Endless November? Citizen Beliefs Concerning Wood As A Construction Material Under Extreme Weather Events

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Abstract

Climate change places great pressure on the construction sector to decrease its greenhouse gas emissions and to create solutions that perform well in changing weather conditions. In the urbanizing world, wood construction has been identified as one of the opportunities for mitigating these emissions. Our study explores citizen opinions on wood usage as a building material under expected mitigation and adaptation measures aimed at a changing climate and extreme weather events. The data are founded on an internet-based survey material collected from a consumer panel from Finland and Sweden during May–June 2021, with a total of 2015 responses. By employing exploratory factor analysis, we identified similar belief structures for the two countries, consisting of both positive and negative views on wood construction. In linear regressions for predicting these opinions, the perceived seriousness of climate change was found to increase positive views on wood construction but was insignificant for negative views. Both in Finland and Sweden, higher familiarity with wooden multistory construction was found to connect with more positive opinions on the potential of wood in building, e.g., due to carbon storage properties and material attributes. Our findings underline the potential of wood material use as one avenue of climate change adaptation in the built environment. Future research should study how citizens' concerns for extreme weather events affect their future material preferences in their everyday living environments, also beyond the Nordic region.

1. Introduction

Increasing awareness of climate change since the launch of the IPCC (2018) 1.5-degree special report has set great pressure to the aim of rapidly decreasing global greenhouse gas (GHG) emissions. With the increasing recognition that climate change is a serious matter causing a real crisis, public perceptions on mitigation and adaptation measures need to be studied. According to a recent study by Moran et al. (2020), changes in consumer practices and consumption patterns may reduce carbon footprints beyond business-as-usual by roughly one fourth in Europe, with primary actions targeting transport and food systems, and the building sector.

The built environment is responsible for 40% of final energy consumption, 35% of total GHG emissions, 50% of the utilization of extracted materials, and 30% of water consumption in the European Union (EU), including not only construction processes, but also the use phase of buildings (European Commission, 2011). Toward 2050, the EU carbon neutrality target will require significant measures for decarbonizing the housing stock, particularly through improving the energy efficiency of buildings. With new residential buildings already being built with strict energy efficiency requirements, lower embodied carbon building materials should be increasingly adopted in the future.

Substituting more energy-intensive and fossil-based materials, such as concrete and steel, with wood in contruction offers ways to reduce the embodied (fossil) carbon in buildings (e.g., Cabeza et al. 2014; Gustavsson et al. 2010; Upton et al. 2008). Building with wood has strong traditions in the forest-rich countries of Finland, Norway, and Sweden, with approximately 90% of detached houses constructed with wood as the load-bearing material (Schauerte 2010). Despite this, the annual market share of wood in new apartments remains at approximately 5% in Finland and 20% in Sweden (Sipiläinen 2018; Swedish Federation of Wood and Furniture Industry 2020). Due to this, efforts to promote building with wood been targeted at wooden multistory construction in residential and public buildings in both Finland and Sweden have, especially since the 1990s (Gustafsson et al. 2006). Compared with international discourse on wood construction, these aims have been similar to other countries, where the possibilities of building with wood are seen to connect particularly with the need to provide solutions for urban building (Wiegand & Ramage 2021).

The construction of multistory residential and public service buildings (such as schools and kindergartens) with wood has also been spurred by innovation in industrial prefabrication (Hildebrandt et al. 2017), referring to the off-site manufacturing of elements and components. This allows combining several work phases in a single off-site location, potentially resulting in productivity and quality gains (Malmgren 2014). The prospects for increasing wood use in urban areas have also been considered positive in Finland and Sweden (e.g., Toppinen et al. 2018), due to environmental regulation extending to include the embodied emissions of construction products and the related support measures favoring wood in public procurement.

Besides mitigation, buildings must be constructed to adapt to the changing climate-induced extreme weather, such as higher rainfall during winter months, extended heat waves, or flooding.[1] Extreme weather events are currently widely discussed by the public and in the media, with awareness of climate change and the related crisis building a momentum in society to change the existing building regimes. This connects to enhancing the use of lower carbon building materials, techniques, and solutions that perform well in changing weather conditions while supporting climate change mitigation. For example, Sisco et al. (2017) found relative abnormalities in local temperatures to generate increased awareness of climate change, and Osaka and Bellamy (2020) identified an association between climate change beliefs, personal experiences with extreme weather, and pro-environmental attitudes in respondent backgrounds. According to Bergletz and Al-Saqaf (2020), the extreme weather and climate change are increasingly co-mentioned in social media, which is indicative of improved understanding of the link between extreme weather and climate change. This is essential for legitimizing policymaking on climate change mitigation and adaptation. This publicity can create a higher level of awareness concerning climate change -induced risks and the need to adapt infrastructure for coping with extraordinary weather events. According to Lucas et al. (2021), a personal experience of extreme weather events may affect an individual’s likelihood of purchasing home insurance. In addition, climate events are likely to affect operational costs, insurance requirements, and the capital cost of building assets, and thus increase the perceived risks of rising operating and maintenance costs (Alzahrani et al. 2016).

