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Stakeholder perceptions of wood-based products in the built environment: A literature review

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Abstract

Current global environmental challenges, such as climate change, set an urge to seek renewable low-emission alternatives to substitute fossil fuel-derived products while transitioning towards circular bioeconomy. Wood has proven to be a versatile renewable material that is able to substitute fossil-based materials. However, the market potential and uptake of wood-based products is also dependent on the preferences of consumers and other stakeholder groups. This paper presents a systematic literature review of studies examining stakeholder perceptions of wood-based products, which also resulted in the identification of research gaps and suggestions for future research directions. The results show that while there has been an adequate amount of research concerning perceptions of wood construction and wood products in the built environment especially in recent years, the perceptions of other wood-based products and emerging innovations, such as wood-based textiles and chemicals have previously been studied only marginally. The results show that relevant stakeholders can be divided into two major groups: professionals at different places in the forest products value chain and end-users. Stakeholders are interested in wood-based products in the built environment, seen as competitive to conventional non-wood alternatives. Wood-based products are seen as interesting and environmentally friendly, but also expensive and not easily available. Moreover, there is a lack of information regarding product characteristics. To improve the market share of especially new wood-based products, the focus needs to be on both product development as well as providing information, including information on the environmental performance, on different products.

Keywords

circular bioeconomy; construction; literature review; perceptions; wood-based products

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1 INTRODUCTION

Governments all over the world have actively started to seek solutions to replace fossil-based materials (Dietz et al., 2018; Stupak et al., 2021; Lier et al., 2021) as there is an ever-growing concern about the future availability of traditional fossil resources and their greenhouse gas emissions and other negative environmental impacts (Hagemann et al., 2016; Giurca and Späth, 2017). This is reflected in the European Union through the formulation of a comprehensive set of new legislation under the European Green Deal. As a part thereof, the European Commission adopted the new Circular Economy Action Plan in March 2020. Measures that will be introduced under the new action plan aim to make sustainable products the norm in the EU; empower consumers and public buyers; focus on the sectors that use most resources and where the potential for circularity is high such as electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water and nutrients; ensure less waste; make circularity work for people, regions and cities; and lead global efforts on circular economy (European Commission, 2020).

With new technologies and innovations, wood has proven to be a versatile material that can contribute to bioeconomy development by substituting fossil and fossil-intensive (products that have a high demand for fossil energy in production) products and materials, creating a transition towards forest-based circular bioeconomy (D'Amato et al., 2019; Näyhä, 2019; Toppinen et al., 2020). Circular bioeconomy refers to the frugal and cascading use of renewable bio-based resources instead of the linear use of fossil-based resources (D'Amato et al., 2019, Toppinen et al., 2020). According to recent studies, the wood-based product categories that have most commercial potential in the future are likely to be construction products and textiles, as well as chemicals and biofuels and their applications such as cosmetics, food additives, pharmaceuticals, and plastics (Hurmekoski et al., 2018; Kunttu et al., 2020; Näyhä 2019).

The environmental performance of wood-based products varies, but some applications such as platform chemicals ('building block chemicals' that can be converted to multiple different chemicals) and wood-based composites together with other construction elements and textiles can have notably high climate benefits when replacing their fossil-based equivalents (Aryapratama and Janssen, 2017; Leskinen et al., 2018; Leskinen et al., 2020; Sommerhuber et al. 2015; Verkerk et al., 2021). In addition, carbon stored in wood products over their lifecycle creates additional positive climate impacts, as CO₂ sequestered into the wood product is not released into the atmosphere. The climate benefits of carbon storage in wood products are especially important in large-scale products with long lifecycles, such as wooden buildings (Bergman et al., 2014). However, the market share of wood-based products is still relatively small in most product categories. In construction it varies between regions, but the average share of wood construction is between 8 and 10 % of total construction in Europe (Alderman, 2013, Hildebrandt et al., 2017). Similarly, man-made cellulosic fibers (MMCFs) accounted for 6.4% of global textile market in 2018 (Textile Exchange, 2019).

New bio-based innovative products have been developed especially in the past ten years, following the implementation of different bioeconomy strategies (de Besi & McCormick, 2015). Moreover, the market environment is changing rapidly, nowadays shaped by Internet and digitalization. Engaging different stakeholder groups is crucial in order to increase the market share of these emerging wood-based products in particular. Especially the power of consumers has increased due to the increased ICT use and

