Climate Change, Natural Hazards, and Risk Perception: The Role of Proximity and Personal Experience

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Abstract

Understanding public risk perception related to possible consequences of climate change is of paramount importance. Not only does risk perception have an important role in shaping climate policy, it is also central in generating support for initiatives for adaptation and mitigation. In order to influence public knowledge and opinion, there is a need to know more about why people have diverging attitudes and perceptions related to climate change and its possible consequences. By using representative survey data for Norway and multivariate analysis, the authors of this article show that differences in attitudes and perceptions are partially explained by factors such as gender, educational background, and people's political preferences. However, an important factor explaining people's perception of climate change and its possible consequences is their direct personal experience of damage caused by climate-related events such as flooding or landslide. Furthermore, the results show that personal experience of damage has the largest impact on the respondents' belief that there will be more natural-resource hazards locally than in Norway or globally. The results show that merely living in a more exposed area but not having a personal experience of damage does not affect the respondents' concern towards climate change.

Keywords: climate change, distance, natural hazards, personal experience, place effect, risk perception

Introduction

Understanding public perception of the possible consequences of anthropogenic climate change is of paramount importance for both mitigation and adaptation. By better understanding people's risk perception, decision-makers can ensure support for initiatives for climate-change adaptation as well as mitigation efforts among the public. To provide such a foundation, we examine how people in Norway consider the possible consequences of climate change. Our focus is to study how direct personal experience of damage caused by natural hazards and living in an exposed environment affects people's concern for climate change and its effects.

We base our analysis on survey data collected in 2010. The survey included a sample of 1334 persons with data on the respondents' socioeconomic background and answers to more than 40 climate-related questions. This article contributes to the growing literature on risk perception regarding natural hazards in general and climate change in particular. Our contribution is twofold because we study not only the impact of personal experience but also the place effect of living in an exposed area. Furthermore, because results from such national surveys can be culturally bounded, our results for a country with a homogenous population and significant geographical variation in exposure to climate-related hazards contributes to a growing understanding of what shapes the perception of risk related to climate change. Particularly, we look at Norwegians' perception of hazard risk at different levels of scale, namely, globally, nationally, and locally. On the methodological side, we employ empirical methods more rigorous than those commonly used in the field so far by taking into account the survey structure of the data, by using fixed effects to control for unobserved factors, such as local institutions and infrastructure, that may affect the results, and by using an ordered logistic estimation method to fully incorporate the ordered information from the survey responses.

The article is organized as follows. We first summarize the present understanding of the relationship between living in exposed areas and risk perception. Thereafter, we briefly present contemporary understandings of the possible effects of climate change in Norway. Before turning to the analysis, we present the data and methods used in our research. Then, we discuss our main findings and close by discussing some implications for climate policy and research.

Natural hazards, climate change, and perceptions

Risk research has shown that people consider events that appear to be involuntary, uncontrollable, and dramatic, with disaster potential and that are close in time to be more threatening than events that are more gradual, diffuse, and likely to happen in the future (Slovic 1987). The latter includes the time-delayed, abstract, and statistical nature of climate change, which therefore does not evoke strong emotions leading to action (Weber 2006, p. 103). Certain types of natural hazards such as storms and floods, however, are more threatening and can be perceived as a manifestation of changing climate (IPCC 2012; Peterson *et al*. 2013).

The perception of climate-change risk is influenced greatly by affective and emotional factors (including broader values and political preferences) and less by analytical reasoning and rational choice (e.g., Leiserowitz 2006; Myers *et al*. 2013). Dessai *et al.* (2004) describe the aforementioned situation as a conflict between external expert-based versus internal experience-based definitions of risk. A person's perception of climate change may thus be partially formed by her proximity to "danger", for example, through personal experience of an event or by living near or in a hazard-prone area. A review of the case-study evidence of risk perception and natural hazards by Wachinger *et al.* (2013) concluded that direct experience is the factor with the largest impact on risk perception: those who have personally experienced the consequences of a hazardous event tend to be more worried about hazards than those who have not had such experiences.[1]

Although climate change is likely to increase both the frequency and the strength of natural hazards (IPCC 2012), it is not necessary that the experience of such events automatically leads to changes in attitude towards climate change. Whitmarsh (2008), for example, finds evidence that, although direct experience of flooding leads people to perceive flooding as a genuine personal risk, their attitude towards climate change differs little from that of non-victims.

Recent studies, however, find evidence that people's personal experience of natural hazards or climate change[2] are related to their attitude on climate change and climate policy (e.g., Akerlofa *et al.* 2013; Donner and McDaniels 2013; Hamilton and Keim 2009; Howe *et al*. 2013; Leiserowitz 2006; Myers *et al*. 2013; Spence *et al*. 2011, 2012; Weber 2010). Spence *et al.* (2011), for example, find that those who have experienced flooding express more concern over climate change and that this translates into a

[1] There is some evidence for risk denial when facing natural hazards. Research on flood-prone areas, for example, has shown that people living in flood-prone areas, and even those who have experienced flooding, sometimes downplay and underestimate the risk of personally experiencing damaging floods in the future (see, e.g., Harvatt *et al*. 2010 and Krasovskaia *et al*. 2001).

[2] Personal and localized experience with climate change can come through direct experience with extreme climatic events or through personal experience (real or perceived) of more subtle and gradual changes in temperature, rainfall, snow cover, ecosystem, etc. In some studies, such as that by Myers *et al*. (2013), the exact nature of personal experience has not been collected, which makes it more difficult to isolate the effect of different types of experience of changing climate.

willingness to take action in the form of saving energy. However, understanding how personal experience of climate change translates into changes in attitude towards climate change and policy and for whom the impact is the largest is partially unclear. Myers *et al.* (2013), for example, by using a longitudinal study, find that personal experience interacted with prior beliefs in climate change so that personal experience has the largest effect on those who initially had a low prior engagement in climate-change issues.

A person's proximity to the perceived manifestation of climate change and the distance to where the person believes the climate change is likely to have the largest impact potentially play an important role on how people feel about climate change and how threatening they deem it for them personally, locally, or globally. Spence *et al.* (2012) operationalize the concept of distance into four categories of psychological distance[3]: spatial distance, temporal distance, social distance, and uncertainty. Spatial distance is the physical distance to experiencing the impact of climate change, temporal distance measures how soon people think the effects of climate change can be felt, social distance refers to people believing that climate change will have an impact on people similar to themselves, and uncertainty refers to the degree to which a person thinks climate change is taking place and uncertainty about the potential impacts.