Citizen perceptions can provide valuable information for the decision-making of construction sector professionals and for policymakers advocating a transition to a lower-carbon economy at national and regional levels. However, public views concerning the benefits of wood construction are more limited in the high-rise context and may even connect with prejudices, which relate to both building with wood in urban milieus and its technological properties as a building material (Lähtinen et al. 2019; Lähtinen et al. 2021). Connected to wood material use in construction, awareness of the need for climate change mitigation does not only concern public perceptions of timber as a building material but also the public's requests for sustainable forest management practices in raw material procurement (Petruch and Walcher 2021). According to Viholainen et al. (2021), citizens from seven countries held multifaceted opinions regarding the technical, environmental, social, and economic aspects of using wood as a construction material. Citizens from forest-rich countries (especially Finland and Norway) emphasized different aspects compared to citizens from less-forested countries (UK, Germany, Denmark), which were more skeptical concerning the environmental ramifications of harvesting timber needed for wood materials. As a result, citizen views of wood construction may be sensitive to their engagement, either via employment or forestland ownership (Ranacher et al. 2017).

Regarding previous literature, it remains unknown whether citizens regard wood construction as beneficial from the perspective of climate change mitigation and adaptation, and how these opinions may be affected with increased occurrence of extreme weather events. Stagrum et al. (2020) reviewed literature on the effects of, and adaptation measures for climate change relating to buildings and found that evidence concerning relevant adaptation measures is limited in cold climates such as the Nordic area. Construction professionals perceive wooden structures to be more expensive to maintain (Ijäs 2013), but the cost differences between alternative materials may be decreasing due to the negative impact of extreme weather on all facade materials. Long and mild winter seasons with wet conditions could have adverse effects on wooden structures, especially on the facades, and citizen views could become averse to wood despite carbon storage benefits. Hence, from a sustainability perspective, this is a potentially "two-sided coin" situation that complicates the opinion-making of citizens: extreme weather may be a risk factor for using wood in the exterior applications of buildings and comes with increasing maintenance costs while concurrently the increase in the embodied carbon stock in the building sector is principally motivated by the urgency of climate change adaptation measures.

Our study sets out to fill the research gap through the following research questions: 1) How do citizens in Finland and Sweden perceive climate change (its origin, level of concern, and treatment in the media) and wood as a construction material under the effects of extreme weather events? and 2) What socio-demographic characteristics explain citizens' beliefs of wood as a construction material in Sweden and Finland?

Finland and Sweden are chosen as target countries, where global warming is expected to increase the risk of heavy and slanting rains, which are especially damaging in urban areas with limited capacity for the soil to absorb excess water (see e.g. Gregow et al. 2021). For example, national climate change expert panel scenarios indicate that a combination of increased rainfall and rising average temperatures will be a likely outcome in Finland (Gregow et al. 2021), where the public commonly refers to the seasonal phenomenon as "endless November". Most residential buildings in the Nordic countries are not typically equipped with mechanical cooling systems, and experiences from the recent 2018 heatwaves have shown the need for installing active cooling systems to avoid overheating, which is forecasted to increase energy demands toward 2050 (Farahani et al. 2021). Forest fire frequency has also increased following summer heatwaves, with several out-of-control fires in Sweden in the summer of 2018. With private family ownership being predominant in both countries, these events have been widely publicized and have caused widespread concerns.

[1] In this paper, we understand extreme weather events to also include a more gradual change in average weather that may have drastic impacts to infrastructure, such as radically increasing rainfall during the winter months.

2. Material And Methods

2.1 Data

Data were collected from the general public in May–June 2021. An Internet-based survey was deployed to a consumer panel from Finland and Sweden, with approximately 1000 responses targeted from both countries. The respondents are fairly in line with population data from the two countries regarding certain key socio-demographic variables such as gender, age, and education level (Statistics Sweden 2021; Tilastokeskus 2021). Due to the sampling techniques and reliance on a consumer panel, we will not attempt to make a full generalization of our results.[1]

The survey elicited information on citizen perceptions of construction materials, with emphasis on wood as a construction material. The survey was offered in the native languages of each country, and panelists responded in their native language. The survey did not specify between residential or public buildings, nor between new or renovation construction. Thus, the focus of the survey was to gain general information on citizen perceptions of wood as a construction material. The survey measured respondents' opinions towards 1) climate change (five statements); 2) wood construction, climate effects, and the trade-offs with the natural environment (six statements), and 3) using wood in construction, especially under extreme weather conditions (nine statements) (See Appendix 1 in supplementary materials). Nine-point Likert scales (1=strongly disagree…9=strongly agree) were used to understand respondents' opinions on these climate- and construction-related statements.

Table 1 shows a summary of respondents' socio-demographic characteristics and response distributions related to forest sector association, their familiarity with wooden multistory buildings (in the survey, defined as "any building of a wooden structure with a minimum of three stories/floors"), and their views of wood as the preferred load-bearing construction material for the respondents' own homes.

In the survey, association with the forest sector was examined with two binary (yes/no) questions: whether a respondent works/has worked in the forest sector and whether the family owns any forestland. For the analysis, these two variables were combined to examine any association with the forest sector. Moreover, the current residential location was originally a five-choice categorical response option, but for the analysis, it was transformed into a three-choice categorical, where 'metropolitan' and 'large city' were combined into ‘large city’; ‘countryside’ and ‘village’ into ‘countryside’; and ‘small/medium-sized city’ remained its own category. The education groups were divided into two, where ‘lower education’ consisted of primary and secondary education and ‘higher education’ consisted of a bachelor’s, a master’s, and a doctoral degree. Fifty-five percent of the Finnish respondents and 60% of the Swedish respondents had completed a ‘lower education’.

Table 1. Summary of Finnish (FIN) and Swedish (SWE) respondents’ socio-demographic characteristics and response distributions regarding wooden building-related factors.