solutions (Pires et al., 2006). ICT solutions empowers consumers by allowing them to access more information and to exchange it with other consumers, instead of market knowledge being controlled by suppliers (Pires et al., 2006). Consumers should be encouraged to shift their consumption patterns towards more environmentally friendly choices and for that, they should have up-to-date science-based knowledge of the environmental performance of different wood-based products and their conventional alternatives. Previous studies have shown that awareness and knowledge about environmental issues are linked to pro-environmental behavior (Li et al., 2019; Liobikienė and Poškus, 2019). While opposite results have also been found, and it can be stated that increasing factual knowledge alone is not enough to get consumers to shift their consumption patterns (Kollmuss & Agyeman, 2002), knowledge is at least a prerequisite to a pro-environmental behavior (Siegel et al., 2018). In terms of construction, studies have found out that consumer demand is a driving force in increasing the share of wood use in construction (e.g., Franzini et al., 2018; Ratnasingam et al., 2019). The growth of the middle class especially in East Asia and Latin America also means that the demand of living spaces is increasing (e.g., Knauss 2019), thus creating market opportunities such as for wooden multi-story construction. Professionals, such as architects and engineers who are creating and supporting wooden innovations also play a key role in increasing the market share and availability of wood-based products from multi-story wood-frame buildings to wood-based textiles and chemicals (e.g., Hemström et al., 2011).

There is extensive previous research related to perceptions of ecological or 'green' products and consumption (e.g., Maniatis, 2016; Sun et al., 2018; Tan et al., 2016) and some studies on consumer perceptions of bio-based materials and products in general (e.g., Lynch et al., 2017; Meeusen et al., 2015; Sijtsema et al., 2016). Studies indicate that the overall image of bio-products is positive, and the market acceptance is relatively high (Meeusen et al., 2015). Bio-products are seen as environmentally friendly and contributing to climate change mitigation (Pfau et al., 2017; Sijtsema et al., 2016). Still, bio-based concept and products are not very familiar to end-users (Sijtsema et al., 2016). Consumers think that the lack of knowledge on such products is an issue (Meeusen et al., 2015), and it can be a barrier to market development (Pfau et al., 2017). However, perceptions on bio-based products can vary depending on the actual resource used (e.g., Scherer et al., 2018); therefore, research results from other biomass resources than wood, such as agricultural biomasses, cannot be straightforwardly generalized to be perceptions of wood-based products.

In this study, perceptions are understood as beliefs or opinions based on how things seem, typically used when studying public views (Persson et al., 2022). Further, we perceive perceptions as the processes of interpreting and organizing sensory information (stimuli) by individuals to produce understanding and experience of the world, closely linked to attitudes (see e.g., Pickens, 2005).

The aim of the study is to explore stakeholder perceptions of wood-based products according to current research and knowledge. To meet this aim, a systematic literature review of published scientific papers is presented. This holds value for product development and marketing, as it shows how different stakeholders currently view wood-based products and which barriers are identified in previous literature. Consequently, this study can benefit stakeholder dialogue and its development, increasing the social acceptability of the sector. From the wider perspective, information on stakeholder perceptions is also beneficial for various actors in the society, creating understanding of the role and

potential for wood-based products in the sustainable transition and the factors affecting their wider market uptake. Moreover, this work can guide future research by showing relevant research gaps.

2 MATERIAL AND METHODS

In this study, the principles of systematic literature review (Xiao and Watson, 2019) were applied in order to identify and analyze all the relevant scientific, peer-reviewed publications concerning stakeholder perceptions of wood-based products. The steps of the review included planning the review, conducting the review, and reporting the analyzed results (Mengist et al., 2020; Xiao and Watson, 2019). The steps of the systematic literature review are presented in Fig. 1.

First, the research aim was shaped, the scope of the study was determined, and search terms were identified. Boolean search string used for searching article titles from the database was: (perception OR attitude OR acceptance OR preference OR view) AND (wood* OR timber OR cellulose* OR (forest AND product)). Studies were searched from scientific databases. As the field of stakeholder studies is interdisciplinary, Web of Science and Scopus databases were used in order to reach articles from a variety of journals. In previous studies it has been noted that the use of both these databases yields, in general, the most comprehensive search results (Li et al., 2010). The timeframe was set to studies published between 2000 and 2020 as the wood-based products before the year 2000 were produced and consumed in a very different market environment. In particular, the market environment of the past 20 years has been shaped by the Internet and digitalization (e.g., Pires et al., 2006). Moreover, the market environment has transformed with the development of new innovative bio-based products through impetus of bioeconomy strategies, especially in the past ten years (de Besi & McCormick, 2015).

Initial literature review yielded 551 findings from Scopus and 478 findings from Web of Science; most of them being duplicates. After removing duplicates, papers were initially evaluated based on their abstract, and studies clearly out of scope were removed, following inclusion criteria presented in Table 1 (after e.g., Sharma-Wallace et al., 2018). Papers concentrating solemnly on aesthetic and haptic perceptions (i.e., how does wood as a material feel and look) were excluded at this point as the aim of this study was to get a wider understanding on perceptions of wood-based products, not of wood as a material per se. In other words, papers needed to include considerations of the functional attributes (such as durability, quality, or usability) of products to be accepted in the review. Papers focusing on bioenergy were also excluded. After the initial evaluation, full texts were retrieved, and the final evaluation was done before accepting them for the analysis. Moreover, additional sources encountered when going through search hits were used as supplement to database findings (i.e., snowball searching). These include, for example, papers identified from the references of analyzed articles (so-called backward search; Xiao and Watson, 2019). For some papers, a forward search was also conducted in Google Scholar, meaning that the articles referring to that paper were extracted and screened (Xiao and Watson, 2019). In the end, 67 papers were included in the analysis after retrieving full texts.