In the Spence *et al*. (2012) survey, the respondents believed more that their local areas were likely to be impacted by climate change than faraway places, whereas the respondents believed at the same time that climate change would mostly affect developing countries. Their regression analysis, however, suggests that those who

[3] Scannell and Gifford (2013) use the concept of psychological distance in their study on how framing of the climate change as a locally or globally relevant phenomenon affects the respondents' engagement with climate-change issues.

perceive climate change as more certain (low uncertainty) and think that climate change will affect people like the respondent (short social distance) in the local area (short geographic distance) in the near future (short temporal distance) are most likely to express more concern for climate change.

The study by Spence *et al.* (2012) is not able to differentiate whether the respondents' personal experience – or proximity to such experience – plays a role in determining people's attitude towards climate change. In other words, the study concludes that people are more concerned when they perceive climate change as having the potential to affect them or people like them in the area where they live. An additional dimension to this is to study whether the respondents' personal experience of or proximity to natural hazards or other climate-related phenomena has an impact on their attitude towards climate change. Brody *et al.* (2008), who explore people's perception of climate change and natural hazards in relation to geographic proximity to different types of risk, for example, find that such proximity is of limited importance compared to socioeconomic and attitudinal variables.

In this article, we examine to what extent direct personal experience with an extreme event or simply living in a more exposed area influences the respondents' concern for climate change. Our expectation is that people living in places that experts assess to be more risky or having personal experience of damages from climate-related hazards are more concerned about climate change than those who do not live in such places or do not have such experiences. More specifically, we anticipate that a more hazardous environment increases the likelihood that a respondent lists climate change among the most important challenges for Norway. Furthermore, we expect the respondents living in such environments to have a higher level of concern for the personal consequences of climate change in general. When considering that people tend to be more concerned for local manifestation of changing climate (Spence *et al*. 2012), we expect (1) that personal experience is more salient than merely living in a more exposed area (spatial distance to experiencing danger) and (2) that experience of and exposure to climate-related hazards have a larger impact on people's risk perception of local consequences of climate change than of the global consequences (social distance). We explore these aspects controlling for the potentially cofounding effects of gender, age, education, political orientation, income, attitude to climate change, and set of place-bound factors such as local institutions and geography.

Climate-change effects in Norway

Climate change will affect different countries and regions differently. Norway is likely to experience an increase in temperature between 2.3 °C and 4.6 °C by the year 2100. All seasons are expected to become warmer, and temperatures are expected to increase relatively more in northern Norway. Annual precipitation is expected to increase by 5–30%, with winter precipitation increasing in parts of the country by up to 40%. Sea levels are expected to rise between 40 cm and 70 cm, depending on the height of the continental rise in the different parts of the country (Hanssen-Bauer *et al.* 2009).

The direct economic consequences of climate change for Norway are, according to some studies, likely to be mixed, possibly even positive for some regions and sectors (Vennemo and Rasmussen 2010, see also Smith 2011). An increase in temperature may lengthen the growing season (Hanssen-Bauer *et al.* 2009), which could have a positive impact on agricultural production (O'Brien *et al.* 2006). An increase in winter temperature will reduce the need for heating and thus reduce energy consumption in the winter season. Finally, more rainfall may lead to more water available for hydropower electricity production (Vennemo and Rasmussen 2010).

However, climate change will undoubtedly have direct negative consequences. Førland *et al.* (2007) conclude that there probably will be more winter floods and maybe more floods in late summer and autumn and that some parts of the country will be more prone to landslides as a result of increased precipitation. There are few casualties from natural-hazard events in Norway but flooding, landslides, and storms cause major damage to buildings and infrastructure and thus appear as the more concrete and dramatic expression of the possible consequences of climate change (Rød 2013). it is likely that there will be considerable geographical variation in terms of both exposure and vulnerability to climate-related hazards at the regional and local level (Holand and Lujala 2013; Holand *et al.* 2011; Lujala *et al.* 2014; Rød *et al.* 2012).

When asked about the overall impacts of climate change for Norway, less than one-quarter of the respondents (23%) in the survey used in this study believed that climate change would be entirely negative for Norway, more than half of them (55%) believed that there would be both positive and negative consequences, 20% believed that there would be few or no consequences, and 2% believed that there would be mainly positive consequences. These results are in agreement with evidence from Britain suggesting that people perceive the negative consequences of climate change to outweigh the benefits (Spence and Pidgeon 2010).

Data

The data used in this analysis come from the TNS Gallup Climate Barometer survey conducted in March and April in 2010 (TNS Gallup 2010). The sample consists of 1334 respondents that are representative for the whole population of Norway. The data were collected by using electronic and postal questionnaires. The main objective of the Climate Barometer is to study people’s attitude towards a number of general climate and energy issues, but the 2010 survey contained in addition questions related to people's perception of climate change and natural hazards. The descriptive statistics for the variables used in our analysis are included in Tables 1 and 2.

Dependent variables

In this article, we concentrate on the responses to three survey questions that provide insight into people's risk perception about climate change regarding (1) climate change as one of the main challenges for Norway, (2) concern for personal consequences, and (3) concern about the increased number of climate-related natural-hazard events globally, nationally, and locally.

1. Climate change as one of the main challenges for Norway

In the survey, the respondents were asked to choose the three most important challenges that Norway is facing.[4] They ranked climate change as the sixth largest challenge after road standards, health care, immigration and integration, violence and crime, and education. Of the 1334 respondents, 24% listed climate change among the three main challenges (Table 1). For the analysis, we code this variable as a dummy that takes the value of 1 when the respondent chose climate change as one of the main challenges and 0 if they did not.

[4] The question was: "In your opinion, what are the largest challenges in Norway today? Choose up to three from the following list." The list included the following entries: the queues in health care, immigration and integration, increasing violence and crime, school and education, climate change, poverty and injustice, unemployment, narcotics, economic growth, defence, terrorism, financial crisis, and culture.

