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Increasing house owners adaptive capacity: Compliance between climate change risks and adaptation guidelines in Scandinavia

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ABSTRACT

Climate change is expected to intensify weather related risks affecting the existing building stock. To increase the understanding of how the capacity among individual house owners to mitigate such risks can be improved, this study analyses the compliance between anticipated climate risks and existing adaptation guidelines to house owners in Denmark, Norway and Sweden. The assessment of climate risks is based on a review of climate change and building research literature. The compilation of available guidelines is based on an assessment of information from government authorities, municipalities as well as insurance companies and organizations. Results reveal a high compliance between available guidelines and risks for already experienced weather risks, while somewhat new risks from anticipated climate change impacts are less covered. To better facilitate adaptive responses, further adaptation guidelines would earn from explicitly targeting house owners, as well as highlighting relationships between anticipated climate impacts, existing weather risks and individual management practices. Public–private cooperation is identified as an important means for making information more accessible and easily available.

1. Introduction

The Scandinavian countries (Denmark, Norway and Sweden) are often considered having a relatively low vulnerability to climate change effects (Juhola et al., 2012, 2014). However, a trend toward increased cost for claims payments to individual house owners from weather related damage has been observed during the last years (Forsikring and Pension, 2013), and these costs are expected to increase further in the future due to anticipated climate change impacts (IPCC, 2012). Within the region climate change is expected to intensify experienced impacts leading to higher likelihood of; (1) drastic and devastating events such as floods, landslides, heat waves and storms, and (2) more gradual changes such as increased risks for water leakage and mold. To a varying degree these changes are expected to generate negative outcomes for residential buildings and public health (Stocker et al., 2013). The severity of current and anticipated impacts depend on both recent severe

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weather events and on societal changes such as urbanization, and are therefore most pressing in urban areas due to dense settlements and economic activity, as well as high pressure on existing infrastructure (Glaas and Jonsson, 2014).

To support individual house owners in mitigating such climate change impacts, information on how to incorporate climate change consideration in individual decision-making processes is a decisive aspect (Lisø et al., 2003). Such information has been presented as one among several determinants of society's adaptive capacity, often conceptualized under the heading of "information and skills" (Engle and Lemos, 2010:7). Here adaptation guidelines represent one important means for building adaptive capacity among house owners, provided they are targeting relevant risks and are available for this specific group of actors (Glaas, 2013; Eriksen et al., 2011; Adger et al., 2007). So far, assessments of adaptive capacity have often focused on the public sector, highlighting the capacity of institutions to manage challenges posed by climate change (e.g. Storbjörk and Hedrén, 2011; Glaas et al., 2010; Urwin and Jordan, 2008), while the preconditions for building private and individual capacity to adapt remains poorly understood (Tompkins and Eakin, 2012; Agrawala et al., 2011).

In all of the Scandinavian countries, various types of adaptation guidelines have been developed for managing weather impacts when maintaining, renovating and (re)building houses, which potentially could facilitate such decisions. However, currently this information is widely dispersed and it is thereby not clear what impacts are most and least covered by existing guidelines, how current guidelines need to be improved, for what risks new guidelines need to be developed and what type of information should be included.

To contribute to the understanding of how climate change adaptation can be facilitated among individual house owners, this study analyzes the compliance between anticipated climate change risks and available adaptation guidelines to this target group in Denmark, Norway and Sweden. Individual house owners refer, in this context, to non-professionals maintaining a residential building such as a private house, cottage or condominium. The overview of anticipated climate change trends and impacts on residential buildings is based on a review of climate change and building research literature, while the compilation of available guidelines to house owners is based on an assessment of information from government authorities, municipalities as well as insurance companies and organizations on their official webpages. The study was guided by the following research questions:

1. Which climate change related risks to residential buildings are anticipated for the Scandinavian region during this century?
2. To what extent do exiting adaptation guidelines to house owners cover the anticipated risks in the region?
3. What actors and countries are most active in developing such guidelines?
4. How should further adaptation guidelines be developed to better facilitate adaptation among individual house owners?

