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RESEARCH ARTICLE

Beliefs on environmental impact of wood construction

Anders Roos [a], Elias Hurmekoski[b], Liina Häyrinen[c], Jaakko Jussila[b], Katja Lähtinen[c], Cecilia Mark-Herbert [a], Emil Nagy[a], Ritva Toivonen [b] and Anne Toppinen [b]

[a]Department of Forest Economics, Swedish University of Agricultural Sciences, Uppsala, Sweden; [b]Department of Forest Sciences, Faculty of Agriculture and Forestry, University of Helsinki, Helsinki, Finland; [c]Natural Resources Institute Finland (LUKE), Helsinki, Finland

ABSTRACT

People have different beliefs about the environmental impact of forest products. This quantitative web-survey study investigated public beliefs in Finland and Sweden about the environmental and climate impacts of using wood as a construction material for multi-story buildings. It was conducted with consumer panels reflecting the average populations of the two countries. The study analyzed factors affecting beliefs that multi-story Wood Buildings: (1) contribute to mitigating global warming, and (2) adversely impact biodiversity and the climate. It used consumer panel and multivariate statistics. Favorable climate-related beliefs were associated with Finnish nationality, male gender, age, children in household, university degree, and beliefs that climate change is induced by humans and causes weather disasters. Beliefs that wood buildings drive global warming and harm biodiversity were associated with non-rural residence, female gender, young age, children in household, low income, and beliefs that climate change causes weather disasters. No associations were recorded for current residence types. These findings highlight the importance of the wood construction industry to improve, document, and communicate to the public its impact on climate and biodiversity. They also indicate how market information can be formulated and targeted to communicate an accurate environmental image of wood construction.

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Introduction

The building sector and forests play key roles in the World's climate. The building sector contributes in total to 37% of today's global CO2 emissions, including energy for heating and cooling (IEA 2020). Energy demand from the global building sector is expected to continue increasing in the coming years (IEA 2022). Policy measures are, therefore, being introduced to reduce the sector's climate impact (IEA 2022). Accordingly, the European Union (EU) has assigned the construction sector an important role in enhanced sustainability, reduced carbon emissions, and people's well-being (European Commission 2021a), and to decarbonize its housing stock by 2050 (European Commission 2021b), which, in turn, will require bold policy decisions in the coming decades (IEA 2022).

Wooden multi-story buildings can contribute to a low-carbon construction sector since they store carbon for prolonged periods, substituting for materials with higher climate impacts (Gustavsson et al. 2010; Cabeza et al. 2014; Geng et al. 2017; Churkina et al. 2020). Comparisons also find that multi-family houses create a lower climate impact per person, or square meter, compared to single-family houses (Lavagna et al. 2018). Multi-story wood buildings (MSWBs), do consequently, represent a promising construction segment that aligns with current environmental and climate ambitions, especially since urbanization is a continuing global process (Gustavsson et al. 2010; Lavagna et al. 2018; Heräjärvi 2019; Churkina et al. 2020). The interest in wood building is therefore on the increase in Finland and Sweden, two countries with long-standing wood traditions and climate ambitions (Jussila et al. 2022).

However, the current Nordic forest management methods are also debated in the two countries. One view is that the most practiced forest management methods do not provide short-term climate benefits (e.g. Seppälä et al. 2019; Köhl et al. 2020). Conversely, Högberg et al. (2021) argue that rotational forestry methods instead contribute to a build-up of carbon stocks in trees in the long term. The forest sector also faces challenges regarding its alleged impact on biodiversity as it, for instance, fails to establish a green infrastructure and habitat networks (Angelstam et al. 2020). This discussion about forest practices is also reflected in media in Finland and Sweden (DN 2021; HBL 2021). The public debate is, therefore, showing different views in the policy debate spanning from approval of intensive forest management practices to claims that today's forest management methods are bad for the climate and threaten habitats and biodiversity (Ranacher et al. 2020; Sotirov et al. 2021).

CONTACT Anders Roos anders.roos@slu.se Department of Forest Economics, Swedish University of Agricultural Sciences, Box 7060, SE-750 07 Uppsala, Sweden

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Surveys and qualitative studies among the public reflect similar diverging beliefs about the environmental and climate impacts of the forestry sector (Ranacher et al. 2020) as well as of wood construction (Petruch and Walcher 2021; Viholainen et al. 2021). Hence, a division stands between claims that forestry for wood products contributes to climate change mitigation when renewable forest resources are used in place of materials with a larger carbon footprint; and the view that forest management and wood use lead to a simultaneous short-term increase of net greenhouse gas emissions and reduced forest biodiversity.

Likely, the future development of wood buildings will depend on public attitudes towards wood and beliefs about the environmental consequences of using timber in house constructions from harvesting to the final use in wooden buildings (Ranacher et al. 2020; Toivonen et al. 2021; Viholainen et al. 2021).

Previous user and consumer studies have shown that customer segments perceive wood as being natural and environmentally friendly (Gold and Rubik 2009; Høibø et al. 2015; Petruch and Walcher 2021; Harju and Lähtinen 2022). This aligns with sensory analyses showing associations between wood materials and positive characterizations, such as *warm* and *natural* (Jonsson et al. 2008). In a representative study on German citizens, 70% fully agreed that wood in construction was *eco-friendly* and 88% answered that wood in construction is *very* or *rather advantageous* from an environmental viewpoint (Gold and Rubik 2009). Furthermore, wooden materials have been addressed with sustainable properties such as longevity in use (Luo et al. 2018), increased comfort in living environments (Rhee 2018), and perceptions of aesthetic qualities (Lähtinen et al. 2021) together with environmental friendliness. A favorable view among citizens on the role of the forest sector to reduce climate change in British Columbia was reported by Peterson St-Laurent et al. (2018) and Floress et al. (2019) drew similar conclusions from a study in Wisconsin. Considering age as a factor, young people in Oslo, Norway were more environmentally concerned than older respondents but also more positive toward building in wood (Høibø et al. 2015). The perceived quality of wooden building materials is found to differ depending on consumers' socio-demographic characteristics and situational variables (Harju 2022).