2. Personal consequences of climate change

On a five-point Likert-type scale, the respondents were asked to rate whether they were concerned about possible personal consequences of climate change.[5] Circa 60% of the respondents partially or totally agreed with the statement. The variable is coded by using a scale from 1 to 5, where the value of 1 is given for the lowest level of concern.[6]

3. Climate-related hazards

On a five-point Likert-type scale, the respondents were asked to indicate to what extent they believed that climate change would cause more natural-hazard events in the world, in Norway, and in their own neighbourhood. The respondents were asked to indicate their level of concern separately for six hazard types: flooding, slides, storms, drought, extreme temperatures, and sea-level rise.[7]

We coded the answers for each hazard type by using a 1-to-5 scale and then calculated the average score for each respondent.[8] This was done separately for "World", "Norway", and "Neighbourhood". On average, the respondents thought that there would be larger increases in the number of events on the world scale than in Norway or locally (Table 1). The differences in means between the global and more

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[5] The respondents were asked to give their response to the statement: "I am worried about the consequences that climate change may have for myself and my family."

[6] Because we use ordered logistic regression as our analysis method, it is not possible to incorporate the "I do not know" answers as a separate category in the analysis. Therefore, here and with the other variables, those who did not answer the question or answered "I do not know" are coded as missing.

[7] The question was: "To what degree do you believe that climate change will cause more of the following events in the world?"

[8] If the respondent did not answer or responded "I do not know", we assigned 0 points. If the respondent answered "I do not know" to all hazard types or did not provide an answer to any of them, we coded the final score as missing.

local scales are statistically significant at $p = 0.01$ level. The Cronbach's alpha shows a high internal consistency for each of the constructed measures (all three variables have $\alpha > 0.85$).

In general, more people agreed that there will be more natural-hazard events in the world than in Norway or locally across the different hazard types (Figure 1). Across the different hazard types, in average 22% disagreed with the statement that there will be more hazard events globally. In contrast, in average 44% disagreed that there would be more events in Norway, and 56% disagreed that there would be more events locally. The respondents had especially low confidence that there would be more droughts, whereas they believed that there would be more landslides and floods in Norway. However, when asked about events in their neighbourhood, the respondents listed storms and extreme temperature as the most likely to increase.

Independent variables

Our main variables of interest measure the respondents' direct personal experience of climate-related hazard events and whether the respondents live in exposed areas. The data for the former is derived from the TNS Gallup Climate Barometer survey, and the measures for the place effect are based on expert evaluation (see Table 2).

Direct personal experience of damage caused by a climate-related hazard event

The respondents were asked whether they themselves or someone they knew in their home place had experienced damage due to slides, drought, storms, or flooding.[9] As Table 1 shows, 44% of the respondents had experienced damage from at least one type

[9] The question was: "Have you, or someone you know, been affected by the following events at the home place?"

of hazards (the variable *Affected* in the table). The experience of flooding was the most frequent (32%), followed by storms (24%) and slides (14%). Only 5% had experienced damage caused by drought. These variables are coded as dummies.

Figure 2 shows the variation in the variable *Affected* when the data are aggregated at the county level. On the basis of the respondents' personal experience, the coastal counties in the west and the northern counties seem to be among the most exposed to natural-hazard events.

Place effect

The background information in the TNS Gallup Climate Barometer survey indicates each respondent's postal zone (in 2010, there were over 3000 postal zones in Norway). This allows us to generate a variety of "expert" evaluations for hazard exposure for the area where the respondent lives. We use flood hazard zones, flood susceptibility mapping, proximity to coast, existence of quick clay, elevation, slope, and historic slides to evaluate the exposure of a given postal zone. The different variables are listed in Table 2, together with definitions and descriptive statistics.

Control variables

Earlier studies of natural disasters and climate-change effects indicate that age, gender, educational background, income level, and political and environmental attitude affect people's view of climate change and its effects (e.g., Akerlofa *et al*. 2013; Leiserowitz 2005; Wachinger *et al*. 2013). Furthermore, it is likely that those who believe more strongly that human-induced climate change is taking place more actively seek evidence for it (Myers et al. 2013), exposing the analysis for potential reversed causality. We include therefore these factors as control variables in our analysis.

Demographic

Education is coded by using a 1-to-4 point scale where the lowest score is given to the lowest level of education (the respondent has completed lower secondary school) and the highest score is given to those with a master's degree. The respondent's gross income per annum is indicated by categories with an interval of NOK 200 000 (approximately EUR 27 000). Almost 30% of the respondents either did not know the answer or chose not to answer the question. The income is coded on a scale from 1 to 5, where the lowest category takes a value of 1. Age is controlled by including the respondent's age in the analysis, and gender is controlled by a dummy that takes the value of 1 if the person is female.

Attitude

In the analysis, we need to control for the potential cofounding effect of political inclination and the respondents' general attitude to and knowledge of climate change. The respondents' political leaning is categorized into support for leftist, centre, and rightist parties according to their vote in the parliamentary elections in 2009.[10] Those who did not remember which party they voted for (11), did not vote (51), were not allowed to vote (35), did not want to reveal their vote (78), and voted for other parties (14) are included as a separate category (Other). In the analysis, the dummy "Other" is used as the reference category.

We measure personal attitude towards environmental issues by looking at how much the respondents were willing to pay extra for renewable energy in addition to their current energy bill. The survey measures the willingness to pay by using NOK 500

[10] As leftist parties we include The Norwegian Labour Party, The Red Party, and The Socialist Left Party; centrist parties include The Centre Party, Venstre (the social liberal party), and The Christian Democrats; and rightist parties include The Conservative Party and The Progress Party.

intervals from NOK 0 to NOK 5000 and more. We code the variable “Green certificates” by using a scale with values from 1 to 12, where the value 1 denotes “Nothing” and the value 12 denotes “over 5000”.

As a general measure of people’s attitude to climate change, we control for their tendency to believe that climate change is human-induced.[11] This is measured on a 5-point Likert-type scale. Furthermore, we measure people’s willingness to take responsibility to protect themselves by looking at who had implemented any measures to safeguard their property from the possible effects of climate change.[12] Only 5% of the respondents had implemented measures to limit damage. A dummy for this variable codes a positive answer as 1.

Our two last variables measure the extent to which the respondents felt they understood the concepts "passive house" and "carbon capture and storage".[13] The respondents had the option to answer either yes or no to the first question, and 23% replied that they were familiar with the term passive house. This is coded with a dummy where the value 1 is given for a positive answer. With regard to carbon capture and storage, the respondents were given the option of grading their familiarity with the concept on a 5-point Likert-type scale. This is coded with a variable taking values from 1 to 5, where 1 notes respondents answering “Have not heard of it” and 5 “Know very well”.

