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Holistic design of taller timber buildings (HELEN)

STATE OF THE ART REPORT

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COST Association AISBL
Avenue du Boulevard - Bolwerklaan 21, box 2 | 1210 Brussels, Belgium
T +32 (0)2 533 3800 | office@cost.eu | www.cost.eu

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Holistic design of taller timber buildings (HELEN)

Sustainability and Durability of Taller Timber Buildings:

A State-of-the-Art Report

Edited by
Steffen Franke

Funded by
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The sole responsibility of the content of the various contributions lies with their authors.

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IMPRESSUM

Sustainability and Durability of Taller Timber Buildings: A State-of-the-Art Report

Working Group 4, COST Action CA20139 - Holistic Design of Taller Timber Buildings - HELEN

Working Group 4 Leader: Steffen Franke

Co-leaders: Stephan Ott, Jens Frohnmüller, Shady Attia, Bettina Franke

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LCA of wood-based structures for taller timber buildings

Rafael Novais Passarelli, UHasselt (Belgium)

1 Introduction

This study develops a literature review of all papers published in the Journal of Building and Environment from January 1st, 2000, to July 31st, 2022, on the LCA (Lifecycle Assessment) of taller timber buildings. By studying the body of knowledge in this field in the past two decades, the study aims to shed light on its evolutional path, past and current trends, and, most importantly, open scientific gaps to tackle in future research.

2 Method

Using the ScienceDirect database, I performed two searches for papers published in the Building and Environment since 2000 that included all three following terms: 1) LCA, Wood, Construction; or 2) LCA, Timber, Construction. The searches yielded 166 and 102 results, respectively. Search terms were intentionally broad to deliver the highest number of hits possible. Then, an automatic check for duplicates excluded 77 entries, leaving 191 papers denominated as the initial collection (IC). The IC was manually inspected for compliance with the topic, using the following questions: 1) Does the paper develop an LCA study of wood-based construction systems or elements? 2) Do the wood-based construction systems/elements fulfill a structural role in the case study? 3) Is the structural role of the construction system or element in the case study applicable to taller timber buildings with four or more stories? The order of inspection was the following: 1) Title; 2) Keywords; 3) Abstract; 4) Full manuscript (only when needed). If one of the questions above had a negative answer, the paper failed the compliance inspection. Conversely, if all three questions were positive, the paper passed the compliance inspection and became part of the final collection (FC). At the end of the compliance check, 26 entries from the initial collection answered positively to all three questions and constituted the FC. Finally, the FC papers were thoroughly analyzed, with their aims and conclusions summarized in Annex 1.

3 Results and Discussion

Despite taller timber buildings with four or more stories being a reality for more than two decades, there was a surprisingly low number of publications about their LCA in the Journal of Building and Environment, with the vast majority of entries dating from the last couple of years. The count of papers by year (Figure 1) indicates the number of publications on the topic was relatively constant between one and two from 2009 to 2020. In 2021, however, there was a sharp increase in publications with nine published papers. Likewise, the year 2022 already portrays five entries until July. This result suggests a sudden interest in the field by the researchers and the journal. Further analysis of the number of publications by the geographical scope of the study (Figure 2) shows a predominance of Central European countries (9 entries), followed by Canada (5 entries), which most likely coincides with the incidence of mid-to-high-rise timber buildings. Hence, one hypothesis is that the concentration of taller timber buildings in a few countries around the globe contributes to limiting the relevance and interest in LCA studies about these buildings, thus leading to a still small number of papers.