Groups of customers also argue against the beneficial sustainability impacts of harvesting wood for construction. This is linked to the public appreciation of recreational and other non-wood ecosystem services from forests, alongside the production of timber (Upton et al. 2015; Ranacher et al. 2017). In a review of studies in European countries, Ranacher et al. (2020) reported both a public wish to protect forests but also positive views of wood as being an environmentally friendly building material. These partly conflicting perceptions of wood in construction, including when wood sourcing methods are taken into account, were also found by Larasatie et al. (2018), Viholainen et al. (2021), and Petruch and Walcher (2021).

Studies conducted to date indicate attributes and factors that can potentially influence beliefs about wood construction's environmental and climate impacts. National differences in these beliefs have been observed in both forestry (Ranacher et al. 2020) and wood construction (Lähtinen et al. 2021; Aguilar et al. 2023). It was shown by Eriksson et al. (2015) that German respondents put stronger emphasis on non-wood forest values compared to Swedes. There are also indications that individuals living in rural areas are favorable to the standard forest management methods (Eriksson 2012; Hemström et al. 2014; Upton et al. 2015; Aguilar et al. 2023). In their literature review, Ranacher et al. (2020) concluded that age, income, education, and knowledge about forestry may influence beliefs about management and the forest sector. In studies outside the construction field, it has also been found that beliefs about the seriousness and causes of climate change may influence the acceptance of an industry or a product (Bradley et al. 2020; Smith et al. 2021).

Although the specific roles of wood building for sustainable construction have gained increasing interest, there is still a lack of empirical studies on public beliefs about the possible beneficial, and adverse, environmental and climate effects of wood construction. Such focused analyses are needed to assess the prevalence of acceptance for continued wood building development. Insights on factors affecting such beliefs are also useful to understand the possible deliberations that shape them. A deeper insight into these matters would highlight areas for further improvement and innovation in the sector and help form market communication efforts to manage misconceptions (Lähtinen et al. 2017, 2021).

Therefore, this study aimed to examine factors affecting people's beliefs about the climate impact of using wood as a building material in Sweden and Finland. Further, it studied factors affecting the support for, or opposition to, the view that the use of wood in construction adversely influences both the climate and biodiversity. For this inquiry, it was hypothesized that beliefs about the environmental and climate impact of wood construction are influenced by variables connected to demographics, education, economic situation and beliefs about climate change.

The analysis relates to the use of wood in structural, load-bearing functions. Moreover, it studies elicited *beliefs* about wood construction's climate and environmental impact. Consequently, no inference or assessment of the accuracy for, or evidence behind, these beliefs is made in this study.

Method

Model specification

The analysis is conceptually based on the definition of beliefs as "something that is accepted, considered to be true, or held as an opinion: something believed" (Merriam Webster 2022). Beliefs are incorporated into wider interlinked belief systems and discourses, such as those related to environmental change (Corral-Verdugo et al. 2008; Spence et al. 2010). We assume that the most people are aware of different aspects of the climate and forest debate, and may have certain opinions and beliefs on these issues. The percentage of the population that hear about climate change in their daily

lives was 64% in Finland and 66% in Sweden. High percentages of the two populations also agreed that they had knowledge about climate change, that it was happening and was caused by human activities (Leiserowitz et al. 2022). However, this study does not assume a complete knowledge among the respondents about the carbon cycle and its association with the climate. Answers can have been given based on misconceptions. The review of previous studies on public beliefs regarding wood construction and forest management, as well as global environmental change, guided the formulation of hypotheses for the analysis (Table 1).

Data collection and preparation

This study used data collected in a web-based consumer panel survey in Finland and Sweden about public experiences, preferences, and beliefs on multi-story wood construction. The data was collected under the project Nordic Forest-Based Sector in Bioeconomy. A quantitative approach was selected because it corresponded to the aim to analyze the distribution of and associations between variables describing respondents' beliefs and attributes. The respondents, 1009 in Finland and 1008 in Sweden, were over 18 years of age.

Online panel research has developed and improved and is widely used in marketing research owing to its advantages of speed, convenience, and cost (Evans and Mathur 2018). Walter et al. (2019) found that online panels generated similar psychometric outcomes as those obtained from conventionally collected data. The method approach is, thus, able to combine data of good validity at a reasonable cost. However, because of the sample size and sampling techniques, we will not make a full generalization of our results (Lynn et al. 2007).

For the project, a master questionnaire was designed in English based on a previous survey round in 2018 and on multiple review rounds among Scandinavian researchers. It was translated into Finnish and Swedish and expert-validated by researchers with a thorough knowledge of wood construction.

Data were collected via an internet-based survey in May–June 2021. The respondents complied with population data from the two countries based on key socio-demographic variables, such as gender, age, and education level (Statistics Finland 2022; Statistics Sweden 2022).

Questions covering beliefs about the impact of wooden housing and climate change were presented as statements with a 9-point Likert scale for the answers (1 = Strongly disagree, 9 = Strongly agree) capturing strong opposition or strong agreement to statements. Additional questions concerned socioeconomic information, and preference for materials in wood buildings. All steps in the data collection followed European General Data Protection Regulation. Respondents were drawn from a panel with full and informed consent.