Method

[11] The statement was: “I believe climate change is man-made.”

[12] The question was: “Have you taken steps to reduce the risk of future climate change to your own property?”

[13] The questions were: “Are you familiar with the term passive house?” and “How familiar are you with the concept CO2 capture and storage as a climate mitigation approach?”

Because our first dependent variable is binary – either the respondent listed climate change as a major challenge for the future in Norway or they did not – we use logistic regression to analyse it. Our other dependent variables can take discrete values that have meaningful sequential order: respondents could indicate on a five-point scale their level of concern for the consequences of climate change. However, we cannot assume that there are equal-sized intervals between the response options. Hence, the dependent variables are ordinal outcomes and are therefore analysed by using ordered regression.

In ordered logistic regression, only the order information in the variable is used, not the actual values. Thus, the values assigned to the variables do not affect the results. This is an advantage compared to, for example, ordinary least squares (OLS) regressions, where the regression coefficients change if other values are assigned to the answers. On the other hand, multinomial logistic regression would have disregarded the order information embedded in the answers.

The TNS Gallup Climate Barometer survey in 2010 weighted the survey answers by age, gender, and education so that they reflect the total population of Norway as closely as possible. To avoid biases in the estimates and to correct standard errors, we use the weights in the analysis. We use first-order Taylor-series linearization to calculate robust standard errors. STATA 12.1 is used in all analyses.

Naturally, our study results are vulnerable to unobserved heterogeneity due to factors that we are not able to include in the analysis. Such factors may be related to, for example, geography, differences in culture, infrastructure, and local institutions, which in turn may relate to the respondents' level of concern. The effect of such omitted factors on the results can be reduced by using a fixed-effects approach that only relies on the within variation, and therefore, we include fixed effects on county in all model specifications. We also check that our main results are robust to excluding the observations with the largest residuals.

Analysis

The results of simple cross-tabulations and correlation analysis suggest that there is a tendency for those who have personally experienced damage from natural-hazard events to be more concerned about climate change and its effects. For example, 56% of those who have no personal experience are concerned about the consequences of climate change, whereas the proportion is 66% for those who have experienced natural-hazard events. Although simple cross-tabulations and correlations suggest a link between personal experience and attitude towards climate change, we are interested in studying whether this effect is present after we have controlled for possible confounding factors. In the following, we analyse each of our three dependent variables in turn. The results for climate change as a major challenge for Norway and concern for personal consequences are presented in Table 3, and the results for more natural hazards globally, in Norway, and locally are presented in Table 4.

Climate change as one of the main challenges for Norway

We first analyse whether the respondents affected by natural-hazard events are more likely to list climate change among the three main challenges for Norway. The models presented in Table 3 show the odds ratios for logistic regressions: values larger than 1 indicate an increase in the respondents' likelihood of reporting climate change as a major challenge, and values less than 1 indicate a decreased likelihood. The odds ratios provide an intuitive interpretation for discrete variables such as gender or age and for our dependent variables. For example, in Model 1, the odds ratio of 1.316 for gender is interpreted as follows: one unit increase in the control variable, i.e., being a woman, increases the chance of reporting climate change as a major challenge by about 32%.

From Model 1, we can see that the respondents' personal experience of damage (*Affected*) does not have an impact on the likelihood that they list climate change as a major challenge for the future in Norway. This result holds when we control for additional factors that may affect our dependent variable (Model 2).[14] We also include the various place-effect measures for living in more hazardous areas in the models. None of the measures are related to the likelihood of reporting climate change as a major challenge for Norway (results not shown).

The control variables show that respondents with a political leaning towards left and centre are more likely to list climate change as a major challenge, whereas those leaning to the right are less likely to do so. For Model 1, the components of this composite variable (the category "Other" is the reference category) are jointly significant at p = 0.01 level. In Model 2, they are only weakly significant at 12% level (p = 0.12). This means that, when we control for the strength of the belief that there is a human-induced climate change, the political leaning has limited explanatory power.

Respondents with a higher level of education tend to consider climate change as a major challenge. The impact of education is considerable and statistically highly significant. Age, income, and gender do not have any predictive power with regard to listing climate change as a major challenge.[15]

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[14] The results on *Affected* are also robust to removing 5% and 10% of observations with the largest residuals.

[15] All models presented in this article are estimated with *income* as a further control variable. Unfortunately, the variable is missing for almost 400 respondents (30% of the sample). We approached the missing income data in two ways in the analysis. First, we used listwise exclusion of observations with missing information. Second, because listwise exclusion leads to a considerable loss of

As Model 2 shows (not unexpectedly), there is a strong relationship between reporting a higher level of belief that climate change is human-induced and listing climate change as a major challenge. We also see that the respondents who are willing to pay more for green energy and are aware of passive houses are more likely to report climate change as a major challenge.

Personal consequences of climate change

In this section, we study how having personal experience of damage and living in an exposed area affects the respondents' level of concern for the *personal consequences* of climate change. The results of the analysis are presented in Table 3, Models 3-5. Like for Models 1 and 2, Table 3 shows the odds ratio, but here, we have used ordered logistical regression.[16]

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information and inefficient results in the form of larger standard errors and less explanation power and may also give biased results in cases where these observations are not representative for the whole sample, we used *multiple imputation* to include the observations for which income data are missing. This method is a flexible, simulation-based statistical technique for handling missing data. To impute the income values, we used age, gender, education, whether respondents owned or rented their dwelling, and what type of dwelling the respondents had (detached house, semi-detached/undetached house, apartment, or bedsit) in the linear regression imputation model. Income was not significant in any of the models. Furthermore, income had little effect on our variables of interest or the control variables. Therefore, we report results in this article without the *income* variable.

[16] The approach assumes that the odds across the categories are proportional. We tested this underlying assumption by running a test called "omodel", developed by Rory Wolfe from the Royal Children's Hospital Melbourne and William Gould from Stata Corp, College Station, Texas. Furthermore, we ran a generalized ordinal logistic regression and tested whether the reported coefficients were significantly different across the equations. The results of the tests suggested that ordered logit is the appropriate model for the data.