To confirm the sufficiency of the selected search string and searching from article titles only, additional wider search from title, abstract and keywords was made with the following Boolean search string with looser search words: (perception OR attitude) AND (wood OR forest) AND (product OR construction). In Scopus, this yielded 1217 results (time span 2000-2020). The results were skimmed through, and relevant papers were added to the analysis. This additional search yielded 15 new papers for the

analysis. As it was noted that this search string could not provide any significant additions to the papers already identified, the original search string was used as the primary method for sourcing studies.

Table 1. Inclusion and exclusion criteria used in the literature review.

Inclusion criteria	Exclusion criteria
Focus on stakeholder perceptions, attitudes and experiences of wood-based products	Focus on perceptions of bio-based products in general, products from other sources than forest biomass, bioenergy, or purely aesthetics
Peer-reviewed article or conference paper in scientific journal	Not a peer-reviewed article or conference paper in a scientific journal
Written in English	Written in other language than English
Date range: 2000-2020	Date range: before 2000, after 2020

After the final evaluation of full papers and combining hits from snowball searching and additional database search, 82 papers were included in the final analysis. Selected papers were carefully read, and qualitative content analysis with an inductive approach (Elo & Kyngäs, 2008) was carried out. Studies were coded according to their content, grouping papers based on the stakeholder group in question, the product category in focus, methods used, geographical location, and sample size. Lastly, common themes and findings among different groups were identified. According to the principles of systematic literature review, the aim was not to summarize the variety of studies but to create a synthesis of what is already known and what is yet to be studied (Xiao and Watson, 2019).

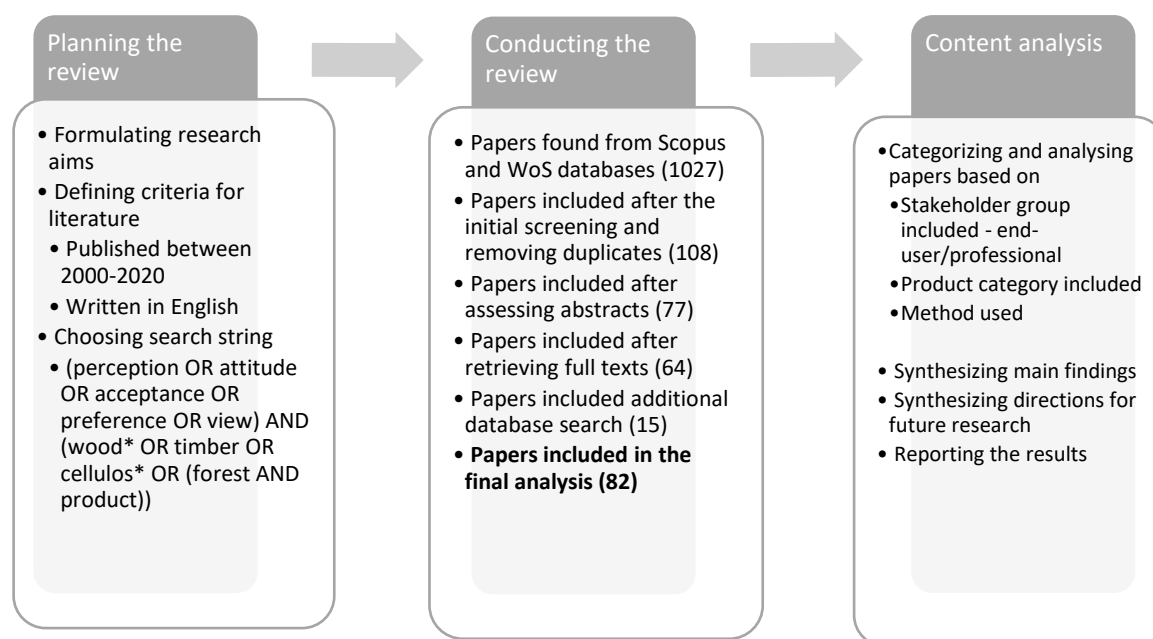


Fig. 1 Outline of the systematic literature review method used in this study

3 RESULTS

3.1 Descriptive analysis of the systematic literature review

In total, 82 papers focusing on stakeholder perceptions of wood-based products were identified and analyzed. All papers included in the analysis are listed in Supplementary material I.