2. Climate impacts in Scandinavia

Societies have always been effected by, and have had to adapt to, varying weather conditions. Due to the location of the Scandinavian countries, cold winters and relatively large amounts of rain and snow have been considered important aspects when houses and infrastructure have been built and maintained. However, climate change is expected to have impacts on these weather conditions by influencing central climate parameters and by generating long term effects such as sea-level rise. Such changes combined with an existing and increased sensitivity of the building stock (due to e.g. densely built urban areas, a high proportion of paved areas, residential areas built closer to watercourses and high pressure on municipal sewage systems) are expected to increase the risks for weather related damage on buildings (IPCC, 2012). Here, the condition of the existing building stock is an important contributory factor to the severity of the anticipated climate impacts presented below.

2.1. Anticipated climate change trends

Recent climate change scenarios show increasing trends for some climate features in Scandinavia during the course of this century, while the development of other features is still more uncertain. In the latest assessment report by the Intergovernmental Panel on Climate Change, distinct increases for e.g. mean summer and winter temperatures, for mean precipitation during winter and for sea level rise are presented, while the trends for changes in wind patterns (including storms) are argued less certain (IPCC, 2013).

The IPCC uses four main climate scenarios, called RCP[1] 2.6, 4.5, 6.0 and 8.5 (Stocker et al., 2013). In this paper, results from a scenario describing a rather low degree of future change (RCP 4.5) were used. Similar trends as presented below are visible also in the other scenarios, but mostly with higher increases. We discuss results for Scandinavia based on a large ensemble of global climate model (GCM) projections from CMIP5 (Climate Model Intercomparison Project Phase 5) put forward in the IPCC assessment (e.g. Christensen et al., 2013). These projections give a broad picture of climate change for the Scandinavian region under RCP 4.5. However, as land-sea contrasts and altitude of the mountains are not well-resolved in the relatively coarse-scale GCMs, some features of the climate are not well captured. Furthermore, some processes are not represented in a good way at the coarse resolution. A particular problem with this is that some extreme events, like heavy precipitation, have small-scale features that

[1] Representative Concentration Pathways.

need a good representation. Therefore, we also discuss results from high-resolution regional climate models (RCM) that to a higher degree can simulate such extreme events (e.g. Rummukainen, 2010). Recently, RCMs have been used to downscale CMIP5 scenarios based on RCP 4.5 and RCP 8.5 to high resolution for Europe (e.g. Jacob et al., 2013). These RCM-produced scenarios show very similar results on the larger scales as the CMIP5 GCMs. But, there are also differences, in particular in the simulation of some extremes. For instance, the climate change signal in extreme precipitation is larger in the RCMs than in the GCMs (Jacob et al., 2013).

For summer temperatures (June–August), the selected scenario shows an increasing trend for the Scandinavian region up to the end of this century with an increase of 1–4 °C (up to the period 2081–2100), with the biggest increase in the north-eastern part of Sweden. For winter temperatures (December–February), the change is expected to be bigger, with an increase of 2–6 °C. Also here the biggest change is expected in the north-eastern part of Sweden. Even more pronounced are the projected changes in cold winter temperature extremes (Nikulin et al., 2011). As an example the coldest day in winter (December–February) could on average become up to 10 °C warmer in the northernmost parts of Scandinavia in the RCP 4.5 scenario in 2071–2100 as compared to 1971–2000 in an ensemble of nine RCM-simulations (Strandberg et al., 2014). The general warming trend further leads to a shortening of the snow season, a shorter period with risk of frost and on an annual basis less days when the temperature fluctuates around 0 °C. The latter, however, shows a more complicated pattern with an increase of zero-crossings in northern parts of the domain where temperatures today are well below zero in winter.

For winter precipitation (October–March), the selected IPCC scenario shows an increasing trend with a change of 0–20% from the current situation with the biggest change in the northern parts. However, here the differences are smaller within the region than for temperature. In most parts of the region, a larger fraction of the precipitation is further expected to be in the form of rain rather than snow. At the same time, however, heavy snowfall will lead to high, and maybe sometimes even increased, snow loads during sufficiently cold periods mainly in the northern parts. For summer precipitation (April–September), the results are less unified within the region and the change in the CMIP5 ensemble is presented in the interval between −10% and +20%. In the eastern parts of southern Scandinavia this trend points toward drier summers than currently, while the biggest precipitation increase is expected in northern Norway (IPCC, 2013). The RCMs generally follow the global climate models with increasing amounts of precipitation. Based on these models it is expected that also precipitation extremes on time scales of one day or less are expected to become more intense in all of Scandinavia in all seasons (e.g. Christensen and Christensen, 2003; Nikulin et al., 2011; Jacob et al., 2013). For sea level rise, an increase is considered unavoidable. However, the magnitude still varies largely depending on the underlying scenario. In the "summary for policy-makers" in the IPCCs fifth assessment report, global mean sea level is estimated to rise between 0.32 and 0.63 m up to the period 2081–2100 when the RCP 4.5 scenario is used (Stocker et al., 2013). The regional and local response is more difficult to assess as local gravitational effects from changing ice cover, wind- and thermally-driven changes as well as isostatic movement of the land surface comes into play. In large parts of northern Scandinavia, however, it is clear that land uplift will counteract the general rise in sea level which is not the case in the southern parts.