Model 3 shows that personal experience of damage (*Affected*) has a considerable and significant effect on the respondents' concern about personal consequences. Respondents with such experience were 40% more likely to be more concerned.[17] The result is robust across the different model specifications.[18] A more detailed analysis of the marginal effects reveals that, when keeping all the other variables at their means, personal experience increases the likelihood of reporting the highest level of concern ("Completely agree") from 17% (when not affected) to 22% (when affected), a five-percentage-point increase.

When we introduce all four hazard types into the analysis simultaneously instead of the variable *Affected*, all four variables have positive estimates, although only flooding is significant at the conventional significance level (results not shown). Among our variables for the place effect, only flood-zone hazard mapping is related to the respondents' concern for personal consequences (Model 4), but it is only significant at 10% level (p = 0.10) in Model 5 when we control for attitude and knowledge for climate change.

Among the control variables, gender, education level, and political orientation have a large predictive power. Women and those who are comparatively more educated are more concerned about the personal consequences of climate change. Respondents with political leanings to the left and centre are more likely to be worried about the consequences, whereas those leaning to the right tend to be less worried. As previously, controlling for attitude and knowledge towards climate change weakens the impact of

[17] More precisely, the interpretation is as follows: The odds ratio indicates that the likelihood of reporting a one-category higher degree of concern (e.g., responding "Partially agree" instead of "Neither agree nor disagree") is increased by 40%.

[18] Excluding observations with the highest residuals (both 5% and 10%) does not affect the results (results not shown).

political leaning (Model 5). Model 5 reveals that a stronger belief in human-induced climate change or an inclination to be willing to pay for green energy correlates with a greater concern for personal consequences. What is noteworthy is that the inclusion of these controls does not affect the size or the significance of our variable of interest (*Affected*).

Natural hazards

In our last set of analyses, we study the extent to which the respondents believe that there will be more climate-related hazards in the future. The responses are studied separately for the categories World, Norway, and Neighbourhood by using ordered logistic regressions.

World

Table 4, Models 6 and 7, shows the results of our analysis of the impact of personal experience on the respondents' belief that there will be more climate-related hazards in the world. It is apparent that personal experience of damage has a large and significant effect across the model specifications: Model 6 shows that those with personal experience are 67% more likely to believe that there will be more events.[19] An analysis of the marginal effects shows that the likelihood of reporting one of the two highest categories (i.e., "To a great extent" or "To a very great extent") increases by 13 percentage points (from 41% to 54%).

Disaggregation by the hazard type shows that flooding and storms positively and significantly predict the outcome, whereas landslides and drought also have positive

[19] When we remove the observations with the largest residuals, both the size and the significance level of the impact increase (results not shown).

estimates but are not significant (results not shown). None of our variables for the place effect predict the outcome.

Our control variables show that older people and those leaning to the right are less likely to believe that there will be more climate-related hazards in the world, whereas women tend to believe that there will be more. People who believe that climate change is human-induced, those who are willing to pay more for green energy, and those who have a better knowledge of carbon capture and storage believe that there will be more climate-related hazards in the future.

Norway

Models 8 and 9 show the results of our analysis of whether the respondents believe that there will be more natural-hazard events in Norway. By taking Model 8 as our starting point, we find that the respondents with personal experience of damage are 50% more likely to think there will be more events. A marginal-effects analysis shows that personal experience increases the likelihood of reporting one of the two highest categories by 7 percentage points (from 18% to 25%). The size of effect and significance level seem to decrease a bit compared to the global-level analysis.

As for the global level, the disaggregation of the hazard type indicates a positive relation between each of the different hazard types and the outcome, with flooding and storms being statistically significant (results not shown). None of our variables for the place effect predict the outcome variable (results not shown). Our control variables behave in a fashion similar to that found in the analysis of the global effects except that age and knowledge about carbon capture and storage are less salient.

Neighbourhood

Lastly, we run the analysis for the lowest level of scale, the immediate neighbourhood in which the respondents lived. The results are shown in Models 10-12. As can be seen from the models, having personal experience of damage strongly and significantly predicts a higher level of belief that there will be more climate-related hazard events in the neighbourhood: personal experience increases the likelihood of reporting a higher degree of concern by 160%.[20] For those who have experienced damage, the likelihood of reporting one of the two highest categories increases by 13 percentage points (from 10% to 23%).

All hazard types contribute to the positive relationship, landslides being the only variable to fall below the conventional significance level (results not shown). Among our measures for the place effect, the variable for storms predicts the outcome: the higher the number of storm hours within the postal zone, the higher the belief that hazard frequency will increase locally. The controls in our models behave in the same manner as those in the previous analysis on Norway.

Discussion of the main results

Our starting point for this study was that people living in more hazardous places would be more concerned about climate change and its consequences than those who do not live in such places. Our results show that Norwegians with direct personal experience of damage due to a natural-hazard event are more likely to be concerned about the personal consequences of climate change and believe that there will be more natural-hazard events globally, nationally, and locally. However, this direct experience does not affect their likelihood of listing climate change as a major threat for the future of Norway.

[20] Excluding the observations with the largest residuals increases both the size and the significance level of the estimate (results not shown).

There are many possible explanations for the fact that many of the TNS Gallup Climate Barometer survey participants in Norway did not agree with the statement that climate change represents one of the greatest challenges for the future of Norway and that direct exposure did not increase the likelihood of agreement with this statement. Temporal distance and uncertainty, two of the four categories for psychological distance described by Spence *et al*. (2012), may partially explain this result because the most severe consequences of climate change lie far ahead in time and are rather diffuse and uncertain for Norway. It is also possible that people's perception reflects the realities of the future in a reasonable and realistic way. Although a person may expect that there will be more natural-hazard events and may personally have experienced some of the negative consequences of such events, people may not believe that the events will have severe consequences for the country as whole and possibly only limited consequences for those directly affected by hazards.

Personal economic consequences of hazard events are limited in Norway because of insurance arrangements. It is therefore possible that future effects of climate change are discounted. According to Prytz (2010), the insurance coverage in Norway is among the most comprehensive arrangements in Europe. In Norway, all buildings with fire insurance are by law also automatically insured against natural damage, which includes riverine flooding, storms, storm surges, and landslides. The arrangement is administrated by the Norwegian Perils Pool, and all insurance companies selling fire insurance in Norway are members of the Pool. In 2012, the insurance rate was set at 0.007% of the amount of insurance against fire damage. This rate is equal for all, regardless of their place of residence in Norway or which insurance company they use. This unique arrangement may have a reassuring effect for those living in Norway and contribute to the perception of an increased temporal distance.