It can be seen that research related to stakeholder perceptions of wood-based products has increased drastically, especially after 2016 (Fig. 2). Fourteen papers were published in 2018 and thirteen papers in 2020; otherwise, there has been maximum seven new papers published per year. The articles were published in a variety of journals from Wood Material Science and Engineering to British Food Journal. Forest Products Journal was the most common journal with eight published papers, followed by the Journal of Cleaner Production (6 published papers), BioResources (5 published papers), Scandinavian Journal of Forest Research (4 published papers), Acta Facultatis Xylogologiae Zvolen (4 published papers) and a Croatian wood industry journal Drvna Industrija (4 published papers). Eleven writers were the first author in more than one paper, the total number of individual first authors in 82 papers being 65, suggesting that a variety of researchers has been focusing on this topic.

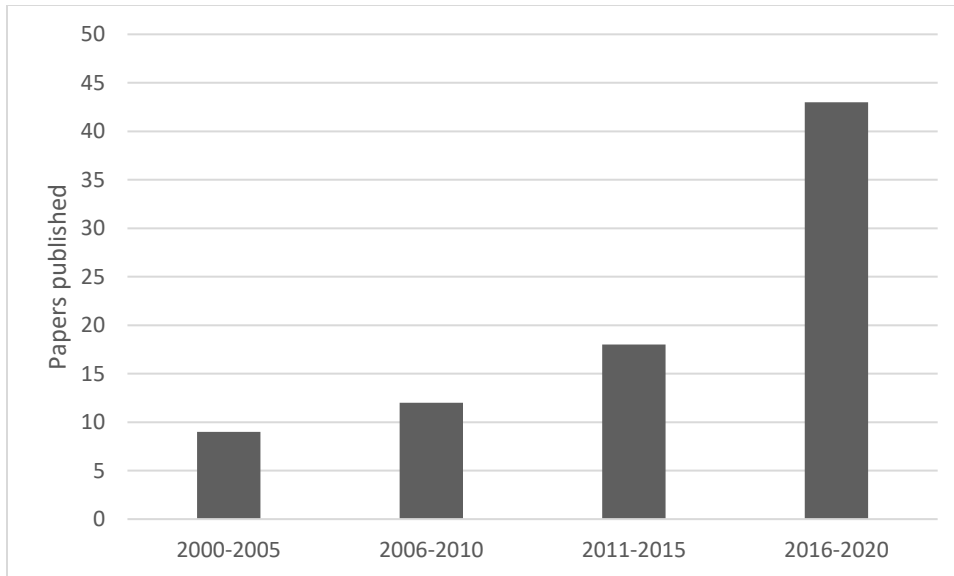


Fig. 2 Papers related to stakeholder perceptions of wood-based products published between 2000-2020

Two major stakeholder groups could be identified from the papers. 48 papers (59%) focused on end-user perceptions whereas 32 (39%) examined the attitudes of professionals such as architects, engineers, and municipal civil servants, and one paper included both aspects. One paper was classified as a review study. This one review study (Gosselin et al., 2017) focused on construction only and included scientific articles and grey literature. It was excluded from the rest of the content analysis to avoid issues with double counting. The studies identified in this review focused on one or more product category. The number of papers discussing each product category is presented in Table 2. It is notable that perceptions of wood construction were studied in most (in total 61) papers. Some construction-themed papers focused on timber construction, some on cross-laminated timber (CLT) or on engineered wood products (EWP). Papers related to construction focused either on actual wooden buildings (low-rise or high-rise) or on the use of wood in for example interior design, flooring, or decking. Thirteen papers studied perceptions on wooden furniture, while 13 papers focused on other categories such as playground equipment, packaging, wood-based food additives, or wood-based innovations and products on a general level rather than any particular end-product. No peer-reviewed papers related to attitudes towards wood-based textiles, for example, were identified in this literature review.

Table 2. Published papers by product categories.

Product category	Number of papers discussing the topic
Construction	61
Furniture	13
Wood products and innovations in general	7
Playground equipment	2
Packaging	2

Food additives	1
Infrastructure elements	1

Using questionnaires was the most common method of studying attitudes and preferences; most papers used either online or postal questionnaires (e.g., Knauf, 2015; Luo et al., 2018; Ranacher et al., 2017; Sasatani and Eastin, 2012). Some studies utilized either face-to-face interviews or computer-assisted telephone interviews (CATI) (e.g., Costa et al., 2011; Gold and Rubik, 2009; Kuzman et al., 2012). Some in-store or exit surveys were conducted as well as focus group discussions (e.g., Anderson and Hansen, 2004; Häyrynen et al., 2020; Roos and Hugosson, 2008, Strobel et al., 2017). A few studies utilized multiple methods, such as combining online questionnaire with data from focus group discussions. A Delphi method where multiple rounds of questionnaires or interviews are carried out was used by for example Toppinen et al. (2018, 2019). The sample size of the studies varied from 8 to over 1500 persons. A few papers used only secondary sources such as reports, meeting minutes and newspaper articles. Studies have been conducted in different parts of the globe. Most studies were European, but studies were also conducted in North America, Oceania and New Zealand and Asia, with a notable lack of South American and African studies. Plenty of papers had issues with their sample being not suitable for generalization, for example the sample was very small or consisted only of respondents from certain socioeconomic class or from a very limited geographical area.