For storms, which are another central climate feature, model results are less unified. Some results indicate that the Scandinavian region will be facing a higher frequency up to the period 2081–2100 (Stocker et al., 2013) while other studies find only little or no change in extreme wind conditions (Nikulin et al., 2011). Storms have contributed to high economic costs within the Scandinavian countries historically (Forsikring and Pension, 2013) and should thereby be taken seriously despite the high uncertainties.

2.2. Anticipated climate risks to buildings and human health

Since the performance of residential buildings is significantly dependent on the climate conditions they are exposed to, and since such houses are built for long lifetimes of 50–200 years, climate change creates new types of risks that need to be considered in building management (de Wilde and Coley, 2012; Hallegatte, 2009). To "climate adapt" buildings has therefore grown to become an important management issue (Gupta and Gregg, 2012). The expected changes in the above climate features increase the risks both for direct climate related damage to buildings and for negative health impacts for its residents in various ways (Camillen et al., 2001). It is furthermore important to distinguish between extreme weather events and changes in everyday climate, when it comes to risks, effects and measures. While extreme weather events could cause significant damages on a building object overnight, changes in everyday climate might have a rather long exposure-time before damages are revealed. On the other hand, looking at the whole building mass, the changes in everyday climate have (in total) higher social/private costs than extreme weather events.

Different parts of a house are exposed differently depending on the house type, the materials used, the location of the house, and how the house is maintained. This section presents anticipated risks to various house parts and materials, and possible negative health impacts that the above climate change trends can engender. The overview is built on previous research studies that address one or multiple climate features. An overview of identified risks can be found in Table 1 below.

Changes in annual precipitation patterns are an anticipated effect from climate change which is expected to be distributed differently around the globe (IPCC, 2013). Generally, areas which already have high levels of precipitation are expected to get more, while historically drier areas are expected to get less. Such patterns are claimed already to be occurring, for example in Europe where the northern parts have an increased share of annual precipitation of about 10–40% during the twentieth century, while the southern parts have experienced a decrease of up to 20% during the same time period (Cuevas, 2011). The immediate risks, that an increased annual precipitation gives rise to, are foremost connected to various

Table 1
Anticipated climate risks to buildings and human health in Scandinavia.

Climate feature	Climate risk
Increased annual precipitation/more common and intensified cloudbursts	Water leakage – roofs, façades, basement walls Mold – attics, suspended foundations Rot-decay – wooden façades Frost-decay – stone/brick façades Flooding – basements and gardens Water intrusion from backflow – basements Land-slides – gardens
Increased annual temperatures/more common and intensified heat waves	Dehydration of roofing felt and paint covers – roofs, façades and windows Mold and rot (due to higher humidity) – attics, façades and foundations High indoor temperatures High outdoor temperatures
Sea level rise and more common storm surges	Flooding – gardens, façades and foundations
Changes in snow cover	Damage due to heavy snow loads – roofs Water leakage from thaw – basements Snow and ice falling on people or property
Higher frequency of storms	Construction damage – roofs and façades Falling trees or branches – roofs and façades

forms of water leakages through un-proofed roofs and facades as well as cracks and openings in basement walls (Kvande and Lisø, 2009). However, more rain combined with a higher annual temperature also gives rise to a more humid climate, which, in turn, increases the risk for mold in attics and suspended foundations (Nik et al., 2012), rot-decay in wooden façades and windows (Almås et al., 2011; Lisø et al., 2006) and frost-decay in stone façades (Lisø et al., 2007).