The collected data was inspected for consistent answers. Consequently, observations where identical ratings (mainly "1" or "9") were provided on all sub-questions were removed (Hair et al. 2010). Outliers were deleted before the

Table 1. Factors and their expected influence on beliefs about climate and biodiversity impact of using wood for construction (+: Agree that "using wood for construction is good for climate" and do not agree that "using wood for construction is bad for climate and the environment"; − : Opposite relationships).

Factor	Expected influence	Explanation and reference
Nationality (Finnish)	+	Beliefs about environmental effects of forest management and the forest sector differ between European countries (Ranacher et al. 2020). Finnish citizens are more approving of the forest sector (Pätäri et al. 2017)
Urban	−	Urban people rank non-wood ecosystem services higher than people living in rural areas and are, therefore, less approving of using trees for house (Eriksson 2012; Hemström et al. 2014; Upton et al. 2015; Lähtinen et al. 2021; Aguilar et al. 2023)
Currently living in an apartment (normally in a concrete structure)	−	Multi-family houses are mostly built in concrete, whereas wood dominates low-rise buildings. It is therefore hypothesized that the current residence in a non-wood house (i.e. apartment) increases the approval for selecting concrete, and also reduced acceptance of wooden housing (Ajzen 2011; Larasatie et al. 2018).
Gender (men)	+	Women value conservation and non-wood ecosystem services higher than men (Ozanne and Smith 1998; Ranacher et al. 2020). Forestry and construction are male-dominated. Acceptance of managing forests for timber in buildings is expected to be higher among men than among women (Eurofound and European Commission Joint Research Centre 2021)
Age	indefinite	Young respondents regard wood construction as environmentally friendly. However, they may be critical of forest management practices (Ranacher et al. 2020; Petruch and Walcher 2021)
Household with children	indefinite	Wood is perceived as warm and assumedly children friendly (Jonsson et al. 2008). Having children in households strengthen the respondent's belief that wood is climate-friendly (Lawson et al. 2019). Environmental concern and skepticism towards forest management methods can, on the other hand, be amplified with children in the household (Ranacher et al. 2020)
Income	−	Higher income correlates with higher support for conservation instead of use for buildings (Ranacher et al. 2020)
Education	−	Higher education correlates with higher support for conservation (Ranacher et al. 2020)
Disastrous climate events	+	The belief that climate change causes disasters is assumed to increase the likelihood of accepting wood construction. However, this may depend on mediating factors (Bradley et al. 2020; Smith et al. 2021)
Humans cause climate change	+	The belief that humans cause climate change increases the likelihood of accepting wood construction. However, this may depend on mediating factors (Bradley et al. 2020; Smith et al. 2021)

Based on previous studies, Table 1 describes that beliefs about the climate and biodiversity impacts of wood construction relate to location, economic and demographics, together with beliefs about the seriousness and causes of climate change.

Table 2. Data selection steps, number of observations.

Step	Finland	Sweden
Original dataset	1009	1008
After inconsistent answers were removed	998	982
After the removal of outliers	992	967

Table 3. Beliefs about climate and biodiversity impact of wood construction.

Variable	"In my opinion": (1 = Strongly disagree, 9 = Strongly agree)	Mean	Std dev
Stores carbon	Wood as a construction material keeps carbon stored thus can help reduce net emissions of global warming gases	6.01	1.70
Climate friendly	Building with wood is more climate-friendly than concrete or steel	6.11	1.69
Destroys habitats	Building with wood destroys important habitats for rare and endangered species	5.29	1.95
Emit greenhouse gases	Building with wood contributes significantly to higher greenhouse gas emissions	4.69	1.90
Attractive carbon storage	Carbon stored in wooden building materials will significantly increase the attractiveness of using wood in construction	5.48	1.66

regression stage based on regression standardized predicted value and regression standardized residual (Yan and Su 2009) (Table 2).

The analysis was conducted on pooled data with both Finnish and Swedish survey answers. The observations were weighted according to the total populations of the two countries in 2021, which produced a weight of 1 per observation for Finland and 1.8828 for Sweden. This corresponds, after weighting, to 992 observations for Finland and 1821 observations for Sweden.

Variables describing beliefs about the climate and environmental impacts of wood construction are shown in Table 3 and Figure 1.

The two statements that wood counteracts global warming (Stores carbon and Climate friendly) received the most support from the respondents. The lowest average score was noted for the assertion that wood construction leads to the emission of more greenhouse gases. No difference between the variable means was significant on the 5% level.

Independent variables for respondent attributes are listed in Table 4, encompassing conditions about location, demographics, economic situation, education, and beliefs about climate change.

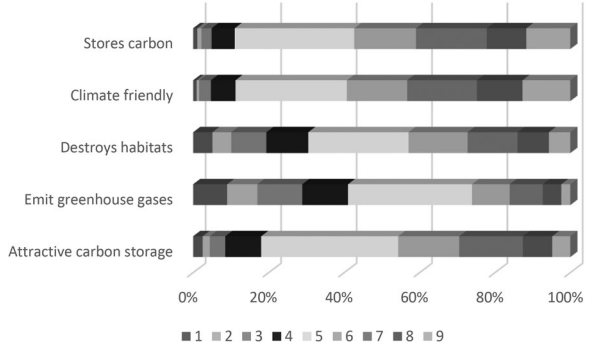

Figure 1. Belief ratings.