With regard to geographic distance, our results are in line with the results of Spence and Pidgeon (2010): people, to a significant degree, think that there will be more climate hazards in the world than in Norway or where they live (Figure 1). Personal experience of natural hazards increases people's likelihood to report a stronger belief for more hazard events globally, nationally, and locally. However, the effect is the largest for the local scale. This implies that social distance is salient and that people perceive local "danger" as more threatening.

We also expected that living in or near exposed areas would influence people's attitude towards climate change and its consequences. Our results suggest that only direct experience of a hazard has this effect; we find no systematic evidence that living in an exposed area alone has an impact on attitude.[21] This lack of impact from living in a hazardous area is in line with previous studies on natural hazard and risk perception (e.g., Brody *et al*. 2008 and Wachinger *et al.* 2013). These results support the notion that emotional and experience-based learning is more effective in changing attitude towards climate-change issues than intellectual-based learning, which relies on processing information on climate change and its potential consequences (e.g., Dessai *et al*. 2004 and Myers *et al*. 2013).

Implications for climate policy

The fact that only direct personal experience of hazards seems to be relevant for attitude towards consequences of climate change and that such an experience does not have any

[21] Of our 12 exposure measures and 5 dependent variables, only 2 models showed significant relation to our outcome variable: (1) increased risk of floods in the postal zone positively predicted a higher level of concern for personal consequences and (2) a higher number of storm hours positively predicted the belief in the likelihood of more natural hazards in the future at the neighborhood level.

impact on listing climate change as a major challenge in Norway has some important implications for climate policy and how it should be communicated to people outside the realm of research and policy-making.

People without personal experience of an extreme event need to base their risk understanding on external sources of information, such as education and media. Wachinger *et al.* (2013) find that information and indirect experience through education and media seems to have an effect when people lack direct experience of natural hazards. The media also play a role for those with previous personal experience because media coverage can help in recalling past events and thus reinforces and reactivates memories of past experiences.

Visualization is one recent approach to communicate the risk associated with climate change. Although the effects of climate change for many may be described as vague, abstract, and hidden, science-based visualization is a powerful way to communicate with the public, politicians, practitioners, and stakeholders, helping them to know, see, and recognize the possible effects of climate change (Opach and Rød 2013; Sheppard 2012). As such, visualization tools have the potential to raise people's awareness of what makes places vulnerable to natural threats and to reduce the uncertainty regarding the possible outcomes of climate change.

To mitigate and adapt to climate change, people must be motivated to take preventive actions. Two crucial preconditions for people to take action is that they are aware of what kind of negative effects they may be exposed to because of global warming and that they are aware of what kind of preventive actions would be effective. A third important condition is that they could be personally responsible for damage caused by hazard events. Making municipalities and households bear at least partially the cost of living in high-exposure areas could force better local adaptation. Insurance is mainly an economic coverage of the unexpected, but if an area becomes regularly flooded, such an event may no longer be considered as unexpected. The fact that good mechanisms for economic compensation exist in Norway seems to create weak incentives for precautionary actions (Dannevig *et al.* 2012). If those who live in hazard-exposed areas have to cover a larger share of the cost of resulting damage, local politicians and people will likely be motivated to take measures to increase their resilience to natural-hazard events.

Media, visualization tools and more limited insurance coverage may be ways of increasing awareness of consequences of natural hazards. However, as long as people and local public administrators do not link the natural hazards to climate change explicitly, the most likely response is local adaption to contemporary weather related extreme events, not to climate change as such. Framing the local hazards in the wider context of climate change, and projecting possible future changes in frequency and severity of local hazard events, can help people to link hazards and climate change more clearly and change peoples' perception about climate change and its consequences.

The fact that distance plays a role and that people seem to be more impacted by perceived climate change in the area where they live supports the notion that framing climate change as a local and personally relevant phenomenon is important for engaging the public in climate-change issues (e.g., Scannell and Gifford 2013; Spence *et al*. 2012). However, whether more concern to climate change and its effects translates into more efforts for mitigation and adaptation among the public is not yet firmly established. Although studies such as that by Spence *et al*. (2011; 2012) find evidence for such behaviour, others studies, such as that by Dessai and Sims (2010), find that awareness or experience of climate-related challenges does not necessarily turn into action. This again may be a framing issue. Evans *et al*. (2013) document that promoting a specific environmental action by using economic self-interest as motivation (such as saving money by changing behaviour) does not necessarily promote broader environmental goals, because the motivation is specific to that particular action only. However, if the same behavioural change is promoted by using environmental motives only, the likelihood of inducing other pro-environmental behaviour increases. This illustrates the need to understand, and the complexity of understanding, how personal experience can be turned into a broader support for climate policy.

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Table 1. Descriptive statistics

	Obs	Mean	Std. Dev.	Min	Max
Dependent variables					
Major challenge	1334	0.24	0.43	0	1
Personal consequences	1303	3.54	1.22	1	5
Future climate-related hazards					
World	1299	3.11	0.97	0.2	5
Norway	1294	2.54	0.85	0.2	5
Neighbourhood	1315	2.34	0.75	0.3	5
Independent variable					
Affected (at least by one of the sub-types)	1323	0.44	0.50	0	1
Flood	1313	0.32	0.47	0	1
Slide	1301	0.14	0.35	0	1
Drought	1292	0.05	0.21	0	1
Storm	1297	0.24	0.43	0	1
Control variables					
Education	1326	2.49	0.84	1	4
Income	946	2.29	0.93	1	5
Age	1333	52.0	16.79	15	91
Gender	1334	0.50	0.50	0	1
Voting					
Left	1334	0.40	0.49	0	1
Centre	1334	0.17	0.38	0	1
Right	1334	0.28	0.45	0	1
Other	1334	0.14	0.35	0	1
Green certificates	1228	3.74	3.12	1	12
Human-induced climate change	1302	3.72	1.11	1	5
Limit damages	1285	0.05	0.23	0	1
Passive house	1329	0.23	0.42	0	1
CO2 capture and storage	1267	2.43	0.89	1	5