Cloudbursts are a climate feature which globally have increased in number and are causing extensive damage, especially in densely populated areas (Cuevas, 2011). Important risks and common impacts emerging from these events with heavy precipitation over a short period of time include foremost various types of urban flooding and water leakage (Nie et al., 2009). On the individual house scale, the risks that are found most commonly occurring are similar as for increased annual precipitation, i.e. water leakage due to plugged or broken gutters/pipes and cracks or openings in roofing felts, basement walls or façades (IPCC, 2012). However, risks are anticipated to be high also for flooding in basements and low situated houses without basements due to increased rainfall-runoff, among others leading to high water levels in nearby water courses and ground recesses (Nikolowski et al., 2013), and backwater inflow (water pushed up through floor drains, toilets, etc.) as a result of deficient or poorly managed stormwater drainage or sewage overloading (ten Veldhuis et al., 2011). Risks related to flooding on the ground floor are likely highest for properties surrounded by a high proportion of paved areas (e.g. asphalt or paving stones), which decreases the possibility of the ground to infiltrate excess water. Landslides are another impact, which is triggered by more rain-fed slopes (due to e.g. cloudbursts or other types of intense or long lasting rainfall), changes in water levels, and/or human activities such as building construction or deforestation (Can et al., 2005; Wasowski, 1998). These events are caused by movements of rocks, earth and debris down a hillslope which can demolish or damage property and injure or kill people. Landslide risks are generally higher in unstable and exploited slopes (Dai et al., 2002).

A global average temperature increase has been documented over the last half century and annual temperatures now show a general increase of about 0.8° from pre-industrial levels (Stocker et al., 2013). Increased annual temperatures are anticipated to create three main types of risks to residential buildings; water leakage from dehydration of roofing felts and paint covers, mold (especially in attics, see Nik et al., 2012), and rot-decay in wood façades. The two latter risks are influenced by a likely more humid climate (as presented above) while the former is influenced by an expected intensified solar radiation.

As average temperatures are expected to rise, climate scenarios further indicate that heat waves will occur more frequently and with increased intensity during the summer months (Stocker et al., 2013). Anticipated risks from heat waves include mainly indirect damage to residential buildings in form of health impacts caused by high indoor and outdoor temperatures due to increased solar radiation which can lead to deaths and considerable harmful health effects from heat stress and dehydration, or can more generally influence people's well-being negatively (Nikolowski et al., 2013; Guan, 2012). A demonstration of society's sensitivity to heat stress was seen in the summer of 2003 when a heat wave in Western Europe led to around 40,000 reported excess deaths, especially among the elderly share of the population (Haines et al., 2006). Due to climate change, heat waves of this sort are expected to be more commonly occurring, also in currently cold areas such as Scandinavia where there is a low preparedness to deal with these types of events (Coley et al., 2012).

As presented above, increased global temperature is also expected to lead to sea levels rise during the coming century from melting glaciers and ice sheets, thermal ocean expansion and decreased polar ice and snow around the poles (Nicholls and Cazenave, 2010). Risks from sea level rise include foremost various forms of flooding of buildings in coastal areas. These risks are higher in low lying and flat areas where storm surges push sea water far up on land (McInnes et al., 2003). In Norway, for example, as many as 110,000 buildings are situated so close to the shoreline that they will, in some way, be affected by future expected sea level rise (Almås and Hygen, 2012).

During winter season, the expected precipitation increase in the Scandinavian region may come in the form of higher snow loads, which might damage roofs and facades, lead to water leakage when melting, or fall on people or property and thereby create damage (Meløysund et al., 2006). Such risks are higher when the snow is wet.

Increased occurrences of storms and high wind speeds are expected for the Scandinavian region during the course of this century, even though the magnitude of such changes is highly uncertain (Stocker et al., 2013). Risks emerging from such high wind speeds include damage to building structures (e.g. damaged roofs which might increase risks for water leakage), decreased ventilation and heat transfer efficiency, as well as increased risks for damage to the construction from falling trees or branches (Steenbergen et al., 2012).

3. Method

What constitutes an adaptation guideline is in this paper defined as information directed to individual house owners or the like on how to respond to risks (and potentially also benefits) that emerge from weather and climate change effects (c.f. Isoard and Winograd, 2013). The compilation of guidelines is based on information from three types of actors; government authorities, municipalities as well as insurance companies and organizations, highlighted as important actors in spreading information about, and creating incentive to adapt to, extreme and changing weather conditions (Adger et al., 2007). To build an understanding of the availability of guidelines for individual house owners, information has been gathered from web-pages of selected actors. Here, both guidelines developed by the actors themselves and information material and guidelines linked from other pages were selected, sorted and analyzed in accordance with the research questions.