3.2 Findings from the systematic literature review

In general, stakeholder perceptions of wood-based products seem to be positive. Stakeholders are interested in wooden construction, wooden furniture, wood-based packaging, and emerging wood-based products and innovations such as nanocellulose and its applications, and have a positive attitude towards them (e.g., Orzan et al., 2018; Ranacher et al., 2018). In this systematic literature review, most of the papers identified were focusing on perceptions of wood-based products in the built environment, including wood construction, furniture, and playground equipment. In other product categories, the very limited number of papers poses challenges to making conclusions based on them. As the translation of perceptions of wood-based construction to other wood-based product categories is not studied and needs more research attention, results cannot be generalized to present the perceptions of for example wood-based textiles, packaging, and chemicals. Therefore, the present results and analysis focus on wood construction and wood products in the built environment.

As the papers included in the review were conducted with varying methods in varying geographical areas and had different focus points in their analysis, making generalizable conclusions based on them is difficult. Some studies point out that differences in perceptions exist between even neighboring countries; for example, perceptions are more positive in Slovenia than in Croatia (Kuzman et al., 2012). However, some studies state that the differences between countries are small when studying countries with long traditions of wood construction, such as the Nordic countries and Austria (Strobel et al., 2017). Stakeholders also view different product attributes as important depending on their country of residence. For example, in the case of construction, termite resistance is the most pressing issue in some countries (e.g., Vlosky et al., 2009a, 2009b) and nearly irrelevant in others. Thus, it is important to recognize that stakeholders form multiple groups that emphasize on different attributes and have

clearly distinct information needs. However, recurrent themes in the results of identified studies can be clearly pointed out. These findings are further discussed in chapters 3.2.1 and 3.2.2.

A big question in terms of bringing wood-based products to market is the chance for an intention to purchase to translate into an actual purchase decision. Research has shown that there is a significant link between attitudes and behavior (Ajzen, 2001). Typically, the studies on the subject rely on two traditional and vastly cited theories: the Theory of Planned Behavior, TPB (Ajzen, 1991) and its predecessor, The Theory of Reasoned Action, TRA (Ajzen and Fishbein, 1980). These theories suggest that attitudes, amongst other variables such as perceived behavioral control and subjective norms, serve as predictors for behavioral intentions. The theories rely on behavioral intentions, in turn, being able to predict actual behavior of a person (Ajzen and Fishbein, 1977). In the framework of green consumption choices, both models have been used regularly (e.g., Han et al., 2010, Paul et al., 2016, Yadav and Pathak, 2017). However, the critics of the Theory of Planned Behavior claim that the relationship between attitudes and actual behavior is not as strong and unambiguous as suggested in these models. It is also important to note that behavioral intention may not necessarily lead to action as such, as the relationship between intention and target behavior is not always strong (Fredricks and Dossett, 1983). Despite this critique, it can be stated that attitudes and behavior are inter-linked and therefore, it is possible to study attitudes to find out implications for future behavior. In the context of this paper, perceptions of wood-based products could implicate the future behavior of professionals and end-users. Several papers showed that both end-users (e.g., Cai and Aguilar, 2013; Knauf, 2015) and professionals (e.g., Markström et al., 2018; Toppinen et al., 2019) are often *willing* to use or purchase wood-based products and sometimes even *plan* to do so in the near future. This indicates that the behavioral intention is high, leading to action more likely than with low behavioral intention. However, studies to verify the link between how preferences result into concrete purchase decisions remain yet to be conducted.

3.2.1 Professionals' perceptions of wood products in the built environment

According to multiple studies, professionals, such as engineers and architects, are willing to use wood in the future and mostly also believe that wood use especially in construction will increase in the future (e.g., Januzi-Cana, 2017; Kuzman et al., 2018, Markström et al., 2018; Toppinen et al., 2019). It seems that young professional might be more interested in using wood in construction than more experienced ones, thus education plays a crucial role (Matová and Kaputa, 2018). In terms of constructing with wood, professionals appreciate the speed of bringing up buildings and the 'workability' of wood (e.g., Gosselin et al., 2017; Markström et al., 2018; Ratnasingam et al., 2019; Roos et al., 2010). Wood is praised for its ecological performance and viewed as a healthy and safe material (e.g., Franzini et al., 2018; Li and Xie, 2013;). Especially those who have a good knowledge of wood as a material are also aware of its environmental benefits (Wang et al., 2014). Moreover, wood is praised as aesthetically pleasant (e.g., Li and Xie, 2013; Markström et al., 2018), even though papers considering only aesthetics were not included in this literature review.