	FIN respondents (n=1007)	SWE respondents (n=1008)
Gender		
Male	49%	50%
Female	51%	50%
Age groups	mean age 46 years	mean age 46 years
18–35	30%	31%
36–55	35%	36%
56-99	35%	33%
Residential location Large city	47%	46%
Small/medium-sized city	37%	36%
Countryside	16%	19%
Education level		
Primary education	9%	9%
Secondary education	46%	51%
University degree, bachelor	28%	29%
University degree, master	15%	10%
University degree, doctoral	1%	2%
Association with forest sector (Yes)	33%	19%
Familiarity with multistory wooden buildings (Yes)	76%	63%
Preference for load-bearing material in own home		
Primarily wood	26%	20%
Wood with other materials	34%	32%
Other than wood (e.g., brick, concrete, steel)	29%	28%
Do not know	11%	20%

2.2 Analysis

2.2.1 Exploratory factor analysis

Exploratory factor analysis (EFA) was conducted for the set of statements regarding wood construction under climate change and extreme weather events, to study whether responses to these statements represent any analogous groups (Fabrigar & Wegener 2012). To begin with, we applied the Kaiser–Meyer–Olkin (KMO) test for sampling adequacy (a minimum value of 0.60 for sampling adequacy) and Bartlett's test of sphericity (Kim and Mueller 1978; Henson and Roberts 2006, Beavers et al. 2013).

Kaiser criterion and parallel analysis were utilized to determine the number of factors to be extracted. According to the Kaiser criterion, the number of eigenvalues greater than one defines the number of factors to be extracted (originally proposed by Kaiser, 1960). On the other hand, the idea of parallel analysis lies in the comparison of eigenvalues from real data, with the corresponding eigenvalues obtained from random data (originally proposed by Horn 1965). Factor analyses were constructed with Maximum Likelihood estimation and Varimax rotation using the R program. Factors that had only one loaded item, along with items that had a loading below 0.4 or above 0.4 for multiple factors, were removed from the final analyses. Moreover, the Cronbach's alpha of each formed factor was studied to measure the internal consistency of the analysis.

2.2.2 Linear regression analysis

The second step of the analysis included a linear regression to study how different respondent socio-demographic background characteristics (age, gender, education, residential location) affected the identified beliefs concerning wood construction under climatic and extreme weather events. Factor scores were used as the dependent variables of citizen beliefs, and separate regressions were executed for both countries. The effect of forest sector association, preferred home load-bearing material, familiarity with wooden multistory buildings, and awareness of the seriousness of climate change were additionally included as moderating variables in the models.

The resulting models were further analyzed with regression diagnostics to study the linear regression assumptions of linearity, residual normality, the homoscedasticity of variance, and the independence of residual error terms (Yan & Su, 2009). Multicollinearity between predictors was studied through generalized variance inflation factors (GVIF), and Bonferroni was used to reveal whether significant outliers exist. Beta coefficients, error terms, and statistical significances are presented for each model in the presentation of the regression models. Diagnostic tests and graphs are available in the Supplementary material together with the R code used. The significance level of all statistical tests and analyses was set at $p<0.05$.

[2] Our survey data can be made available in anonymized form upon request.

3. Results

3.1 Opinions on climate change, extreme weather events, and wood material in construction

The response frequency distributions in Finland and Sweden for the set of questions regarding climate change (Question 13, for full wording, see Supplementary material) are shown in Figure 1. In general, respondents agreed that human activities are causing climate change, climate change is a real and serious matter, and recent extreme weather disasters are caused by climate change. Based on these items, the proportion of respondents denying the seriousness of climate change is just few percentages. Statistically significant differences were not found between the Finnish and Swedish respondents for the latter two statements (Wilcoxon rank test with prob. exceeding 0.05 for these). In contrast, respondents were less homogenous on statements regarding whether climate change depends on natural variations and whether climate change is exaggerated by the media: Swedish respondents were more convinced than Finnish respondents that the media does not exaggerate climate change. On the other hand, Finnish respondents were, on average, more likely to perceive that human activities predominantly cause climate change.

The neutral alternatives (4 and 5 on the scales in Figure 2) were the most frequently chosen responses regarding the question of wood as a construction material in relation to climate change and the effects that wood harvesting has on biological diversity (Q14). Both Finnish and Swedish respondents differed the most in their opinions about whether building with wood destroys important habitats for endangered species.

Regarding the opinions about construction materials and extreme weather (Q15, Figure 3), neutral opinions were again clearly in the majority. The statement concerning the appeal of wooden materials was the only exception, as responses consistently indicated that the majority of respondents either consider wooden materials appealing or do not have a strong opinion about the appeal of wooden materials. When comparing respondents from the two countries, no statistical differences were found for “the use of wood in exterior buildings” or “carbon stored in buildings to increase the attractiveness of using wood”. Overall, respondents from the two countries were found to somewhat differ in their perceptions regarding key areas of opinions (marked in asterisks in Figures 1 to 3), which provides a rationale for analyzing and modelling extreme weather -induced beliefs separately for Finland and Sweden.

