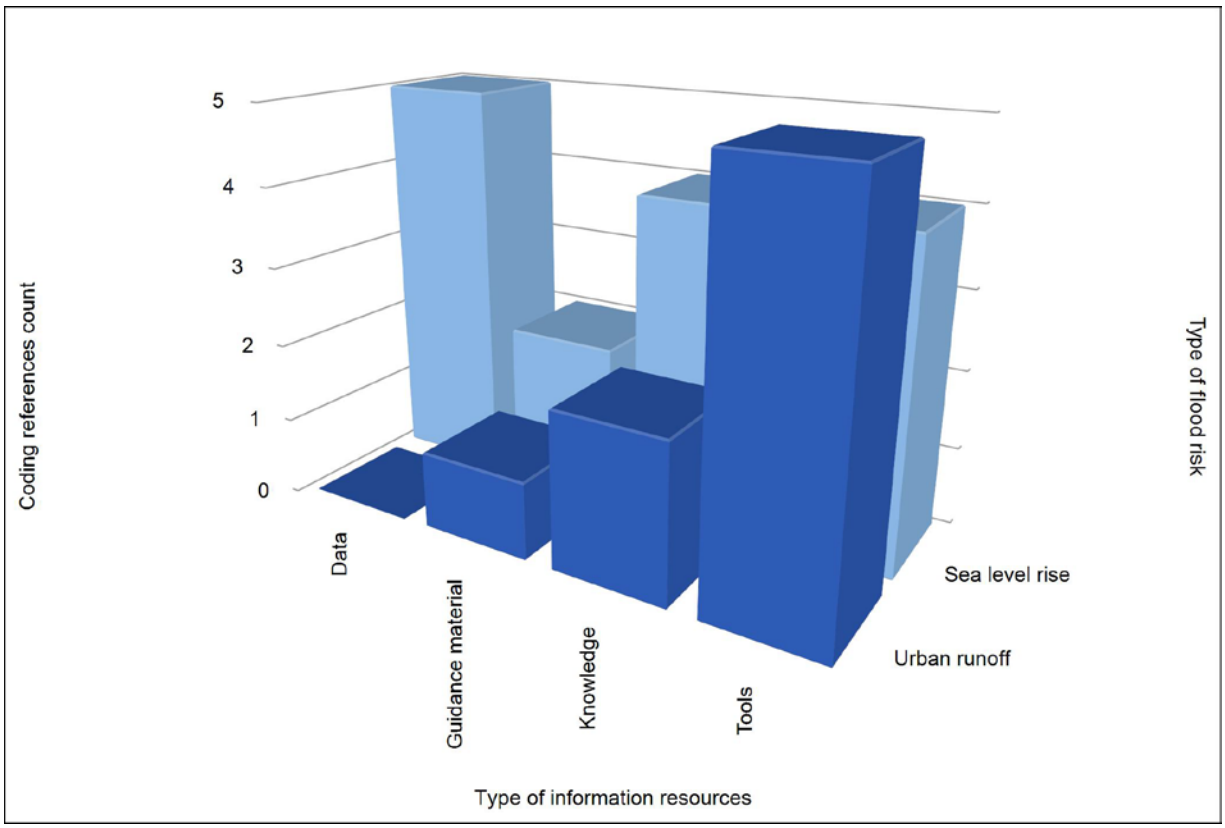

Figure 1: The recurrence of the flood types in relation to the different types of information resources in the interview material.

3.2 Data

Access to data is important in climate change adaptation, both for identifying vulnerabilities and for designing sufficient adaptive measures. **Geographic data** is an important part of the information used to predict and prevent flood risk and is often presented under the form of flood risk maps. One of the key challenges related to geographic data appeared to be the quality of the data sets. "All units try to keep up to date […]. But sometimes we need more precise and more detailed data", said one respondent working with geographic data. Using inadequate data sets in flood risk analyses can result both in that vulnerable spots are missed and that the flood risk zones that require adaptive measures become unnecessarily large. This appeared to represent a critical challenge for mapping waterways. "It is like this with GIS analyses: 'nonsense in, nonsense out'. And this is also the weakness of our old flood way analysis. We see that it does not entirely match with reality [...]. The culverts and streams and such were not sufficiently mapped", said another employee from the geo-data unit. The identification of streams from *Felles Kartdatabase* (FKB) has been based on whether or not the stream is visible on an orthophoto. This approach was reported as problematic in vegetated areas where visibility is low, resulting either in arbitrary mapping or in stream discontinuity.