However, professionals lack technical knowledge and experience especially when it comes to wooden multi-story or large-scale construction (e.g., Januzi-Cana, 2017; O'Connor et al., 2004; Viļuma and Bratuškin, 2017; Xia et al., 2014). Good examples of wooden multi-story buildings should be promoted together with multi-actor collaboration, promoting the networking of different actors (e.g., Hemström

et al., 2011; Kuzman et al., 2018, Roos et al., 2010). Knowledge and expertise could be imported in the form of international co-operation to support professionals in the areas with less experience and examples of wood construction (Arnautović-Aksić, 2016). Some professionals also see that wood and concrete construction sectors should join forces to create new solutions, but on the other hand, this can be difficult due to competition relationship between the sectors (Toppinen et al., 2019).

There are some concerns among professionals regarding the fire safety of wooden buildings (e.g., Xia et al., 2014). More pressingly, professionals in multiple papers point out that building regulations or national building codes for example regarding fire safety are a barrier to wooden construction and the lack of legislative support is an issue (e.g., Januzi-Cana, 2017; Laguarda Mallo and Espinoza, 2015; Mahapatra et al., 2012; O'Connor et al., 2004; Xia et al., 2014). Even though regional differences exist, laws and regulations related to wood construction are clearly an issue faced by professionals regularly in different parts of the world. Other issues brought up in the papers include challenges related to durability, availability of products and materials, and high costs (e.g., Januzi-Cana, 2017; Laguarda Mallo and Espinoza, 2015; Xia et al., 2014).

Based on the studies reviewed, it seems that professionals think product development is still needed to improve the issues such as moisture resistance, acoustic performance, and life cycle length of wooden construction components (e.g., Markström et al., 2019, Roos et al., 2010).

3.2.1 Consumers' perceptions of wood products in the built environment

Among consumers, wood is typically rated as an environmentally friendly material and appreciated especially for its good ecological performance compared to competing products (e.g., Høibø et al., 2015; Hu et al., 2016; Moresová et al., 2019). When used in construction, wood it is seen to be increasing living comfort, making spaces feel cozy, ambient, and aesthetically pleasant (e.g., Gold and Rubik, 2009; Larasatie et al., 2018; Strobel et al., 2017). However, some studies state that the use of wood in construction is more preferred by consumers in residential buildings than public spaces where the excessive use of wood visible in the interior is not favored for aesthetics reasons (e.g., Nyrud et al., 2014).

Consumers view wood as a healthy and safe material (e.g., Gold and Rubik, 2009; Hu et al., 2016; Lakkala et al., 2020; Švajlenka and Kozlovská, 2018). They also think that using wood in construction could also improve the indoor air quality of buildings (Strobel et al., 2017). On the other hand, homeowners with experience in living in a wooden building did not make any positive or negative remarks on the indoor air quality (Viholainen et al., 2020). Durability divides opinions: some studies point out that consumers are worried about the durability of wooden buildings and products (e.g., Hu et al., 2016; Høibø et al., 2015; Thomas et al., 2014) while others view wood as a durable material (e.g., Kuzman et al., 2012; Spetic et al., 2007).

Despite all the positive aspects, barriers to using wood exist as well. One of the biggest issues raised in several papers was, in terms of wood construction, the assumed sensitivity to fire. Various studies have found out that consumers are concerned about the fire safety of wooden buildings (e.g., Gold and Rubik, 2009; Moresová et al., 2019; Thomas et al., 2014) or treated wood products (e.g., Donkor et al., 2003; Vlosky and Shupe, 2002, 2004a, 2004b). Fire resistance treatments have also been seen to degrade the

environmental benefit of wood construction (Viholainen et al., 2020). Other concerns include the difficulty and amount of maintenance needed and thermal comfort (e.g., Gold and Rubik, 2009; Švajlenka and Kozlovská, 2018). Moreover, the sound insulation of wooden buildings raises questions (e.g., Hu et al., 2016; Olšiaková et al., 2018; Roos et al., 2010; Švajlenka and Kozlovská, 2018). The “liveliness” of wooden building can create different sounds (Viholainen et al., 2020), for example, the changes in air humidity can cause clicking, cracking, or popping sounds in the building. However, in general, the homeowners in a study by Viholainen et al. (2020) found the soundscape of a wooden two-story building to be echoless and pleasant.

Pricing and premium prices clearly divided opinions. Many papers point out that price is an important attribute for consumers when making a purchase decision and consumers cannot be expected to pay a premium for wooden product or a sustainable product (e.g., Anderson and Hansen, 2004; Aguilar and Cai, 2010; Kaputa et al., 2019; Kuzman et al., 2012). Similarly, consumers indicate a preference for certified wood products but are rarely willing to pay premium for it (e.g., Shukri and Awang Noor, 2012). Contradictory, some results show that price is not a very significant attribute when making purchase decisions or it is clearly outweighed by other attributes (e.g., Ozanne et al., 2001). According to these studies, attributes like quality and safety are more important; some consumers also view the use of domestic and certified wood as an important factor (Ozanne et al., 2001).