3.2 Step 1: Exploratory factor analysis of citizen beliefs concerning wood material in construction

In the first modeling step, exploratory factor analysis was used to analyze citizen opinions about extreme weather events and construction under Question 15. According to the results, both sampling adequacy (KMO=0.76 for Sweden and KMO=0.72 for Finland) and Bartlett’s test of sphericity ($p<0.001$) showed that the samples are suitable for factor analysis in both countries. Based on Kaiser criteria, we examined the eigenvalues exceeding one and the two- and three-factor solutions from the parallel analysis. The three-factor solution did not yield sensible results, with insufficiently loaded items above 0.4. Thus, the two-factor solutions were extracted from the two country data sets to enable logical interpretation. The items that loaded onto the factors were the same for both models, leading to the interpretation of one factor indicating positive beliefs concerning wood construction (named "positive beliefs") and the other factor indicating negative beliefs (named "negative beliefs") (Table 2).[1]

Table 2. Final factor solution for citizen views concerning construction and extreme weather events in Finland (FIN) and Sweden (SWE). Bolded values are the items selected into a respective factor.

	FIN Positive beliefs	**FIN** Negative beliefs	**SWE** Positive beliefs	**SWE** Negative beliefs
Variables	Factor 1	Factor 2	Factor 1	Factor 2
15D. Extreme weather conditions will increase the use of wood as a load-bearing material in construction	**0.607**	0.101	**0.651**	0.275
15E. Carbon stored in wood will increase wood use in construction	**0.873**	-0.018	**0.887**	0.120
15F. Carbon stored in wooden buildings will increase wood use in public service buildings	**0.851**	0.006	**0.868**	0.110
15I. In outdoor use, wooden materials are more appealing	**0.499**	-0.168	**0.507**	-0.022
15C. Extreme weather will curb wood use in building exteriors	-0.046	**0.644**	0.155	**0.576**
15G. Carbon stored in wooden buildings will not increase wood use in residential housing construction	0.002	**0.658**	-0.068	**0.772**
15H. In indoor use, wooden materials are less appealing	0.004	**0.661**	0.160	**0.635**
Eigenvalue	2.11	1.32	2.28	1.43
Explained variance	0.30	0.19	0.33	0.20
Cronbach's alpha	0.790	0.685	0.821	0.693

Altogether, the two-factor solution for Finland accounted for 49% of the variance explained by the model, while the solution for Sweden accounted for 53% of the explained variance. Cronbach's alphas ranged from 0.685 to 0.821, indicating an acceptable level of internal reliability. The resulting factor scores formed variables for explaining respondent beliefs about wood use as a construction material, and they were used as dependent variables in the regression analyses during the second-stage modeling.

3.3 Step 2: Linear regression models of beliefs concerning wood construction and the effect of respondent characteristics

In the next step, the results of the linear regression analyses examining the effect of respondent characteristics on positive and negative beliefs for wood construction (as measured by factor solutions) by country can be seen in Table 3.[1] Accordingly, a positive beta coefficient indicates a positive relationship, i.e., an increase in the independent variable is associated with an increase in positive or negative beliefs, whereas a negative beta coefficient indicates a negative relationship. Based on GVIF, no multicollinearity was found between the predictors (see Appendix 2 in supplementary material). Looking at the regression diagnostics (see Appendix 3 in supplementary material), the assumptions for linear regression analysis were fulfilled for all models. Bonferroni outlier test further indicated that no extreme outliers statistically differing from the other observations exist for any of the models.

Perceived higher awareness of the seriousness of climate change (Q13C) was significant for the extracted positive beliefs in both countries, which suggests that respondents connect increasing embodied carbon stock in the wooden building sector to be motivated by the urgency of climate change mitigation. A binary variable measuring familiarity with wooden multistory buildings was also found to significantly reflect positive beliefs for both countries. Association with the forest sector was only weakly significant in the Swedish model, and it was linked with positive beliefs. This result is somewhat counterintuitive, as a lower proportion of respondents in Sweden (19%) were associated with the forest sector compared to Finland (33%). However, the result may be indirectly influenced by the higher adoption rate of wooden multistory construction solutions in Sweden than in Finland and hence the higher legitimization.

Table 3. Linear regression results for factor solutions of citizen beliefs regarding construction and extreme weather events in models for Finland (FIN) and Sweden (SWE).

	FIN Positive beliefs	FIN Negative beliefs	SWE Positive beliefs	SWE Negative beliefs
	Factor 1	Factor 2	Factor 1	Factor 2
Intercept	**-0.75 (0.17)*** **	-0.04 (0.15)	**-0.60 (0.16)*** **	-0.21 (0.14)
Age group				
36–55	0.00 (0.07)	**-0.18 (0.06)** **	-0.11 (0.07)	**-0.21 (0.06)*** **
56–99	0.12 (0.07)	**-0.34 (0.06)*** **	**-0.15 (0.07)* **	**-0.51 (0.07)*** **
Gender				
Male	-0.03 (0.06)	-0.00 (0.05)	0.11 (0.06)	-0.08 (0.05)
Education level				
Primary or secondary education (lower)	-0.04 (0.06)	0.08 (0.05)	-0.08 (0.06)	0.05 (0.05)
Residential location				
Large city	-0.04 (0.08)	**0.19 (0.08)* **	0.08 (0.08)	**0.15 (0.07)* **
Small/medium-sized city	-0.07 (0.08)	0.12 (0.08)	0.04 (0.08)	0.11 (0.07)
Opinion on Q13C				
Climate change is real and serious	**0.11 (0.02)*** **	-0.02 (0.01)	**0.10 (0.01)*** **	0.02 (0.01)
Preference for load-bearing material in own home				
Other than wood (e.g., brick, concrete, steel)	**-0.49 (0.08)*** **	**0.42 (0.07)*** **	**-0.37 (0.08)*** **	**0.34 (0.08)*** **
Wood with other materials	**-0.19 (0.07)* **	**0.16 (0.07)* **	**-0.17 (0.08)* **	0.11 (0.07)
Do not know	**-0.55 (0.10)*** **	0.17 (0.09)	**-0.37 (0.09)*** **	**0.18 (0.09)* **
Forest sector association				
Yes=1	0.11 (0.06)	0.08 (0.06)	**0.15 (0.07)* **	0.12 (0.07)
Familiarity with wooden multistory buildings				