The specific actors have further been selected with regards to two criteria; profession and size. The profession criterion is straightforward in the sense that actors should be involved in managing risks from climate/weather events and have a mandate or interest, in spreading such information to house owners. Size was used as a criterion since bigger concerned organizations theoretically have more resources and thereby can work more extensively with these issues.

3.1. Insurance

Due to the direct influence on costs, non-life insurance companies have an interest in facilitating implementation of risk mitigation measures among insurance takers making these actors important to include in the analysis (Mills, 2012). The three biggest insurance companies for non-life insurance in Denmark, Norway and Sweden conjointly covering a majority of the marker were here selected. However, since some of the identified companies operate on more than one of the Nordic country markets, the total number of studied insurance companies was seven instead of nine (Table 2). To complement the information from insurance companies, guidelines from sector interest organizations (one such exists on national level in each country) were included in the analysis. These organizations speak for the entire sector and mediate commonly relevant information to insurance holders.

3.2. Government authorities

Due to their sectoral expertise and responsibilities, government authorities are important providers of information relevant for the implementation of risk mitigation measures (Keskitalo, 2010). In this study, the national adaptation web-portals which have been set up in Denmark (www.klimatilpasning.dk), Norway (www.klimatilpasning.no) and Sweden (www.klimatanpassningsportalen.se) were used to identify government authorities which are mainly addressing the identified climate change risks facing house owners. In total four authorities and organizations were selected in each of the three countries which produce guidelines covering climate risks related to e.g. building and planning, water management, crisis management and health (Table 2). This information was complemented with information mediated directly through these adaptation web-portals, including both actual guidelines as well as climate relevant information from other authorities, organizations and research institutes.

3.3. Municipalities

Municipalities are crucial actors for spreading climate risk mitigative information to individual house owners since they are providers of important infrastructure such as sewage and storm-water systems and since all municipalities by law are obligated to be involved in local risk management (Glaas, 2013). In the selection of municipalities, both individual as well as clusters of municipalities cooperating on climate change related projects were included in the analysis to cover the largest possible share of available adaptation information. For individual municipalities the three biggest municipalities in Denmark, Norway and Sweden were selected. For the clusters, one such was identified and selected in each country (Table 2). The cluster identified in Norway is called “Cities of the future” and consists of 13 municipalities who co-operates with the government on mitigation and adaptation issues (Government of Norway, 2013). The cluster in Sweden is called “The climate municipalities” which is an association of municipalities, counties and regions cooperating in local climate related issues (Klimatkommunerna, 2013). The cluster in Denmark is called “VANDPLUS” and consists of municipalities, companies, research institutes, universities and government authorities cooperating on common case

Table 2
Actors included in the assessment.

	Denmark	Norway	Sweden
Insurance	– The Danish Insurance Association – Tryg Forsikring – Codan Forsikring A/S – Topdanmark	– Finance Norway – Gjensidige Forsikring – If Insurance – Tryg Forsikring	– Insurance Sweden – If Insurance – Trygg-Hansa – Länsförsäkringar
Government authorities	– National adaptation portal – Nature agency – The Danish Storm Council – Coastal authority – Danish ministry of climate, energy and building	– National adaptation portal – Civil protection and emergency planning – Building Authority – Norwegian natural perils pool – Water Resources and Energy	– National adaptation portal – Board of housing, building and planning – Environmental protection – Civil contingencies agency – The Swedish Metrological and hydrological Institute
Municipalities	– VANDPLUS-project – Copenhagen – Aarhus – Odense	– Cities of the future – Oslo – Bergen – Stavanger	– Climate municipalities – Stockholm – Gothenburg – Malmö

projects to facilitate implementation of adaptation and local economic development (Ministry of the Environment Denmark, 2013).

4. Adaptation guidelines

4.1. Coverage of the identified adaptation guidelines

The anticipated climate risks presented in Section 2 are covered to a varying degree by the identified guidelines, stretching from a high to a low level of coverage. In this study the coverage level has been analyzed according to three aspects; (1) how common specific guidelines are among the selected actors, (2) to what extent identified guidelines cover long- and short-term measures, and (3) what type of information is provided on implementation (Table 3), which is highlighted as important aspects for the mainstreaming of adaptation (c.f. Glaas, 2013; Mickwitz et al., 2009).