4 DISCUSSION

4.1 Realizing the potential of wood-based products

Based on the literature review, recommendation concerning wood products and their use in the built environment could be drafted. Recommendation regarding policymaking, product development, supporting the attitude change of consumers and professionals, and improving the outreach of wood products are discussed below.

To improve the market uptake of especially new and emerging wood-based products, focus needs to be on developing high-quality products that are available for consumers as well as communicating about them to the wider public. Policymaking should promote these objectives and thus support transitioning towards bioeconomy and away from fossil materials and resources. This includes removing barriers to wooden multi-story construction and thus supporting the increase in production volumes and the development of the field, after for example Riala and Ilola (2014). Updating existing standards and norms restricting the use of wood in multi-storey construction would be beneficial in many countries. Policies should also support new wood-based innovations, such as wood-based plastics, textiles, and chemicals, to decrease the cradle-to-market time. Moreover, public procurement policies could further support the use of wood-based products and materials to replace fossil resources (de Besi & McCormick, 2015).

The results of the literature review show that the product development should focus on creating products that are able to compete with conventional products in terms of quality, price, and availability. Even though the literature review results suggest that price is not in all cases the most important attribute affecting purchase decisions, consumers might not be willing to pay a premium for a sustainable wood-based product according to multiple studies (e.g., Aguilar and Cai, 2010; Anderson and Hansen, 2004). In terms of availability, it is clear that the production volumes of wood-based products

should increase to ensure availability, but first they need to reach at least comparable functionality with fossil-based ones.

Multiple measures need to be taken in order to improve acceptability, desirability and ultimately the market share of new wood-based products amongst both end-users and professionals. According to the results of this review, the lack of knowledge and objective information is a big barrier to using and purchasing wood-based products. It was brought up in most papers identified in the literature review. Therefore, it can be stated that providing information and changing prejudices and stereotypes, regarding most pressingly the fire sensitivity of wooden buildings - especially high-rise construction - is needed in order to improve the acceptance and attractiveness of wood-based products (e.g., Hu et al., 2016). As knowledge has been found to correlate with positive attitude in previous studies (e.g., Bysheim and Nyrud, 2009; Larasatie et al., 2018; Stern et al., 2009; Wang et al., 2014), communicating about the benefits and for example the quality of wood-based products to the public would be crucial when increasing the market share of new wood-based products and transitioning towards bioeconomy. Moreover, improving industry image and acceptability by ensuring the sustainability of products and processes as well as communicating about these efforts is needed (Stern et al. 2018). One communication strategy cannot fulfil the needs of all stakeholder groups. Research has shown that different consumer groups and consumer types can be detected (Lähtinen et al., 2019), and that different communication strategies need to be adopted to reach each of these groups. Further, based on various technology and innovation adoption models, individuals make technology adoption decisions in different phases of innovation lifecycle (Straub, 2009). Therefore, different communication and marketing strategies will also be needed for those who adopt innovations early and for those who are late adopters (e.g., Reinhardt and Gurtner, 2015).

For different target groups and varied audiences including both experts and the general public, appropriate information channels need to be used to spread knowledge. Especially online media channels should be utilized more in the communication, as the media landscape has significantly changed in the recent decades. Social media allows companies to reach various consumer segments effectively, as well as the consumers to reach companies and search for information (Alves et al., 2016). Consumers increasingly share information in the social media, learning also from their peers. Moreover, it has been suggested that the increased use of ICT is creating a shift in market power from suppliers to consumers, requiring strategic consumer-centric marketing actions (Pires et al., 2006). The internet allows mass-customization and personalization to meet the needs of the empowered consumers. In addition, different labels and standards would help especially consumers to make educated consumption choices and inform them about for example the ecological performance of wood-based products (Sønderskov and Daugbjerg, 2011).

Moreover, lack of experience and good examples of such products was identified as a barrier in a number of papers (e.g., Januzi-Cana, 2017; Viļuma and Bratuškin, 2017). Professionals would benefit from 'expertise trade', and best practice sharing between countries (Arnautović-Aksić, 2016).

4.2 Limitations of the study

It needs to be noted that 20 years is a long timespan in the context of stakeholder and consumer studies, especially when considering the changing media landscape and rise of social media. Therefore,

it is likely that some results in the oldest papers included in this review have already become outdated. This is due to green consumption having become drastically more common as the awareness of consumers has increased significantly during the 21st Century. Moreover, the technological development affecting for example the ecological performance of wood-based products, and thus probably also having an effect on attitudes and perceptions, has been significant during the last 20 years and is likely to continue in the future. The operational environment is very different now than what it was in the beginning of the Century. However, only a small number of papers were published prior to 2010, therefore this should not affect the overall results and conclusions.