Yes=1	**0.30 (0.07)***	-0.07 (0.06)	**0.22 (0.06)***	-0.00 (0.06)
R^2	0.14	0.09	0.12	0.11
Adjusted R^2	0.13	0.07	0.11	0.10
Number of observations	1007	1007	1008	1008

*Indications of statistical significances of beta coefficients are denoted with ***p < 0.001; **p < 0.01; *p < 0.05, and the error terms of the coefficients are given in parentheses.*

Compared to the reference level, i.e., 'primarily wood' as the preferred home load-bearing material, all other preference categories were found to effect on negative beliefs towards wood construction. This was especially noticeable when the preferred material was 'other than wood', as this variable was negatively significant in the positive belief models for Finland and Sweden while showing positive signs for the negative belief models, respectively. Residents in large cities tended to have more negative beliefs of wood construction compared to respondents living in rural areas or smaller cities. Moreover, the two older age groups (respondents above 35 years of age) were associated with negative beliefs concerning building and living with wood. The age group variable did not have a significant impact on positive beliefs. Respondent's education level and gender had no statistically significant effect on any of the identified beliefs.

[3] For both countries, two items, i.e., "Extreme weather has increased wood maintenance costs" and "Extreme weather has not decreased the technical durability of wood" were excluded from the final analysis due to factor loadings below 0.4 or fairly even cross-loadings between the two factors, which disabled interpretation.

[4] Reduced models with backwards elimination were also tested, but for better comparison between the models, only full models are reported.

4. Discussion

Large-scale surveys on citizens' material-related beliefs may provide valuable information for construction sector professionals in their decision-making and for policymakers in advocating for lower carbon economics at national and regional levels. Citizen views affect market development in the construction sector through their home choices in the owner-occupied and rental housing markets. In addition, they have power as voters to affect the democratic processes influencing, for example, initiatives pertaining to building material choices used in multistory residential and public buildings. Despite existing research on the public perceptions of building with wood, the effect of extreme weather events has not been covered previously. Urbanizing, boreal forest-rich countries, with cold climates that require high-quality housing insulation to protect against the highly variable temperatures, are attractive targets for analyzing public perceptions toward living with wood and detecting potential trade-offs in terms of climate change mitigation and adaptation in the construction sector.

Hence, the aim of our study was to shed light on citizen views regarding wooden building under the imperative of climate change mitigation and adaptation to extreme weather events. To achieve this, we used survey data from Finland and Sweden. Further, the idea was to understand how different socio-demographic characteristics may affect these perceptions. Our choice of two Nordic countries is motivated by their ambitious climate policies and because local-level effects and threats associated with climatic change are greatly discussed in the media. Essentially, there is a commonly expressed belief that a combination of increased rainfall and rising average temperatures during the dark winter months could create a new season that the public mockingly calls “endless November”.

According to our results, respondents from Finland and Sweden were found to have similar views on perceived climate change and extreme weather events, but they also showed differences in opinions based on Figures 1 to 3. According to the factor analysis, the loaded items were concerned with the effect of extreme weather on future wood use in construction and the aesthetic properties of wood use in buildings, both indoors and outdoors. However, not all items loaded onto the factor solutions, for example, items regarding the technical durability of wood or increased maintenance costs due to extreme weather events were removed from the factor solution. We interpreted this to mean that these questions fall into the area of expertise of real estate management and are probably difficult to evaluate without a professional background in or familiarity with real estate management. In the analyses, the two factor solutions (positive and negative beliefs) from both countries explained approximately 50% of the variance in the variables, with no significant cross-loadings between the variables, and there was clear interpretability of the factor solutions. Furthermore, the results of our linear regression analysis for Finland and Sweden indicate similarities between the two countries regarding how the different respondent characteristics relate to the expressed beliefs. Based on the linear regression results, positive public beliefs regarding the effects of extreme weather events on wooden building are associated with the perceived seriousness of climate change in both countries, which in turn implies that respondents perceived building with wood as an efficient adaptation measure.

The similarity of our findings between Sweden and Finland in terms of the factor solution and regression analysis is not surprising, as both countries have strong wood building traditions (Schauerte 2010). Previous literature has found perceptions of local temperature increases to also play a role in people’s beliefs concerning climate change. For example, according to Taylor et al. (2014), perceived changes in wet weather-related events may be an even stronger predictor for climate change-related beliefs compared to changes in hot weather-related events, and expected vulnerabilities may also connect to the building stock (Alzahrani et al. 2016), which would potentially resemble our Nordic case.