Laser scanning is mentioned as one of the main solutions for addressing the problems with data resolution, according to NOU 2010:10. "With laser scanning, even in areas with spruce forest, there will be some laser rays reaching the ground, so you get a terrain model also where there is forest", explained one respondent from the geo-data unit. The ongoing nation-wide laser scanning of Norway was therefore observed to be a much-welcomed initiative.

The project began in 2015 and terrain models for large parts of the country are now openly available online. "Previously, the municipalities had to finance and buy this service themselves, but the ongoing laser scanning is actually tax-financed" mentioned a respondent. Hence, in addition to improving the quality of the terrain models, the national laser scan improves the availability of data especially for smaller municipalities that might not have had the resources to conduct mapping projects of their own, thus laying the ground for better flood risk analyses.

Besides geographical data, respondents in both Stavanger and Trondheim municipality noted the importance of **historical data** of flood events. Past flood events were also described as the most reliable source of data for predicting future flood risks. "It is our strongest card in planning, that we prevent [flood risk] based on our previous experiences", said another respondent from the geo-data unit in Stavanger, while agreeing that scenario-based predictions of the future were also important despite their high uncertainty. Both municipalities have records of previous flood events, however the awareness and use of these records seemed to be limited in some of the administrative units, at the same time as being mostly person-dependent. "I have at least not been taught where to look for such information", revealed one respondent from the water management unit. "I know that those who have worked here for a long time know this by heart. But the question is what happens when they leave? Should we then learn it all again?".

The interviews revealed that many of the actors in the planning process have limited or no awareness of the **validity of the data** flood adaptation is based on. "It is a rather simple procedure when I look into the zoning plans", said one respondent at the water management unit. "We just look at the output of these [flood risk] models. But the question is, how well do these results represent reality? I actually don't know that". Only one municipality appeared to actively attempt to verify and validate data used in the planning processes. The verification of data was then primarily based on the engagement of one person at the contingency unit: data could then be verified via the use of external contacts, such as research institutes and national agencies. "I haven't heard about any other [municipalities] that do what I do […] Many just skip this part and hope for the best", said the contingency official. The underlying problem to the lack of data verification is the limited expertise within the municipalities. "It is very specific knowledge that we don't have. There is no one in the municipality [administration] who has expertise on wave impact and such things. And then we are a rather large municipality, so the smaller municipalities don't have a chance to check these things", claimed another informant. As a result, many public officials have no choice but to trust the data provided by external sources.

The inability to verify data also results in the use of **outdated data**. "There were some discussions about what data that would be correct to use for a plan we were working on. You have some [data] [...] and then there was some work […] that was more recent but not approved by the ministry", explained one planner. "We thought we should nonetheless use those that had been approved on a national level [...] even though those numbers were starting to get a bit old". Similarly, one of the respondents from the environmental unit noted that the municipality's flood risk maps, which were made in 2011, were already outdated by newer data. "If you look at the maps on the municipality's website you will see the old sea level estimate from 2011, which says 40 cm sea level rise […]. However, the new guidelines from the Norwegian Directorate for Civil Protection (DSB) [*Direktoratet for Samfunnssikkerhet og Beredskap*] say 70-80 cm, and even more recent research says that we can forget about these small numbers, it will be 100-150 cm". The time lag of acquiring and internalising the most recent data therefore slows down the adaptation process further.

3.3 Tools

GIS software products are one of the key tools in flood adaptation and are used to create flood risk assessments as well as to identify the existing waterways and catchment areas.