It is important to note that no papers related to attitudes towards certain product categories such as wood-based textiles were identified in this study and therefore, the analysis focuses on wood use and wood products in the built environment. It is possible that for example wood-based textile fibers have been discussed in papers with focus on sustainably fashion or sustainable textiles, with abstracts or keywords that do not include the term wood or forest. Nevertheless, there is a notable lack of research covering these topics. Moreover, we would like to note that perspectives in those potential cases where consumers unconsciously choose, apply, or use wood-based products likely remain outside many data sets or/and cause some bias when perceptions are studied. However, in most research settings included in this review, it was specified that the material in question is wood (e.g., asking perceptions of wood-based housing or furniture). Therefore, we believe that this is not a major hindrance in this study.

4.3 Future research needs

In this study, only a few studies regarding other product categories than construction, such as chemicals, packaging, and textiles, were identified. This is not surprising as some of the applications are relatively new, but also because these kinds of products may be more recognized by their market names, which do not typically refer to their wood-based source, at least solely (e.g., Tencel, Lyocell). To perform a review for wood-based products such as textiles, the terms used for search should perhaps focus on market names and accept that the reviewed products can be manufactured from also other cellulose-based materials than only wood. In addition, peer-reviewed literature may not result in adequate number of articles for a review. Therefore, studying for example discourses in the media and social media could be valuable. It is clear that more research regarding the perceptions of these new and emergent product categories is needed in the future.

While the number of studies published have been increasing, however, there is a lack of studies focusing on African and South American markets and consumers, as well as studies having samples representative of the population in the studied country. Apart from the identified stakeholder groups (professionals and end-users), the perceptions of other stakeholders such as NGOs have been overlooked in research.

Moreover, there is a need for new end-user and other stakeholder studies with a statistical sample design to study more explicitly the differences between countries to identify the barriers typical to each country and to set action plans and measures to overcome them. In addition, it would be interesting to study how consumer perceptions can be affected effectively so that prejudices can be converted and attitudes improved. More knowledge on information needs, effective communication strategies and

appropriate information channels, including the effect of social media, is needed. For that, studying current media representation of wood-based products would be important.

Overall, it is very likely that the historical and cultural position of wood utilization affects perceptions and attitudes of humans. It is possible that in forest rich countries and cultures (e.g., Finland, Sweden, Austria, Canada) traditionally leaned heavily on forest resources utilization, wood-based products are accepted more easily, humans inherently viewing forests as being part of the way of living and income (e.g., Berninger et al., 2009; Halla et al., 2021; Petruch and Walcher, 2021; Roiko-Jokela, 2016; Strobel et al., 2017). On the other hand, there are increasing critical voices also in these countries, especially among younger generations, highlighting forests' role as a source of biodiversity, carbon reserves and recreational places rather than industrial resource (see e.g., Berninger et al., 2009; Halla et al., 2021; Halla and Laine, 2022; Petruch and Walcher, 2021). These views deserve more attention and should be studied in the future when exploring new wood-based products diffusion. Based on the data in this study, we cannot explore these issues on in-depth level. Overall, forests and forest-based resource utilization are subject to diverse, often contradictory goals, needs, values and hopes as indicated for example by recent human-forest relationship and forest-based sector transition studies (e.g., Karhunkorva et al., 2017; Halla et al., 2021; Näyhä 2019, 2021). Thus, it is obvious that new wood-based forest products are approached by various perceptions by diverse stakeholders in many cultures, which are inadequately understood at the moment.

5 CONCLUSIONS

In this study, a systematic literature review regarding stakeholder perceptions of wood-based products was carried out. The results reveal that the attitudes of professionals and end-users towards wood construction, including multi-story construction, and furniture have been studied relatively extensively over the last two decades in different parts of the world, but not so for other product categories such as textiles, chemicals, food packaging, and so forth. The results show that wood-based products in the built environment are seen as a promising alternative for conventional fossil-based products by consumers as well as professionals, but also significant barriers exist. Studies state that end-users are concerned about fire safety and maintenance costs of wooden multi-story buildings even though the interest towards wooden construction is clear. Moreover, professionals think that the lack of legislative support and strict regulations pose a barrier to building with wood. On the other hand, the results show that wood-based products in the built environment are perceived as environmentally friendly, safe, aesthetically pleasant, and healthy products. However, stakeholders were uncertain of the durability and quality of these products in previous studies. This suggests that a lot more work needs to be done to overcome these inhibitions towards choosing wood, which may be deeply rooted in culture and traditional attitudes. More information is needed to change the attitudes of stakeholders towards more positive and to correct possibly false prejudices. This includes the increased use of social media in communication. Additionally, stakeholders think that wood-based products are somewhat expensive and, in some cases, not available, at least with bigger market volumes. This can be explained by the fact that wood-based alternatives in many of the product categories are still waiting for commercialization. However, in the future, wood-based options should be readily available in order to get consumers to shift their consumption habits. All in all, the intention to purchase or use wood-based products appears high.

CONFLICTS OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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