Based on socio-demographic background characteristics, gender and education level were insignificant in regression models, while residential location was found to have some effect on respondent beliefs concerning wood construction. In both countries, respondents residing in large cities tended to have negative beliefs more often than those residing in the countryside. This could be associated with wood construction in detached housing being more common in rural areas in both countries, and hence leading to greater familiarity with the material. For example, in a recent study by Hoibo et al. (2015) from Norway, younger people with strong environmental values were found to be the most receptive toward increasing wood-based urban housing, while higher respondent age did not appear significant in any of our models for positive beliefs. Regarding Swedish and Norwegian building material markets, Roos and Nyrud (2008) have previously found that environmentally conscious consumers are often women, have a higher education level, and prefer items with product warranties. While the public perceptions concerning the environmental quality of wooden material-based products may be identified and logical (Toivonen, 2012), the practical meaning of environmental attributes of wooden construction materials may still be vague for most citizens. Moreover, respondents preferring load-bearing materials other than wood or wood combined with other materials were more likely to have negative beliefs about wood construction. Similarly, those who did not know which home load-bearing material to choose i.e., one fifth of the Swedish respondents and ca. one tenth of the Finnish respondents, tended to often have negative beliefs regarding wood construction. From the building maintenance cost perspective, using wood exterior applications has been considered more expensive than plastered surfaces because wood requires more regular maintenance and repainting. Approximately half of our respondents believed that extreme weather has already increased the maintenance costs of buildings. This material-based difference in maintenance costs may even out in the future, as concrete and other mineral facades may also experience increased weather stress, but the issue is likely too vague a topic for the general public to evaluate, at least currently.

The effect of forest sector association on beliefs concerning wood construction was weakly significant for Swedish respondents, indicating positive beliefs among those associated with the forest sector. This is in line with a previous study conducted in four European countries by Ranacher et al. (2017). On the other hand, Peterson St. Laurent et al. (2018) found that while the Canadian public is generally accepting of enhanced forest carbon management strategies, including increased production of long-lived wood products, respondents employed by the forest sector were less likely to support any of the proposed mitigation strategies. This was interpreted to reflect the recent uncertain economic climate in the region and reluctance to alter various environmentally driven forest management strategies. The observed differences between models regarding forest sector association in our study could be partly explained by the unequal distribution of respondents associated with the forest sector in each country: every third respondent in Finland had a connection with the forest sector, as opposed to only one fifth of the Swedish respondents.

Overall, a higher familiarity with wooden multistory buildings associated with positive beliefs in both countries. Prejudices against wood have also been detected in previous literature: citizens in the Nordic region showing appreciation for an urban lifestyle and for living in attractive and reputable neighborhoods expressed increased prejudices against wooden buildings, while higher appreciation of aesthetics and natural milieus decreased the prejudices expressed towards wood (Lähtinen et al. 2021).

This could partly reflect in familiarity being highly significant in models explaining positive beliefs toward wood, regardless of the country.

Citizen beliefs in our study were captured using a limited set of statements and by using a consumer panel-based data set. This is a limitation of our study, as the data set is not fully representable of randomly selected respondents across each country. Furthermore, the explanatory power of the linear regression models was quite modest. However, the resulting model interpretations and effects of the explanatory variables were mostly reasonable in relation to their signs and were consistently similar across the two countries, which can be seen to improve the validity of our results.

As a final thought, the building material-based opinion-making of citizens remains a complex topic. While extreme weather may be seen as a risk factor for using wood material in the exterior applications of buildings, which may come with increasing maintenance costs, investing in increasing embodied carbon stock in the building sector is concurrently positively associated with and sensitive to the urgency of climate change adaptation measures. Ultimately, which one of these views becomes overarching appears dependent on individual citizen background characteristics, at least based on evidence from the Nordic region.

5. Conclusions

At the local level, growing concern and awareness for extreme weather-induced events in the future may trigger growing awareness of climate change impacting residential buildings and renovation material choices. Our findings of the identified positive beliefs underline the potential power of citizen views in adopting lower carbon building materials as one avenue of climate change mitigation- and adaptation-related policies. Moreover, while increased climate concern may potentially increase the future demand for wood from the perspective of embodied carbon in construction materials, concerns for increasing maintenance costs due to extreme weather events were also eminent. Our findings indicate that the development and marketing of wooden multistory buildings must also consider a variety of preferences and views from various groups. More specifically, there seems to be a potential to maintain a positive image among the younger age groups and to gradually increase the acceptability of wooden construction among older segments. Among Swedish respondents, association with the forest sector predicted positive opinions towards wood materials, while this was not the case for Finnish respondents despite associations being more common in national population.

Our study opened many avenues for further research. Examining citizen preferences for low-carbon housing and construction solutions while accounting for climate change adaptation provided interesting results, but this direction clearly also requires new data and analyses. Studying how citizens' climate attitudes, socio-demographic characteristics and their current living practices are reflected in their future housing preferences is important. Empirical research should also add understanding of the preferred mitigation and adaptation measures among citizens with lower socio-economic statuses because these groups are often underrepresented in large-scale surveys or panels. In addition, information is needed on citizen views regarding building with wood beyond the forest-rich Nordic countries.

Declarations

Consent to Participate

Data was collected under panels organized in target countries by Sino International in May-June 2021, with acquired consent from participating citizens.

Consent to Publish

Manuscript does not include material or figures that would be under third party consent.

Ethical Approval

Not relevant for the study with data collection under conducted externally recruited consumer panel with consent.

Authors Contributions

Task contribution	Author contributions
Conception and design of the work	AT, KL, AR
Methodology	AT, AV, EH
Supervision of data collection and statistical analysis	AV, EH, AT
Manuscript drafting	AV, EH, ER, KL, RT, AR, AT
Visualisation of results	AV, AT
Review and final modifications	AV, ER, KL, AR, RT,
Financial responsibility	AT, RT

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Competing Interests:

The authors have no relevant financial or non-financial interests to disclose.