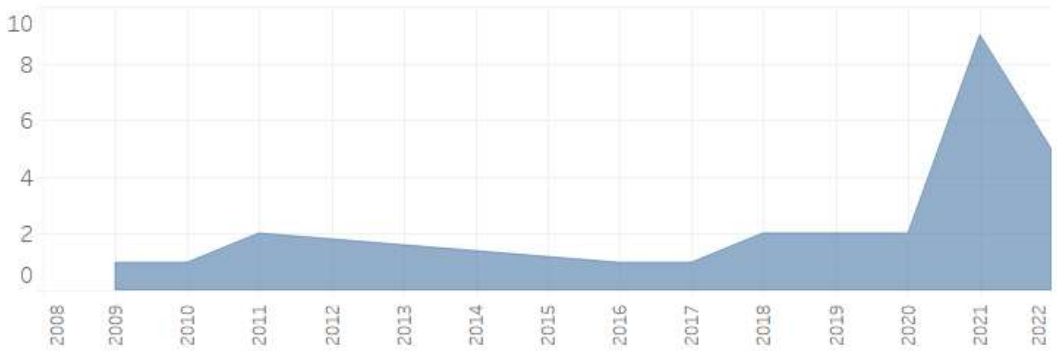

Figure 1: Count of publications by year

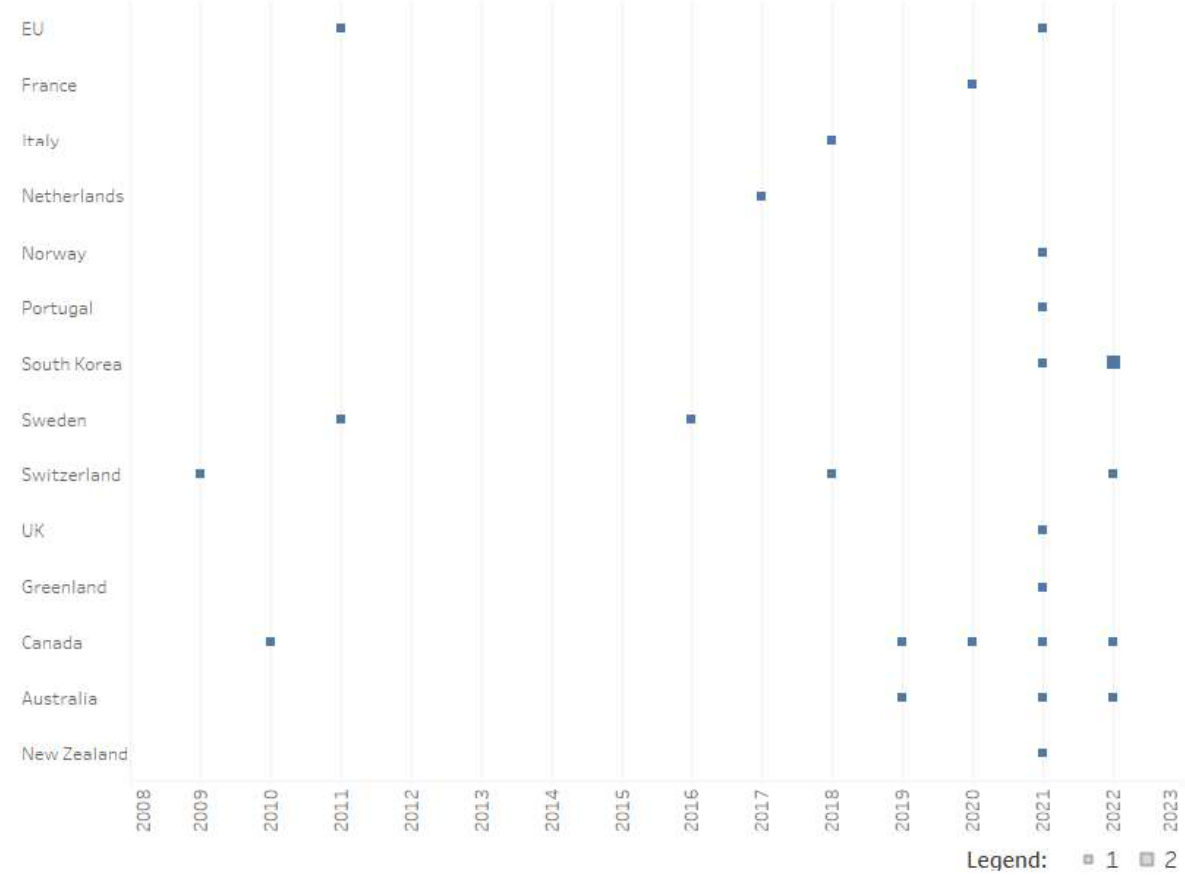

Figure 2: Count of publications by country, by year

The thorough analyses of papers showed that studies from 2010 to 2020 focused on material selection and its evaluation of the environmental impacts of construction. Many publications from this period compared some types of wood-based systems with their equivalent in concrete or steel (Bribián, 2011) (Wallhagen, 2011) (de Klijn-Chevalerias, 2017) (Invidiata, 2018) (Li, 2019). Another set of papers from the same period aimed at discussing the possibilities and shortcomings of the LCA methodology (Kellenberger, 2009) (Sinha, 2016) (Rezaei, 2019). The main goals were to develop more reliable methods and simplified tools to support decision-making during the design and construction processes.