4.1.1. High coverage

Guidelines describing how to manage risks of water leakage in roofs due to broken or blocked gutters, downspouts and drainage pipes were the individually most common guidelines among the analyzed material. These risks are seen intensified by increased precipitation in general and by intensified cloudbursts in particular. Guidelines covering these risks include instructions of how to clear gutters and roof drainage from leafs, branches and moss, how to repair broken downspouts, and what new type of material/equipment to use when renovating or rebuilding roofs in order to decrease long-term risks. These measures are considered efficient and inexpensive actions to decrease water leakage, in particular on flat roofs. Several of these guidelines also present how to avoid or repair cracks in roofing felts and/or broken roof tiles.

Other guidelines which are commonly occurring in the analyzed material covers risks of water intrusion from basement walls, which arguably can be avoided in a long and short perspective by repainting walls, repairing cracks, sealing openings and replacing ventilation hutches. Also guidelines covering risks of backwater inflow in basements are common. Backwater inflow occurs when municipal sewage systems are overloaded, inefficient and/or poorly managed leading to storm-/sewage water being pushed up through e.g. basement floor drains or toilets. Presented ways to avoid, or lowering the cost of, these risks include short-term measures such as moving valuable or moisture sensitive items away from the basement floor and temporarily plugging floor drains before an expected cloudburst, and long-term measures such as changing to resistant floor materials and installing controllable drains, backflow blockers, backwater valves or pumped wells. Measures to decrease risk from flooding in combined sewage and storm water systems include short-term actions such as capturing rainwater by using rain barrels or tanks and/or by removing hard surface materials, and long-term measures such as capturing rain water by installing a green roof or increasing ground infiltration by installing a rain bed.

A last set of risks which is highly covered by the identified guidelines is construction damage due to heavy snow loads, water leakage from thaw, and snow and ice falling on people or property which might be important climate risks in the northernmost parts of Scandinavia due to the anticipated increases in winter precipitation. Guidelines covering these risks include short term measures such as how to shovel roofs to decrease heavy weights without damage underlying roof material and where to put shoveled snow to avoid water leakage, and long-term measures describing how to build houses with increased stability.

4.1.2. Medium coverage

A climate risk that can be considered as only partly covered by the identified guidelines is mold growth in attics and suspended foundations, which is intensified by an anticipated higher future humidity in the Scandinavian region.

Table 3
Categorization for analyzing coverage of the identified adaptation guidelines.

Coverage	Specification
High	– Developed or mediated by a majority of the analyzed actors – Cover both long- and short-term measures – Include detailed information on implementation
Medium	– Developed or mediated by several of the analyzed actors – Focused on either long- or short-term measures – Include some information on implementation
Low	– Developed or mediated by a few or none of the analyzed actors – Focused on either long- or short-term measures – Include limited or no information on implementation

Recommended measures to decrease mold growth are to improve attic ventilation and to install dehumidifiers in, or blowing indoor air into, suspended foundations.

A second climate risks which is somewhat covered by the identified guidelines is flooding in basements and gardens due to high water levels in nearby water courses or urban flash floods emerging from cloudbursts, long periods of heavy precipitation, sea level rise and/or storm surges. Highlighted measures to avoid flooding includes building (temporary or permanent) dykes or flood walls, treating brick or lightweight concrete facades with a water-repellent treatment, or installing various forms of movable bulkhead constructions to cover doors, windows and ventilation.

Landslides, triggered by cloudbursts or long-lasting precipitation events, are another medium-covered risk. Actions to prevent landslides are often extremely costly and should therefore be implemented by a municipality rather than an individual house owner. Nevertheless, some measures that house owners can implement themselves are presented, including; soil nailing (spikes drilled into the soil to stabilize slopes), slope drainage, planting of deep-rooted trees and shrubs, or improving slope stability by adding filling material.

The final risk which is partly covered by the identified guidelines is construction damage on houses from falling trees or branches during storms or high wind speeds. Presented measures include to crop big and wind exposed trees and to cut down decaying trees, however without much information on implementation.

4.1.3. Low coverage

A first set of risks with a low level of coverage among the identified guidelines relates to degrading facades due to rot-decay in a more humid climate, frost-decay from zero-crossings and increased precipitation, and a higher wear of painted facades due to higher temperatures. Damaged facades can further lead to water leakage and mold behind the façade. The few suggested measures to avoid these risks include repainting wooden facades and windows more often, changing to moist resistant paints, and increasing the size of roof eaves. These guidelines, however, in most cases include no information on implementation, for example what specific colors to use.