GIS tools are often used to generate static 2D maps, however several respondents mentioned **3D-visualisations** as one type of tool that could benefit from further exploration. "If you visualise [flood risk] [...] in 3D […] it becomes understandable to everyone", claimed one respondent from the geo-data unit.

To some extent, the needs for data and tools in the adaptation process was observed to trigger the development of **new functions in the existing simulation software**. Users' needs were in some cases communicated back to the provider, who could then incorporate more customized functionalities. According to one respondent from the geo-data unit, it was easier to influence Norwegian software providers compared to international ones. This was particularly relevant when many municipalities experienced similar problems. "If it is a large company that is based in Europe or the United States, then it is rather difficult to have an impact", described the respondent, who also underlined the importance of educating providers who were not necessarily aware of the challenges regarding flood adaptation.

Quantitative evaluations were also mentioned as important for bringing flood adaptation higher up on the agenda. "Everything you quantify and measure gets prioritised", revealed one of the water management engineers in Trondheim. Although both municipalities implemented regulations and guidelines to enhance flood adaptation through the planning process, neither of them conducted any evaluation of the impact of these measures. The definition of key performance indicators is necessary for identifying both successful examples and problems and would result in a more efficient adaptation process.

Economic analyses of adaptive measures and flood scenarios, when combined to quantitative evaluations, represent not only an opportunity for evaluating a strategy in terms of risk reduction and implementation rate, but would also further inform decision-making and lead to more efficient adaptation. "Transforming it into [monetary value] will allow for comparing, when you are dealing with complex issues involving both 'apples and pears'", said one respondent from the water management unit. Yet the interest in conducting economic assessments was observed to be seemingly low. A cost-benefit analysis of flood damage was developed in one of the municipalities: a GIS-based analysis enabled the estimation of future costs of flood damage to infrastructure as well as possible costs and benefits from adaptive measures. "This is a tool that all municipalities could use if you familiarise yourself with it", said an informant from the contingency unit. "I haven't received many inquiries about it so far, so I suppose there is not so much focus on these matters".

Other key tools used in the planning process today are the various **construction standards**, such as the local water management regulation [*VA-normen*] and regulations on technical requirements for construction work [*Byggteknisk forskrift* (TEK17)]. However, standards are inexistent for more specific solutions such as blue-green solutions, although these are viewed as the preferable and more sustainable way of handling urban runoff. Choosing blue-green solutions therefore becomes a riskier investment, since consultants are not responsible for potential flood damage as long as they act in accordance with the approved practice in many cases the existing construction standards. But when no such standards exist, *e.g*. for blue-green solutions, it is more difficult to claim that sufficient measures were taken if damage were to occur. One water management engineer therefore asked for similar standards for construction and dimensions also for blue-green solutions. "I think it is essential for the implementation of blue-green solutions. Consultants and developers need to feel certain that the solutions they implement are reasonable, and perhaps most importantly, that they will not risk getting responsibility for damage that could happen in the future".

Several of the interview participants claimed that the tools that are available today are generally good. When it comes to **possible improvements** the opinions are more divergent. One informant claimed that there were already rather many tools available, while another was surprised that not more tools had been developed and taken into use. The latter also

noted that the main weakness was the quality of the input-data rather than the tools themselves.

Sometime tools exist but are not used by the municipalities. One possible explanation to the **limited use of tools** is the lack of awareness and competence. Toolboxes that collect relevant resources can be found; however, these are not necessarily complete and are often one of many such resources collections. In addition, the employees experience that it is difficult to stay fully updated on developments in the field. "It is a very large organisation and many areas of responsibility and many people, so it is not always easy to keep update on everything that is new", according to a planner.