Reliability was increased by the multiple rounds of reviews of the questionnaire that generated clear questions and removed the possibility of ambiguous answers. The survey was further based on the experiences of an earlier, similar survey conducted in November and December 2018 and presented in, among other publications, Lähtinen et al. (2021).

The risk of common method bias was reduced through the survey design, masking linkages between independent and dependent variables and by varying the response techniques (Kock et al. 2021).

Analysis

Correlation coefficients on the beliefs regarding the impact of forest management for wood construction purposes were examined. A Maximum Likelihood factor analysis with Varimax rotation was thereafter conducted. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity and communalities were conducted to assess the suitability of the data for factor analysis. The significant factor solution was determined based on eigenvalues and the inspection of the Scree plot. Factor loadings equal to or above 0.4 were regarded as significant.

The association of respondent characteristics with beliefs was then analyzed in linear regression. Positive coefficients indicated a positive relationship with the respective belief and, conversely, negative signs implied a negative relationship.

The data were examined for multicollinearity through the variance inflation factor (VIF). Inspections of probability-probability plots, regression standardized residuals, and regression standardized predicted values were used to investigate the normality of the error term. Tests for heteroscedasticity were also carried out through the White test and the normal and modified Breusch–Pagan test (Yan and Su 2009).

Results

Correlations

The used variables presented Pearson correlations are shown in Table 5.

The correlation coefficients indicate an association between the positive statements (Stores carbon, Climate-friendly, and Attractive carbon storage), and the negative statements (Destroys habitats and Emit greenhouse gases). Reasonably high correlations suggest that the dataset is suitable for exploratory factor analysis.

Exploratory factor analysis

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.601, and Bartlett's Test of Sphericity rejected the null hypothesis of uncorrelated variables. Thus, the dataset was suitable for factor analysis. The communality values were less than 0.3 for two variables (Questions Climate friendly and Attractive carbon storage). However, an inspection of

Table 4. Description of the sample, respondent attributes.

Variable	Finland	Sweden	Pooled and weighted sample
Location			
FINLAND, 0 = Sweden, 1 = Finland, Share			0.35
SMALLTOWN, 1=>100,00 and <100,000 inhabitants, Share	0.36	0.36	0.36
LARGETOWN, 1= >100,000 Inhabitants, Share	0.47	0.46	0.46
APARTMENT, 1 = Lives in apartment, Share	0.52	0.55	0.54
Demographic			
MALE, 0 = Female, 1 = Male, Share	0.49	0.50	0.50
AGE, years. Mean value (Std dev.), Share	46.4	45.7	45.9, (16.1)
CHILD, 1 = Children below 17 years, Share	0.27	0.36	0.33
Economic			
HIGH INCOME, 1 = >300000 SEK alt. >30000 Euro, Share	0.34	0.37	0.36
Education			
UNIVERSITY, 1 = University degree, Share	0.44	0.40	0.42
Strong climate change beliefs			
DISASTER, 1 = "9" or "8" on statement "Recent extreme weather disasters are caused by climate change" (9-step scale), Share	0.33	0.33	0.33
HUMAN CAUSE 1 = "9" or "8" on the statement "Human activities are causing climate change" (9-step scale), Share	0.54	0.48	0.50

Table 5. Correlation coefficients between variables describing beliefs (Pearson).

	Stores carbon	Climate friendly	Destroys habitats	Emit greenhouse gases
Climate friendly	0.481**			
Destroys habitats	−0.010	−0.040*		
Emit greenhouse gases	−0.109**	−0.153**	0.549**	
Attractive carbon storage	0.429**	0.399**	0.084**	0.045*

the correlation table and obtained significant factors justified that the variables were kept for further analysis (Child 2006). The rotated factor solution is shown in Table 6.

The factors were labeled concerning wood building as "Wood building is climate-friendly" for Factor 1, and "Wood building is bad for the climate and habitats" for Factor 2.

The two factors conform to two typical positions in the conservation debate in the two countries. The belief that "Wood building is climate-friendly" describes the view that wood has a lower climate impact compared to alternative construction materials (Gustavsson et al. 2010; Högberg et al. 2015); and the belief that "Wood building is bad for the climate and habitats" supports the view that current harvesting regimes to produce construction wood reduce biodiversity and, simultaneously, lead to higher net emissions compared to baseline (a reality that would unfold without an increase in the use of wood in construction) (Angelstam et al. 2020; Köhl et al. 2020).

Table 6. Rotated factor solution.

	Factor number	
	1	2
Stores carbon	0.710	
Climate friendly	0.670	
Attractive carbon storage	0.612	
Emit greenhouse gases		0.914
Destroys habitats		0.603

Extraction Method: Maximum Likelihood. Rotation Method: Varimax with Kaiser Normalization.

Regression analysis

The inspection of the regression model revealed no signs of multicollinearity or non-normality of the error term. However, the null hypothesis of homoscedasticity was rejected. This means that a normal linear regression still produces correct coefficients but incorrect error terms may give inflated significance levels. This problem was avoided by the use of "robust" standard errors (Williams 2015; Flatt and Jacobs 2019). Regression results are shown in Table 7.

Beliefs that wood building is beneficial for the climate were associated positively with Finnish nationality, male gender, (increasing) age, a household with children, university education, and beliefs stated as "Recent extreme weather disasters are caused by climate change" and "Human activities are causing climate change." Being located in urban areas, compared to living in the countryside or a town with less than 10,000 inhabitants, current residence in an apartment, and high income did not present any significant links to the belief that wood buildings reduce global warming by binding carbon.