Availability of data and materials

The dataset analysed during the current study is not publicly available due to being generated under ownership of ongoing multi-country project (NOFOBE), but are available from the corresponding author on reasonable request.

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Figures

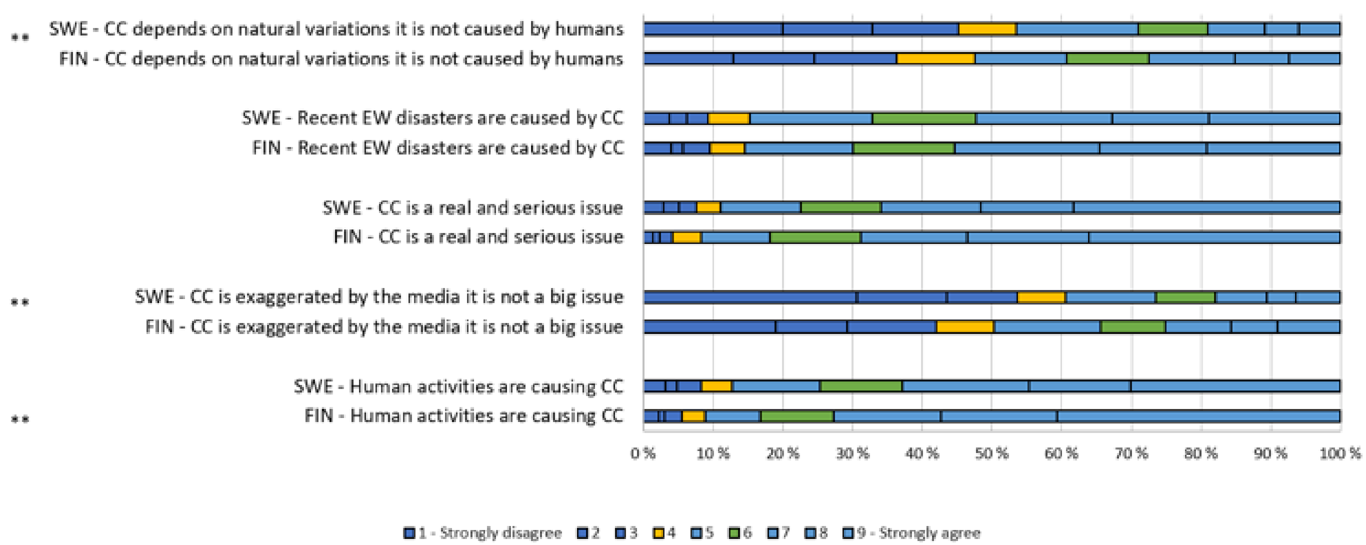

Figure 1

Level of agreement on statements concerning origin of climate change (CC) and extreme weather (EW). The statements with significant cross-country differences marked with asterisks.