Other climate risks with a low coverage are high indoor and outdoor temperatures during heat waves. Suggested measures to decrease health risk from high temperatures include installing sun blockers, air-condition systems and/or reflecting surface material, and planting trees to create shade in the garden.

A last identified climate risk which is rarely included in the identified adaptation guidelines is construction damage and water leakage from storms or high wind speeds. The only suggested measure to decrease such risks is to ensure that roof tiles, barge boards and roof beams are established firmly, however without any additional information on implementation.

4.2. Most active actors/countries

All analyzed actors are involved in developing or mediating adaptation guidelines to house owners to some extent. Nevertheless, some differences can be identified in the productivity among the three countries and the three actor categories, as well as in what type of information that is included and what audiences are targeted by the various guidelines.

Generally, judging from both the sheer number of developed or mediated adaptation guidelines and the included explanatory text on implementation assessed in this study, national authorities in Denmark appear as the most active in spreading such information to house owners followed by authorities in Norway. This seems to have at least three distinct explanations. First, Denmark has been the country which has experienced the most costly extreme weather events during the last years (Forsikring and Pension, 2013), highlighted as an important driver for adaptation action in previous research (e.g. Næss et al., 2005). One such event in particular, a cloudburst in Copenhagen during the summer 2011, alone triggered insured costs of up to one billion euro (c.f. Forsikring and Pension, 2013).

Second, the Danish government together with private actors has created widely distributed forums for spreading adaptation guidelines to some specifically targeted user groups. One such forum offering concrete adaptation guidelines to citizens (including house owners), municipalities and business organizations is the Danish web-portal for adaptation to climate change (www.klimatilpasning.dk) developed by the “Task Force on Climate Change Adaptation”, institutionalized under the Ministry of the Environment. Unlike the Norwegian and Swedish national web-portals, which also collect information developed by national authorities and climate research, the Danish task force more proactively produces targeted guidelines by cooperating closely with, and mediating relevant information from, private companies (e.g. insurance companies) and organizations. One such private organization which has been active in spreading adaptation guidelines is "Bolius", established in 2002 (prior to any intensive discussions on climate impacts in national policy) with the mission to distribute practical management and building advice to Danish house owners (www.bolius.dk).

Third, within the "Action plan for a climate-proof Denmark" the Danish government has commissioned all municipalities in Denmark to prepare action plans for climate change adaptation, which now is being finalized (Ministry of the Environment Denmark, 2012). As a spin-off from this and previous work, all included Danish municipalities (Aarhus, Copenhagen and Odense) have developed specific web-pages collecting adaptation information (including adaptation guidelines to house owners) on their official municipal web-portal.

Similarly as in Denmark, the Norwegian and Swedish national web-portals assemble information on adaptation to climate change through the cooperation of several national authorities. A big difference between these and the Danish portal is, however, the target audience which further seems to have influenced what type of information is posed. For the Swedish portal, the government clearly states that the Swedish Metrological and Hydrological Institute (SMHI) who host the portal shall "produce information and decision support directed to county boards and municipalities…" (Ministry of the Environment Sweden, 2013, p. 2). Accordingly the information mediated through the Swedish portal is – at the time of writing – mostly general information on climate impacts and city planning, rather than detailed guidelines for management of residential buildings (c.f. www.klimatanpassning.se). The Norwegian portal (www.klimatilpasning.no) also targets municipalities as main audience. However, more specific adaptation guidelines are here directed to the building sector.

In general, Scandinavian national authorities and research institutes are active in developing and mediating information on how to manage climate and weather impacts while insurance companies still provide relatively little such information. The guidelines posed by insurance companies and organizations are mostly basic information on how to avoid flooding in basements and other forms of water damage with relatively limited practical information. An exception is the Danish insurance organization 'Forsikring og Pension' which includes more precise adaptation measures for house owners on their web-portal (c.f. www.forsikringogpension.dk).

Another identified difference is how information from actors outside the public sphere has been incorporated into the guidelines. The selected actors in Norway and Sweden mediate adaptation guidelines produced by private organizations and companies to a much lower extent. This can be a result of fewer and/or less influential private actors involved in producing and processing this type of guidelines. However, hybrid public–private organizations such as national research institutes in cooperation with universities have been highly productive in producing and spreading adaptation guidelines directed to the building sector and can thereby be seen as an exception. However, this information is predominantly directed to an expert audience. Such guidelines are mediated but not interpreted by the Norwegian adaptation web-portal. The few identified adaptation guidelines by private actors found among the analyzed actors in Sweden were developed by energy companies and municipal water companies and mostly mediated by insurance companies.