The belief that wood construction has adverse impacts on the climate and habitats (right-hand side regression) was associated with residence outside rural areas (defined as living in a locality with less than 10,000 inhabitants), female, younger age, a household with children, income less than 30,000 Euro, no academic education, and the belief that "Recent extreme weather disasters are caused by climate change." Insignificant coefficients were noted for the country, apartment type, and the belief that "Human activities are causing climate change."

Several coefficients presented significant expected and opposite signs in the two regressions. This was the case for the variables gender, age, and education. However, households with children and a gigh rating for the statement "Recent extreme weather disasters are caused by climate change" generated positive signs in both estimations.

Table 7. Linear regression results for factor solutions of respondent beliefs regarding the impact of wood construction on climate change and biodiversity.

	Coefficient (std. error)	
Parameter	Wood building is climate-friendly	Wood building is bad for the climate and habitats
Intercept	**−0.604 (0.071)*** **	**0.200 (0.080)***
Location		
FINLAND	**0.174 (0.034)*** **	−0.045 (0.038)
SMALLTOWN	−0.052 (0.047)	**0.321 (0.053)*** **
LARGETOWN	−0.041 (0.049)	**0.299 (0.054)*** **
APARTMENT	−0.043 (0.036)	−0.051 (0.040)
Demography		
MALE	**0.157 (0.032)*** **	**−0.105 (0.036)** **
AGE	**0.005 (0.001)*** **	**−0.008 (0.001)*** **
CHILD	**0.164 (0.036)*** **	**0.159 (0.041)*** **
HIGH INCOME	−0.025 (0.034)	**−0.091 (0.038)***
Education		
UNIVERSITY	**0.067 (0.033)***	**−0.090 (0.037)***
Climate change beliefs		
DISAST	**0.267 (0.040)*** **	**0.179 (0.046)*** **
HUMANCAUSE	**0.302 (0.036)*** **	−0.0.35 (0.041)
F-value	27.227	16.605
R^2	0.106	0.068
Adj R^2	0.103	0.064
N weighted (not weighted)	2813 (1959)	2813 (1959)

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.

Comparative F tests of R^2 change indicated that the full model was most appropriate in both estimations. Removing DISASTER and HUMAN CAUSE resulted significant reductions of the Adjusted R^2 values for both regression.

Discussion

This study conducts a regression analysis on identified beliefs regarding the climate and the environmental impact of wood construction. The first belief claims that using wood as a construction material is beneficial for the climate; that wood replaces concrete and stores carbon thereby reducing the amount of greenhouse gases in the atmosphere. The second belief states that wood construction leads to adverse environmental impacts as it increases net carbon emissions by reducing carbon in forests, and harming habitats, which leads to a reduced biodiversity.

The first assertion tends to be associated with Finnish residence, male gender, higher age, having children in the household, university education, and strong beliefs related to climate change stated as "Recent extreme weather disasters are caused by climate change" and "Human activities are causing climate change."

The second belief that wood construction has adverse impacts on the climate and the environment was more frequently held by women, younger persons, persons living in a town or municipality with more than 10,000 inhabitants (compared to a small municipality or countryside), persons with income less than 30,000 Euro or 300,000 SEK, pre-academic education, and the belief that "Recent extreme weather disasters are caused by climate change."

The estimations supported several findings in previous studies. The beliefs in the Finnish sample that wood building mitigates climate change align with recent studies reported by Ranacher et al. (2020). Additionally, they are partly supported by a study on views among Finnish students about the forest Industry (Pätäri et al. 2017). This outcome may reflect the fact that the forest sector has relatively more importance in the Finnish economy and labor market compared to Sweden. Hence, on average, a larger share of the Finnish sample may have some connection to the forest and wood industry sectors and a greater appreciation for the sector and its impacts. A similar explanation can be applied to the lower degree of agreement among rural respondents about the statement that wood construction is bad for the climate and the environment which has been found in earlier studies (Eriksson 2012; Hemström et al. 2014; Upton et al. 2015; Lähtinen et al. 2021; Aguilar et al. 2023). This could be attributed to the fact that the forest sector provides rural jobs and incomes in both countries. This study's findings align with the results by Upton et al. (2015) that rural respondents value timber and employment more and recreation less than most urban respondents.

The unexpectedly insignificant connection between residence in an apartment and beliefs on wood construction is difficult to explain. This might depend on the interaction of several mediating factors related to beliefs about house types and satisfaction with the current dwelling. Additionally, residents in apartments may not always be aware of, or put much importance on, the structural material compared to indoor or cladding materials (Høibø et al. 2015). The impact of age on endorsing the positive role of wood construction can indicate that older respondents more frequently have rural backgrounds and more experience with wood and forest-sector activities. Although young persons may value wood as a building material, they appear to be more concerned with perceived climate change and the environmental problems associated with forest harvesting and the use of wood as a construction material. This outcome seems to be somewhat opposed to the findings of Høibø et al. (2015) and Petruch and Walcher (2021) where young respondents

appreciated wood construction for environmental reasons. Our findings are likely to be owing to underlying climate and environmental concerns in younger age groups (Hickman et al. 2021).

As expected, male respondents showed more positive views on wood construction and its climate and environmental impact compared to females. Possibly, this difference can be attributed to the image of the forest and construction sectors as male-dominated (Eurofound and European Commission Joint Research Centre 2021; Skogsstyrelsen 2022).

In families with children, the study found positive coefficients in both regressions, which appears paradoxical. This group concurs with the statement that wood construction is climate-friendly, but also with the claim that using wood for construction increases greenhouse emissions and destroys habitats. The contradictory positions may reflect simultaneous perceptions that the wood material is natural, with positive climate impacts, alongside a general concern about climate change and the future of the environment. Furthermore, for families with teenagers, the results can hypothetically reflect that environmentally concerned young family members influence the parents' beliefs (Lawson et al. 2019).