Table 2. Variables used for expert evaluation of hazard exposure

Variable	**Obs.**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Definition**
Coast	1312	0.46	0.50	0	1	Dummy variable; Takes the value of 1 when postal zone located on the coast (including fjords)
Distance to coast	1312	13	28	0	179	Distance (km) to the nearest coast (including fjords) from the centroid of the postal zone
Distance to sea	1312	94	50	7	283	Distance (km) to the sea (outer coastline) from the centroid of the postal zone
Storm	1312	0.9	3.2	0	56.3	Annual number of hours with storm wind (above 20.8 m/s), 2000–2011, per postal zone; based on 1 × 1 km raster
Wind speed	1312	6.0	1.0	3.3	9.3	The average wind speed (m/s) at 80 meters above ground level, for postal zone; based on 1 × 1 km raster
Landslide	1312	1.1	3.2	0	29	Number of historical landslide events within the postal zone
Elevation	1312	174	215	0	1382	Average elevation (m) within the postal zone
Slope	1312	6.2	4.3	0	27.5	Average slope (in degrees) within the postal zone
Flood zones						
Hazard map	1312	0.16	0.37	0	1	Existence of the 10-, 20-, or 50-year flood zone within the postal zone
Susceptibility	1312	0.09	0.11	0	0.84	Proportion of postal zone considered susceptible to flooding; based on 20 × 20 m raster
Quick clay	1312	0.17	0.37	0	1	Dummy variable that takes the value of 1 when quick-clay hazard zone exists within the postal zone

Notes: The following sources are used: Kravik (2012) for storm data; Byrkjedal and Åkervik (2009) for wind data; NVE (2012) for landslides and quick clay; NVE (2011) for flood hazard maps; and Peereboom (2011) for flood susceptibility. The landslide and quick-clay data are based on the georeferenced historical landslide inventory from NVE. The database includes the slides registered by the Norwegian Public Roads Administration, the Norwegian National Rail Administration, the Norwegian Geotechnical Institute, and Astor Furseth from the Geological Survey of Norway. Only slides registered by Furseth have the required temporal homogeneity, and consequently, only those are used in the construction of the variable for slides.

Table 3. Climate change as a major challenge for Norway and concern for personal consequences

	Major challenge		Personal consequences		
	1	**2**	**3**	**4**	**5**
Age	0.996	1.009	0.995	0.995	1.009*
	(-0.75)	(1.46)	(-1.17)	(-1.17)	(1.69)
Gender	1.316	1.266	1.527***	1.512***	1.362*
	(1.62)	(1.11)	(3.28)	(3.20)	(1.95)
Education	1.450***	1.310**	1.365***	1.368***	1.174*
	(3.76)	(2.37)	(4.18)	(4.21)	(1.81)
Left	1.574*	1.388	1.570**	1.581**	0.818
	(1.75)	(1.02)	(2.15)	(2.20)	(-0.81)
Centre	1.549	2.181**	1.231	1.260	0.931
	(1.45)	(2.17)	(0.86)	(0.97)	(-0.27)
Right	0.550**	1.161	0.485***	0.485***	0.592**
	(-1.98)	(0.40)	(-3.39)	(-3.44)	(-1.97)
Affected	1.101	0.763	1.395**	1.393**	1.411**
	(0.53)	(-1.33)	(2.49)	(2.49)	(2.24)
Human-induced CC		2.549***			4.387***
		(6.63)			(14.06)
Limit damages		0.996			1.460
		(-0.01)			(1.05)
Green certificates		1.189***			1.092***
		(5.55)			(3.09)
Passive house		1.468*			1.048
		(1.85)			(0.28)
CO_2 capture and storage		0.890			0.974
		(-0.92)			(-0.30)
Flood zone, expert evaluation				1.415*	1.484*
				(1.85)	(1.66)
Observations	1,315	1,116	1,290	1,290	1,104

Models 1-2, logistic regression, and Models 3-5, ordered logistic regression, both with robust t-values in parentheses. All model specifications include county fixed effects. Table shows the odds ratio for the coefficient.
** p < 0.1, ** p < 0.05, *** p < 0.01*

Table 4. More natural hazards globally, in Norway, and locally

	Global		Norway		Neighborhood		
	6	**7**	**8**	**9**	**10**	**11**	**12**
Age	0.981***	0.988***	0.991**	0.995	1.000	1.001	1.007*
	(-4.82)	(-2.77)	(-2.22)	(-0.99)	(0.05)	(0.23)	(1.76)
Gender	1.248*	1.417**	1.378**	1.314*	1.662***	1.667***	1.575***
	(1.79)	(2.46)	(2.49)	(1.78)	(4.04)	(4.00)	(3.06)
Education	1.218***	0.955	1.114*	0.914	1.235***	1.233***	1.041
	(2.86)	(-0.57)	(1.66)	(-1.06)	(3.07)	(3.01)	(0.49)
Left	1.421	0.775	1.024	0.615*	1.025	1.034	0.787
	(1.56)	(-1.02)	(0.11)	(-1.91)	(0.12)	(0.16)	(-0.99)
Centre	1.272	0.875	1.036	0.804	1.204	1.160	0.990
	(0.94)	(-0.48)	(0.15)	(-0.79)	(0.83)	(0.65)	(-0.04)
Right	0.422***	0.545**	0.398***	0.541**	0.597**	0.574**	0.692
	(-3.65)	(-2.42)	(-3.96)	(-2.30)	(-2.35)	(-2.51)	(-1.41)
Affected	1.670***	1.548***	1.502***	1.339**	2.637***	2.697***	2.867***
	(3.98)	(3.01)	(3.10)	(1.95)	(7.27)	(7.37)	(7.11)
Human-induced CC		3.822***		2.816***			1.642***
		(14.79)		(13.15)			(6.95)
Limit damages		1.156		1.008			1.098
		(0.47)		(0.02)			(0.30)
Green certificates		1.134***		1.094***			1.066**
		(4.86)		(3.58)			(2.56)
Passive house		1.182		1.118			0.873
		(1.02)		(0.69)			(-0.83)
CO_2 capture and storage		1.203**		1.058			1.013
		(2.04)		(0.59)			(0.14)
Storm hours (ln)						1.033**	1.035**
						(2.19)	(2.08)
Observations	1,286	1,101	1,281	1,097	1,301	1,279	1,089