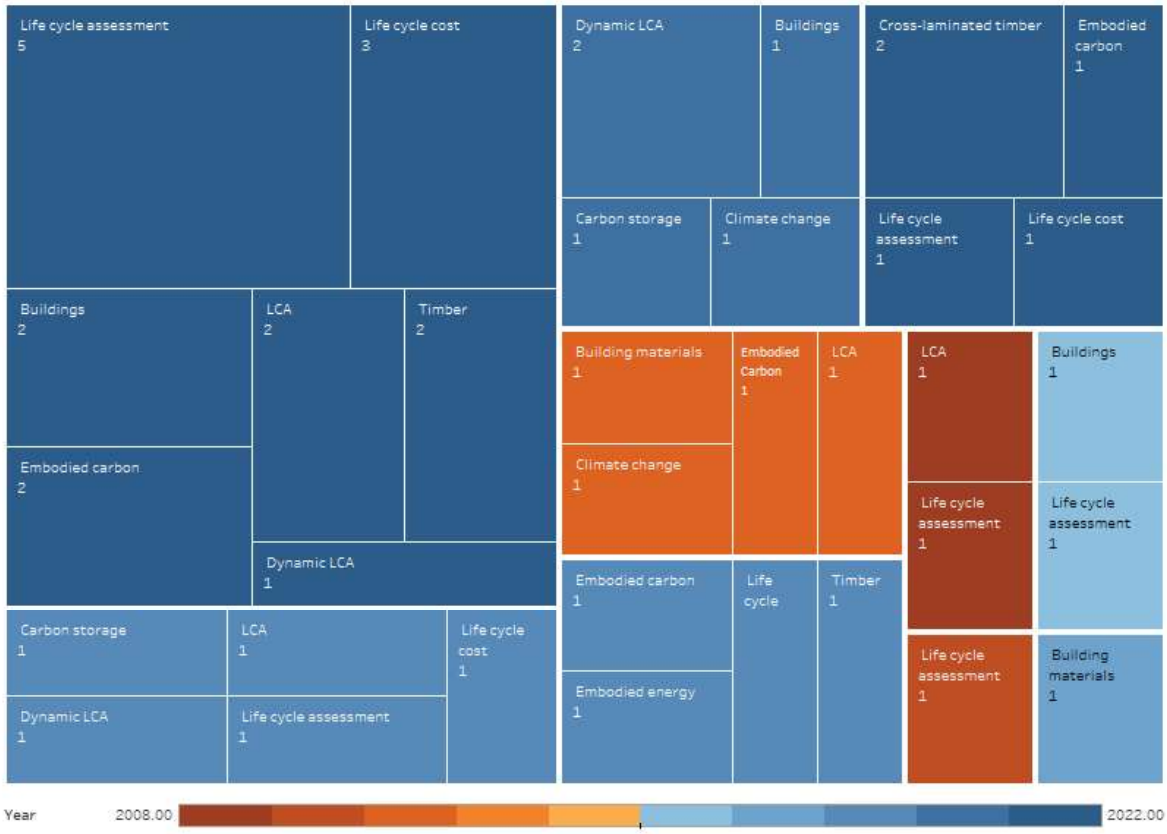

Figure 3: Publication keywords with total incidence > 1, by year.

Nonetheless, a new trend stands out in the transition from the 2010s to the 2020s. Figure 3 displays keywords with more than one hit and indicate an increased interest in the past couple of years in studies involving analyses of carbon storage through a dynamic LCA method. Hence, a considerable number of more recent studies on the LCA of taller timber buildings also started to tackle the time dimension and its influence on environmental performance (Pittau, 2018) (Head, 2020) (Zieger, 2020) (Morris, 2021) (Resch, 2021) (Göswein, 2021) (Robati, 2022). The dynamic LCA studies quantify the extended effects of biogenic carbon storage in fiber-based materials aiming for more accurate assessments of its impacts on buildings and materials. Those studies conclude that considering an expanded time horizon, sometimes up to 500 years (Zieger, 2020), is beneficial to fiber-based products (Zieger, 2020) (Resch, 2021). The results also show that when the timing is considered, the faster the growth rate of fiber-based materials, the more beneficial it is in the short term, which gives an advantage to straw, hemp, and cork over wood (Pittau, 2018), although the differences between fast- and slow-growing biomaterials level out in the long-term (200 years horizon) (Göswein, 2021). In the same line, recent papers started to stress the relevance of the end-of-life scenario and further potential for mitigation of extending the lifespan of buildings and materials through strategies such as design for adaptability, disassembly, and reuse to increase the time-related benefits of wood-based materials (Morris, 2021) (Resch, 2021) (Kröhnert, 2022) (Robati, 2002).

4 Conclusions

This study developed a literature review on the LCA (Lifecycle Assessment) of taller timber buildings from 26 papers published in the Journal of Building and Environment from 2000 to 2022 (July). Therefore, because all results and conclusions refer to only one journal, caution is required when generalizing them to the whole field. The results are, however, useful as an

indication of general trends as they relate to one of the most relevant publications in the domain of sustainable construction.

This review study found a still limited number of publications on the LCA of tall timber buildings in the Journal of Building and Environment. Although tall timber buildings have been a reality for more than two decades, their incidence lies predominantly in central European countries, Canada and Australia, which might be one reason for the past lack of publication on the subject. Nevertheless, this study showed a sudden increase of interest in the topic, demonstrated by the number of publications in the past two years.

It was also noteworthy that recent LCA studies tend to go beyond a single building lifespan, with extended time horizons evaluation to account for a more accurate assessment of biogenic carbon dynamics and its impacts on buildings and materials lifecycle. Likewise, topics such as design for adaptability, disassembly, and reuse and their influence on the LCA of taller timber buildings appear to become increasingly relevant for the field in recent and likely in the coming years.