The acceptance of using wood for construction among respondents with university degree was not expected. This stance seems to echo a view that although recreational forest ecosystem services should be respected and protected, the use of wood for house construction does not compromise these multiple uses.

Likewise, the variable for the strong conviction that climate change causes disasters also produced seemingly inconsistent results. According to the results of the first regression this conviction associated positively with the view that wood construction mitigates global warming, and in the second regression, it was also associated with the belief that wood construction can aggravate climate change and biodiversity. These seemingly contradictory results may reflect the inherently conflicting policy objectives that were illustrated for Finland by Blattert et al. (2022). However, the belief that climate change is caused by humans only correlated significantly with the affirmative belief in wood construction. It had no impact in the second estimation. This variable can reflect the reasoning that human activities and choices can have an impact on climate change. It might also mean that wood construction according to the respondents is more likely to provide long-term than short-term mitigation benefits.

The findings lead to a number of practical implications for the construction sector. Forest and wood-based industry process development and communication efforts should focus to improve and declare the climate and environmental impacts of wood building, for example, by developing low-impact forest management practices that protect habitats and biodiversity. These efforts should also extend to low-impact building operations.

Customer-targeted marketing can, thereafter, document and certify the climate and environmental impacts of wood construction. Marketing efforts should focus on segments that are significantly favorable toward wood to make the use of wood mainstream. However, it is equally central that marketing reaches out to consumer segments that represent future customers and also gatekeepers in building design and planning such as architects and structural engineers. Efforts to increase trust in the sustainability of wooden housing must convey reliable information, be evidence-based, and include specific data about the climate and biodiversity impacts. Specific challenges involve addressing concerns among females, youth, urban residents, and families. This may be done by reviewing reliable information about the climate and biodiversity perils and credentials of different building materials (Kuittinen and Häkkinen 2020).

The study contains limitations worth mentioning. Translations in combination with national differences may have led to biases, although the questions were developed and thoroughly discusses between the cross-national author group. Further, common method bias can, despite the measures taken, have affected the answers' reliability (Kock et al. 2021). The respondents' answers may be based on interacting values and beliefs that are not fully captured by the model.

Further studies could be developed that compare different models of how beliefs about wood construction are formed. Such complex interactions related to the forest sector merit further inquiry in qualitative or exploratory studies, e.g. laddering or econometric models involving multi-item constructs, mediation- or interaction effects. Future studies should also explore environmental beliefs about different forest-based products, including whether the acceptance differs between forest management for timber compared to (short lived) paper products.

Conclusions

The study is an attempt to understand the public beliefs associated with the climate credentials of wood construction. It is novel and expands the current knowledge through the inclusion of demographic, socioeconomic factors, and climate beliefs. The findings indicate that the most negative views are held by females, urban, and young people. The wood construction sector faces a challenge to increase the appeal among these customer segments. Moreover, the sector needs to address the concerns related to the potential negative environmental impacts associated with forest management, including by promoting forest management practices that limit negative climate and biodiversity impacts.

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ORCID

Anders Roos http://orcid.org/0000-0002-8572-3771
Cecilia Mark-Herbert http://orcid.org/0000-0001-7440-9106
Ritva Toivonen http://orcid.org/0000-0001-5894-4790
Anne Toppinen http://orcid.org/0000-0003-0910-1505