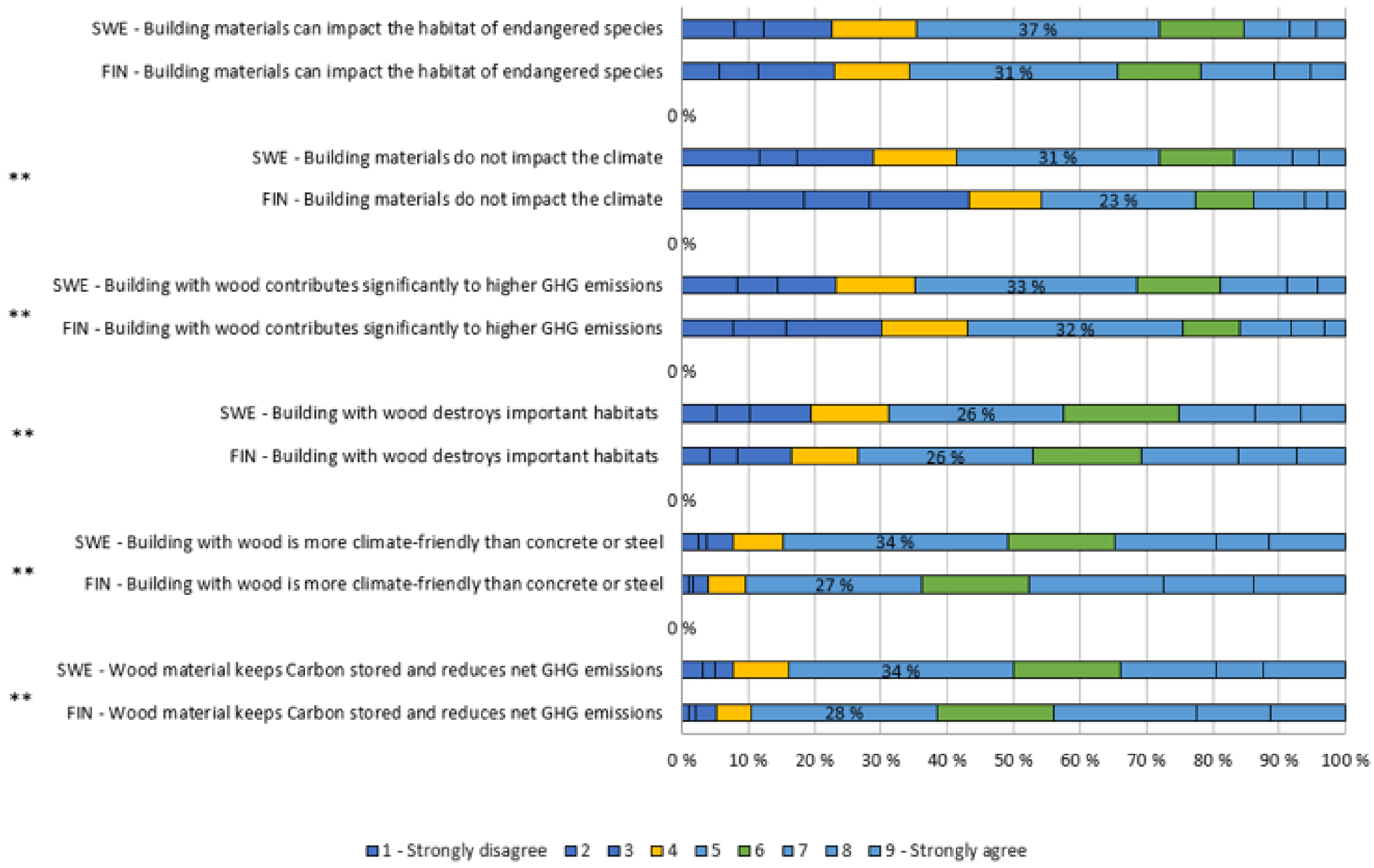

Figure 2

Level of agreement on statements concerning environmental changes and the association with building with wood (WB). The response category with the highest percentages is shown with a numeric value, and statements with significant cross-country differences marked with asterisks.

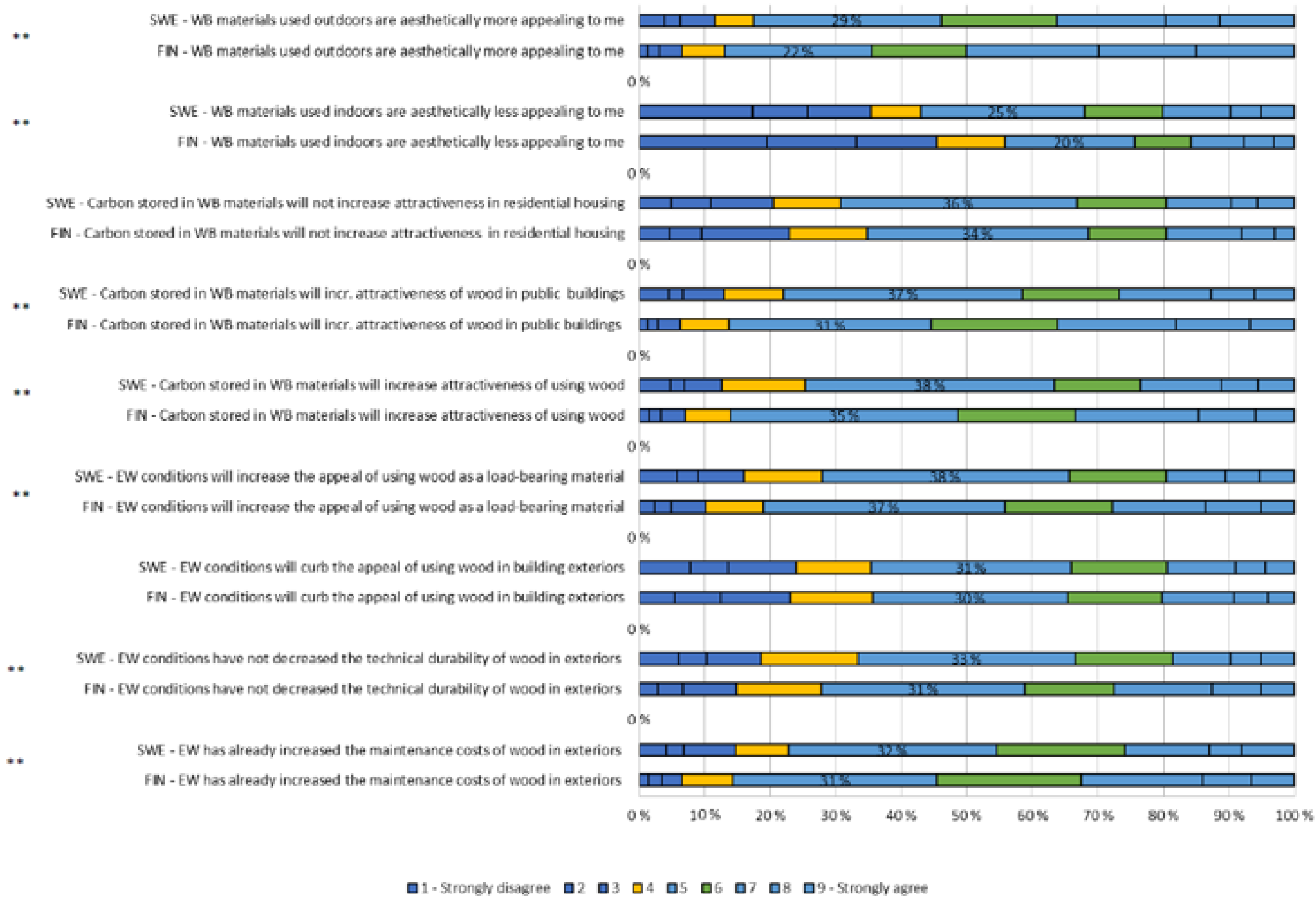

Figure 3

Level of agreement on statements concerning extreme weather (EW) and attractiveness of building with wood (WB). The response category with the highest percentages is shown with a numeric value, and statements with significant cross-country differences marked with asterisks.

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