Last, compared to Danish municipalities, municipalities in Norway and Sweden generally have less information to individual house owners on how to mitigate climate risks for their house. More information is nevertheless provided on the overarching municipal adaptation work and on-going cooperation's with research projects and national authorities. A reason for this might be the focus on public actors as primary agents in the national adaptation work presented within the Norwegian and Swedish adaptation web-portals. The comparatively high number of guidelines developed by Danish municipalities might in turn be a result of the Action Plan for climate change adaptation by the Danish government (2012/2013:13) stating that municipalities should develop adaptation strategies within their jurisdictions.

5. Discussion and conclusions

To build an understanding how Nordic house owners' adaptive capacity can be increased, this study has analyzed the compliance between anticipated climate change risks and available adaptation guidelines to house owners in Denmark, Norway and Sweden.

Climate scenarios up to 2100 indicate anticipated changes such as increased annual temperatures and more common heat waves, increased precipitation, more common and intensified cloudbursts, changes in snow cover, sea level rise, and higher frequency of storms and high wind speeds[2] in the Nordic region. As shown in Section 2 (Table 1), these climate trends are expected to intensify existing weather related risks for residential buildings in the Nordic region such as flooding, water leakage, backwater inflow, heavy snow loads, rot and frost decay, mold and high indoor temperatures.

The assessment of existing adaptation guidelines among the selected actors reveal that guidelines directed to house owners exist to a varying extent. However, these guidelines seldom relate to anticipated future climate change effects from a warmer and more humid climate, such as heat waves, frost and rot decay/mold, as well as risks emerging from higher wind speeds and storms such as construction damage. A majority of the identified guidelines are directed to management of water leakage in un-proofed roofs and basement walls and intrusion of sewage water in basements through drains and toilets. This

[2] The scenarios for increased frequency of storms and high wind speeds are presented as highly uncertain by the IPCC (2013).

indicates that current guidelines often are built on experiences from previous weather impacts and are in this sense reactive, i.e. their development has been driven by experienced rather than expected impacts.

Thus, even though current guidelines are covering existing weather risks from e.g. flooding, water leakage, backwater inflow and heavy snow loads to a high extent, guidelines are generally less developed for how to mitigate future expected climate change risks. As a consequence, existing guidelines do not represent a sufficient medium for conveying messages about anticipated climate change impacts and hazards to citizens. To function as such a medium, the relationship between anticipated future impacts, existing weather related risks for buildings, and management of residential buildings would have to be made more explicit. If so, similar guidelines could serve as a means to increase individual adaptive capacity by functioning as knowledge broker between various information sources which currently are widely dispersed. This could also make them a more adequate source of information for house owners on how to mitigate not yet experienced impacts.

Among the analyzed actors in the three countries, government authorities appear as the most active in developing adaptation to house owners followed by municipalities, while insurance companies yet produce relatively few such guidelines. Generally, actors in Denmark have developed the most detailed information on implementation which likely are a result of the more costly recent weather events, more developed national adaptation policies and more developed public–private channels for spreading information in Denmark. As found also in previous studies (c.f. Agrawala et al., 2011), results here indicate that public–private cooperation is an important aspect for developing adaptation guidelines which can facilitate individual adaptive capacity by making information more easily available and accessible.

The limited amount of actors that were analyzed in this study as well as uncertainties related to the magnitude of climate change impacts in the region have likely affected the overview of available adaptation guidelines and anticipated climate risks to residential buildings in the region. In turn, this has likely influenced the analysis of compliance between existing guidelines and anticipated climate risks. Nevertheless, due to the unequivocal results some general conclusions can be drawn. First, to complement existing guidelines in Scandinavia, adaptation guidelines are required on how to manage risks related to high indoor temperature, mold in foundations and attics, rot and frost decay in facades and construction damage due to high wind speeds which currently have a low or medium coverage. These are somewhat new risks which indicate that climate change considerations currently are not thoroughly incorporated into existing guidelines. Secondly, to increase the distribution of information on adaptation measures, new guidelines should be developed or mediated by private actors such as insurance companies to a higher extent to be more widely distributed and more applied. A general conclusion drawn here is that adaptation guidelines should be developed with specific target groups in mind in order to be an efficient medium for communicating climate change impacts and adaptive measures.

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