Ordered logistic regression with robust t-values in parentheses. All model specifications include county fixed effects. The estimated cutpoints are omitted. Table presents the odds ratios for the coefficients.
** p < 0.1, ** p < 0.05, *** p < 0.01*

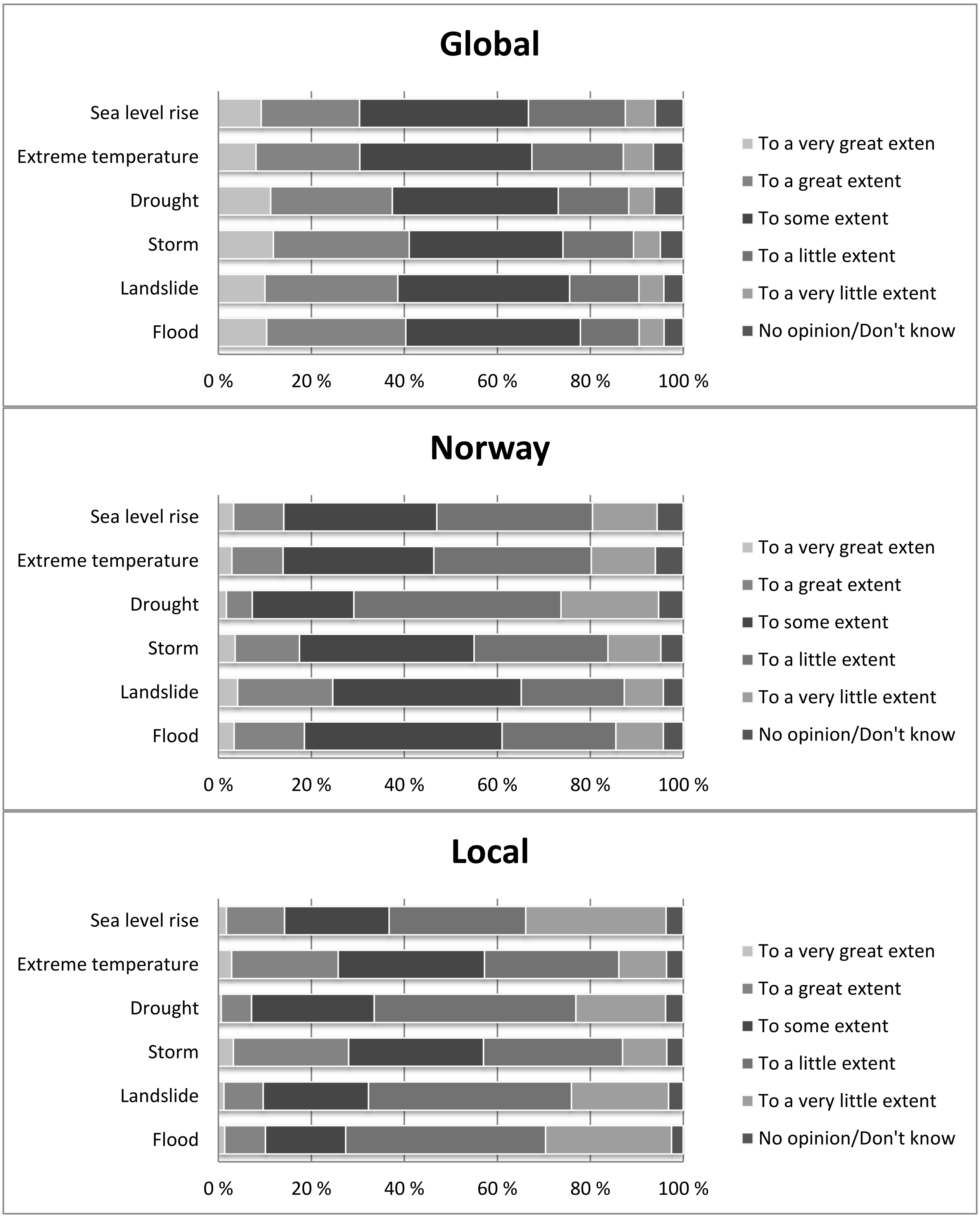
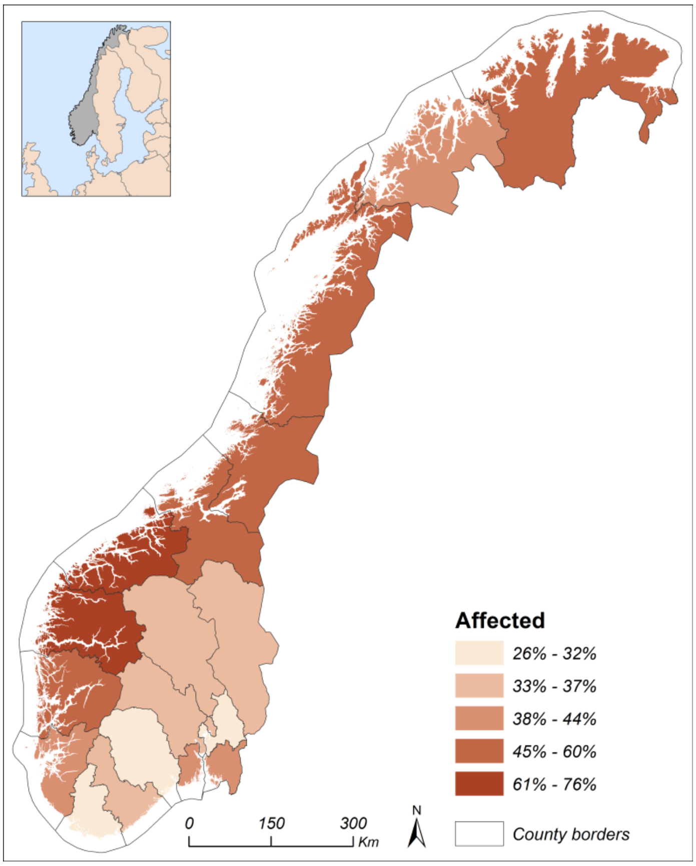


Figure 1. Respondents' agreement with statement "To what degree do you believe that climate change will cause more of the following events in the world/in Norway/in your neighbourhood?'



Note: Natural breaks are used as the classification method. Data from TNS Gallup Climate Barometer survey conducted in 2010.

Figure 2. Geographic variation in the variable "Affected' at the county level. The map shows the percentage of respondents who had personal experience of damage caused by natural hazards.