3.4 Guidance material

A large amount of guidance material on climate change adaptation has been published in recent years. A review of 84 different reports and websites addressing climate change adaptation was published by *Klima 2050* (Hauge *et a*l., 2016) and identified some **general trends** in the existing guidance material. Firstly, it often focuses primarily on general information about climate change, rather than detailed information about implementation of possible solutions. Secondly, much of the guidance material lacks a defined target group, which may reduce the effectiveness of the communication. Moreover, none of the reviewed guidance material focused on decision-making processes and coordination between different sectors in the adaptation process. These findings were also reflected in the interviews.

The guidance material that is available **does not reflect the need** of the users. One respondent described difficulties in finding more technical information in the guidance material. Another one asked for more examples of how adaptive measures could be implemented in practice and for more information about the implementation process. The guidance material was also mentioned to be too much simplified, *e.g*. in regard to the complexity of the impact of waves on sea level rise. At the same time, users reported to experience difficulties when navigating through an overload of information. "If it is like you say that there are more than 80 reports out there, it is rather obvious that it will be difficult to keep track of it all", reflected one planner.

The absence of process-related guidelines was also considered as an opportunity for improvement on adaptation. "There should be [...] guidance material for each phase [in the planning process]", said one informant. "Those who are responsible for the different phases in a project need to get clear guidelines describing that 'here you should watch out for this; and consult these actors and ask about such and such'. Then you can say that this is done; OK, move on to the next phase. [...] There is too much discussion about this [process] in general" observed an informant from the environmental unit.

There is also an **uneven focus** on the different topics covered in the guidance material. The interviews indicated that the available guidance material is more useful for dealing with urban runoff than it is for addressing sea level rise. This is in agreement with the thematic analysis presented by Hauge *et al.* (2016), which showed that 19 percent of the guidelines reviewed focus on urban runoff, compared to merely 1 percent that dealt with sea level rise.

The often **poorly defined target group** is mentioned as another challenge with the current guidance material. "Who is it made for? Is it for someone with a PhD or are they written for [anyone]?" asked one informant from the environmental unit. The unclear target group was also considered to be one possible explanation to the limited usage of the existing guidance material. However, when asked about who primarily uses the guidance material, the general perception was that the resources were used. "Maybe the environmental unit uses it. The building inspection office and the planning office probably also must look into these matters. [...] Guidance material on climate change adaptation should also be something that the water management unit goes though", estimated one planner. Nevertheless, most of the interview

participants primarily talked about others using the guidance material, while those that did use it mainly emphasized its deficiencies.

4 Summary and conclusions

To answer the question: what data, tools and guidance material are needed to improve flood adaptation in municipal planning processes? Twelve interviews were conducted with public officials at administrative units involved in planning processes in Trondheim and Stavanger municipalities in Norway.

Adaptation was shown to gain importance within the planning field, mostly via increased efforts to strengthen competence. However, there is still a need for greater knowledge and awareness on adaptation. The engagement was observed to largely vary, both among individuals and depending on the type of flood risk concerned. The main results suggested that adaptation planning is still not fully institutionalised in the planning practice and is given attention on a more ad hoc basis.

Results showed that there is an ongoing and seemingly accelerating process for improving the quality and access to data used for flood adaptation planning. Yet the major challenges were observed to be related not to the data itself but rather to the ability to make use of it. The interviews unveiled weak points in the organisation of data and the competence of its users, suggesting that these could be possible areas for improvements.

The interviews also suggested that there is a potential for improvements, both regarding the use of existing tools and the development of new tools. The development of tools for visualisation, quantification and standardisation could provide better decision-making support. In addition, organisational and educative measures could probably enhance usage of the already available tools.

Finally, the interviews confirmed the previously observed trend: the available information resources on adaptation do not correspond to the information needs in the municipalities. One measure for improving the usefulness of the guidance material would be to better coordinate the content with the needs as expressed by the users. The use of the existing guidance material would also benefit from better organisation and awareness of the existing material and, perhaps foremost, a reduction in the number of reports and documents.

This study is expected to inform the research agenda and thus to contribute to the development of information resources that are better adapted to the planning practitioners' needs. It is hoped that this study will in the long-term increase the resilience to negative effects of climate change.

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