References

Aguilar FX, Roos A, Haapala A, Lähtinen K, Kniivilä M, Hoen HF. 2023. Dweller preferences for wood as a load-bearing material in residential buildings. J For Econ. 38. doi:10.1561/112.00000537.
Ajzen I. 2011. The theory of planned behaviour: reactions and reflections. Psychol Health. 26(9):1113–1127.
Angelstam P, Manton M, Green M, Jonsson B-G, Mikusínski G, Svensson J, Maria Sabatini F. 2020. Sweden does not meet agreed national and international forest biodiversity targets: a call for adaptive landscape planning. Landsc Urban Plann. 202:103838.
Blattert C, Eyvindson K, Hartikainen M, Burgas D, Potterf M, Lukkarinen J, Snäll T, Toraño-Caicoya S, Mönkkönen M. 2022. Sectoral policies cause incoherence in forest management and ecosystem service provisioning. For Policy Econ. 136:102689.
Bradley GL, Babutsidze Z, Chai A, Reser JP. 2020. The role of climate change risk perception, response efficacy, and psychological adaptation in pro-environmental behavior: a two nation study. J Environ Psychol. 68:101410.
Cabeza L, Rincon L, Vilarino V, Perez G, Castell A. 2014. Life cycle assessment (LCA) and life cycle energy analysis (LCEA) of buildings and the building sector: a review. Renewable Sustainable Energy Rev. 29:394–416.
Child D. 2006. Essentials of factor analysis. 3rd ed. New York: Continuum.
Churkina G, Organschi A, Reyer CPO, Ruff A, Vinke K, Liu Z, Reck BK, Graedel TE, Schellnhuber HJ. 2020. Buildings as a global carbon sink. Nat Sustainability. 3(4):269–276.
Corral-Verdugo V, Carrus G, Bonnes M, Moser G. 2008. Environmental beliefs and endorsement of sustainable development principles in water conservation – Toward a New Human Interdependence Paradigm scale. Environ Behav. 40(5):703–725.
DN. 2021 Oct 25. Minskad skogsavverkning ger direkt klimatnytta. Dagens Nyheter (In Swedish).
Eriksson L. 2012. Exploring underpinnings of forest conflicts: a study of forest values and beliefs in the general public and among private forest owners in Sweden. Soc Nat Resour. 25(11):1102–1117.
Eriksson L, Nordlund A, Schenk T, Westin K. 2015. A study of forest values and management attitudes in the general public in Germany and Sweden: does context matter? J Environ Planning Manage. 58 (8):1412–1431.
Eurofound and European Commission Joint Research Centre. 2021. European Jobs Monitor 2021: gender gaps and the employment structure, European Jobs Monitor series. Luxembourg: Publications Office of the European Union.
European Commission. 2021a. Climate action. [accessed 2021 Oct 21]. https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2050-long-term-strategy_en.
European Commission. 2021b. New European Bauhaus. [accessed 2021 Oct 21]. https://europa.eu/new-european-bauhaus/index_en.
Evans JR, Mathur A. 2018. The value of online surveys: a look back and a look ahead. Internet Res. 28(4):854–887.
Flatt C, Jacobs RL. 2019. Principle assumptions of regression analysis: testing, techniques, and statistical reporting of imperfect data sets. Adv Dev Hum Resour. 21(4):484–502.
Floress K, Vokoun M, Huff ES, Baker M. 2019. Public perceptions of county, state, and national forest management in Wisconsin, USA. For Policy Econ. 104:110–120.
Geng AX, Yang HQ, Chen JX, Hong YX. 2017. Review of carbon storage function of harvested wood products and the potential of wood substitution in greenhouse gas mitigation. For Policy Econ. 85:192–200.
Gold S, Rubik F. 2009. Consumer attitudes towards timber as a construction material and towards timber frame houses – selected findings of a representative survey among the German population. J Cleaner Prod. 17:303–309.
Gustavsson L, Joelsson A, Sathre R. 2010. Life cycle primary energy use and carbon emission of an eight-storey wood-framed apartment building. Energy Build. 42(2):230–242.
Hair JF, Black WC, Babin BJ, Anderson RE. 2010. Multivariate data analysis: a global perspective. 5th ed. Upper Saddle River (NJ): Pearson Education.
Harju C. 2022. The perceived quality of wooden building materials—a systematic literature review and future research agenda. Int J Consum Stud. 46(1):29–55.
Harju C, Lähtinen K. 2022. Consumers' consciousness for sustainable consumption and their perceptions of wooden building product quality. For Prod J. 72(3):155–169.
HBL. 2021 Oct 31. Riksdagen ska avgöra om kalavverkningarna förpassas till historien. HBL Newspaper. [accessed 2022 Feb 23]. https://www.hbl.fi/artikel/riksdagen-ska-avgora-om-kalavverkningarna-forpassas-till-historien/.
Hemström K, Mahapatra K, Gustavsson L. 2014. Public perceptions and acceptance of intensive forestry in Sweden. AMBIO. 43:196–206.
Heräjärvi H. 2019. Wooden building as carbon storages- mitigation or oration? Wood Mat Sci Eng. 14(5):291–297.
Hickman C, Marks E, Pihkala P, Clayton S, Lewandowski RE, Mayall EE, Wray B, Mellor C, van Susteren L. 2021. Climate anxiety in children and young people and their beliefs about government responses to climate change: a global survey. Lancet Planet Health. 5:e863–e873.
Högberg P, Ceder A, Astrup L, Binkley R, Bright D, Dalsgaard R, Egnell L, Filipchuk G, Genet A, Ilintsev H, et al. 2021. Sustainable boreal forest management - challenges and opportunities for climate change mitigation. Swedish Forest Agency.
Högberg P, Ceder L, Astrup R, Binkley D, Dalsgaard L, Egnell G, Filipchuk A, Høibø O, Hansen E, Nybakk E. 2015. Building material preferences with a focus on wood in urban housing: durability and environmental impacts. Can J For Res. 45(11):1617–1627.
Høibø O, Hansen E, Nybakk E. 2015. Building material preferences with a focus on wood in urban housing: durability and environmental impacts. Can J For Res. 45(11):1617–1627.
IEA. 2020. Energy technology perspectives 2020. Paris: International Energy Agency. [accessed 2021 Oct 21]. https://www.iea.org/reports/energy-technologyperspectives-2020.
IEA. 2022. Buildings. A source of enormous untapped efficiency potential. Paris: International Energy Agency. [accessed 2022 Feb 15]. https://www.iea.org/topics/buildings.
Jonsson O, Lindberg S, Roos A, Hugosson M, Lindström M. 2008. Consumer perceptions and preferences on solid wood, wood-based panels and composites – a repertory grid study. Wood Fiber Sci. 40(4):663–678.
Jussila J, Nagy E, Lähtinen K, Hurmekoski E, Häyrinen L, Mark-Herbert C, Roos A, Toivonen R, Toppinen A. 2022. Wooden multi-storey construction market development – systematic literature review within a global scope with insights on the Nordic region. Silva Fenn. 56:1.
Kock F, Berbekova A, Assaf AG. 2021. Understanding and managing the threat of common method bias: detection, prevention and control. Tourism Manage. 86:104330.
Köhl M, Ehrhart H-P, Knauf M, Neupane PR. 2020. A viable indicator approach for assessing sustainable forest management in terms of carbon emissions and removals. Ecol Indic. 111:106057.
Kuittinen M, Häkkinen T. 2020. Reduced carbon footprints of buildings: new Finnish standards and assessments. Build Cities. 1(1):182–197.
Lähtinen K, Häyrinen L, Roos A, Toppinen A, Aguilar Cabezas F, Thorsen B, Hujala T, Nyrud A, Hoen H. 2021. Consumer housing values and prejudices against living in wooden homes in the Nordic region. Silva Fenn. 55(2):10503.
Lähtinen K, Toppinen A, Suojanen H, Stern T, Ranacher L, Burnard M, Kuzman MK. 2017. Forest sector sustainability communication in Europe: a systematic literature review on the contents and gaps. Curr For Rep. 3(3):173–187.
Larasatie P, Guerrero J, Conroy K, Hall TE, Hansen E, Needham MD. 2018. What does the public believe about tall wood buildings? An exploratory study in the US Pacific Northwest. J For. 116(5):429–436.
Lavagna M, Baldassarri C, Campioli A, Giorgi S, Valle AD, Castellani V, Sala S. 2018. Benchmarks for environmental impact of housing in Europe:

definition of archetypes and LCA of the residential building stock. Build Environ. 145:260–275.
Lawson DF, Stevenson KT, Peterson MN, Carrier SJ, Strnad RL, Seekamp E. 2019. Children can foster climate change concern among their parents. Nat Clim Change. 9:458–462.
Leiserowitz A, Carman J, Buttermore N, Neyens L, Rosenthal S, Marlon J, Schneider J, Mulcahy K. 2022. International public opinion on climate change, 2022. New Haven, CT: Yale Program on Climate Change Communication and Data for Good at Meta.
Luo W, Mineo K, Matsushita K, Kanzaki M. 2018. Consumer willingness to pay for modern wooden structures: a comparison between China and Japan. For Policy Econ. 91:84–93.
Lynn P, Hader S, Gabler S, Laaksonen S. 2007. Methods for achieving equivalence of samples in cross-national surveys: the European Social Survey experience. J Off Stat. 23(1):107–124.
Merriam Webster. 2022. [Accessed 2021 Oct 21]. https://www.merriam-webster.com/dictionary/belief.
Ozanne LK, Smith PM. 1998. Segmenting the market for environmentally certified wood products. For Sci. 44(3):379–389.
Pätäri S, Arminen H, Albareda L, Puumalainen K, Toppinen A. 2017. Student values and perceptions of corporate social responsibility in the forest industry on the road to a bioeconomy. For Policy Econ. 85:201–215.
Peterson St-Laurent G, Hagerman S, Kozak R, Hoberg G. 2018. Public perceptions about climate change mitigation in British Columbia's forest sector. Plos one. 13(4):e0195999.
Petruch M, Walcher D. 2021. Timber for future? Attitudes towards timber construction by young millennials in Austria – marketing implications from a representative study. J Cleaner Prod. 294:126324. doi:10.1016/j.jclepro.2021.126324.
Ranacher L, Lähtinen K, Järvinen E, Toppinen A. 2017. Perceptions of the general public on forest sector responsibility: a survey related to ecosystem services and forest sector business impacts in four European countries. For Policy Econ. 78:180–189.
Ranacher L, Sedmik A, Schwarzbauer P. 2020. Public perceptions of forestry and the forest-based bioeconomy in the European Union. Knowledge to Action 03, European Forest Institute. [accessed 2021 Oct 21]. https://doi.org/10.36333/k2a03.
Rhee P. 2018. Beyond green: environmental building technologies for social and economic equity. Archit Design. 88(4):94–101.
Seppälä J, Heinonen T, Pukkala T, Kilpeläinen A, Mattila T, Myllyviita T, Asikainen A, Peltola H. 2019. Effect of increased wood harvesting and utilization on required greenhouse gas displacement factors of wood-based products and fuels. J Environ Manag. 247:580–587.
Skogsstyrelsen. 2022 Mar 19. Sysselsättning i skogsbruket https://www.skogsstyrelsen.se/statistik/statistik-efter-amne/sysselsattning-i-skogsbruket/.
Smith CJ, Dupré KE, McEvoy A, Kenny S. 2021. Community perceptions and pro-environmental behavior: the mediating roles of social norms and climate change risk. Can J Behav Sci. 53(2):200–210.
Sotirov M, Winkel G, Eckerberg K. 2021. The coalitional politics of the European Union's environmental forest policy: biodiversity conservation, timber legality, and climate protection. Ambio. 50:2153–2167.
Spence A, Poortinga W, Pidgeon N, Lorenzoni I. 2010. Public perceptions of energy choices: the influence of beliefs about climate change and the environment. Energy Environ. 21(5):385–407.
Statistics Finland. 2022. [Accessed 2022 May 5]. https://www.stat.fi/til/vrm_en.html.
Statistics Sweden. 2022. [Accessed 2022 May 5]. https://www.scb.se/en/.
Toivonen R, Vihemäki H, Toppinen A. 2021. Policy narratives on wooden multi-storey construction and implications for technology innovation system governance. For Policy Econ. 125:102409.
Upton V, Dhubháin ÁN, Bullock C. 2015. Are forest attitudes shaped by the extent and characteristics of forests in the local landscape? Soc Nat Resour. 28(6):641–656.
Viholainen N, Franzini F, Lähtinen K, Nyrud A, Widmark C, Hoen HF, Toppinen A. 2021. Citizen views on wood as a construction material: results from seven European countries. Can J For Res. 51:647–659.
Walter SL, Seibert SE, Goering D, O'Boyle EH. 2019. A tale of two sample sources: do results from online panel data and conventional data converge? J Bus Psychol. 34(4):425–452.
Williams R. 2015. Nonlinear relationships. [accessed 2021 Oct 21]. https://www3.nd.edu/~rwilliam/stats2/l61.pdf.
Yan X, Su XG. 2009. Linear regression analysis theory and computing. Singapore; Hackensack, NJ: World Scientific.