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Thoughtful: Towards the longevity of wooden buildings for climate change mitigation and adaptation

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Abstract: The building sector is no longer functional; if we wish to maintain a livable planet a major shift in mindset and practice is urgently needed. Wood construction has been identified as an important way to decarbonise the built environment. However, sourcing wood *must* consider *all* the values of the forests; so to avoid overharvesting, biodiversity loss and other damage to ecosystem services, we should use wood thoughtfully. New wood buildings should be designed for adaptation and disassembly and built to last, and the lives of old ones should be extended. Currently, little is known about the factors affecting the lifetime of wooden buildings and holistic comprehension is needed to support the transition towards long-lived and resilient building stock. In this paper we aim to better understand the lifespan of wooden building, the key factors affecting it, and propose means to extend the building lives; this can also support and promote new, durable, wood construction. Using a combination of literature study and semi-structured interviews, we explore factors affecting the longevity of wooden buildings and the reasons for major renovation or demolition. We adopt a process approach that takes the different events in the life cycle of a wooden building as the primary units of analysis and map the underlying reasons affecting building longevity within these units. Preliminary results suggest that the lifespan and sustainability of wooden buildings is a multi-layered complex matter that is already affected long before the actual building process starts, with forestry choices, planning, cultural aspects, investment, and legislation having an impact; and after the start of the building process by design, craftmanship and material choices, local attitudes, the understanding and knowledge of wood buildings and their aesthetics, as well as geopolitical trends, maintenance and renovation.

Introduction

Accounting for over a third of final energy use and nearly 40% of global CO_2 emissions (UN Environment Programme, 2020), the building sector is also responsible for around half of the 100 billion tons of raw materials extracted annually by humankind (Circle Economy, 2020; European Commission, 2004). Moreover, construction and demolition waste accounts for almost half of the total annual wastes in the EU (Eurostat, 2018). With an increasing urban global population needing good-quality dwellings, the demand for buildings is unlikely to diminish; yet if we continue to construct in the way that we do, 35–60% of the remaining carbon budget will be consumed by 2050, even if we are to limit climate heating to 2 °C (Müller et al., 2013). Clearly, the building sector is no longer functional if we are to keep the planet liveable, and a major shift in both mindset and practices is needed. Change is at hand, so we need to ensure that this transition does not create new problems, and for this we require a holistic understanding of the whole building process.

Wood construction has been proposed as a means of facilitating this transition and it has been suggested that the widespread adoption of engineered wood in multi-story buildings could make the sector a carbon sink (Churkina et al 2021). Wood-based products store carbon and substitute functionally equivalent materials (Leskinen et al., 2018). The sequestered carbon stored in wood is only released back to the atmosphere when it is burned or decays, so long-lived wood building products are effective carbon stores.

Why not simply increase the amount of wood construction? Mishra et al (2022) recognized that to increase global wood construction to the level required, the harvesting of unprotected natural forest and an increase in tree

plantations would be needed. In Europe, another study concluded that should wide-scale wood construction be adopted, the net effect on the sink capacity of the forest-harvested wood products sector would be negative (Jonsson et al, 2021) and in an open letter, a group of Finnish researchers stated that increasing the harvesting and use of wood in line with the bioeconomy strategy would decrease biodiversity and accelerate climate change (Researchers' Statement, 2017). Worryingly, these predictions appear to be coming true, since the Finnish land use sector became a source of emissions in 2021, partly because of over harvesting (Official Statistics of Finland, 2022).

To reduce the ever-increasing pressure on forests, we should use wood more thoughtfully and sparingly by extracting as much utility as possible from existing wood products. From a circular economy hierarchy perspective, reducing the consumption of resources, by extending the lifetimes of buildings and the materials that they contain, is preferable to recycling building products after demolition. This also has clear implications for climate change mitigation since, in terms of carbon storage, extending building lifetimes is more beneficial than recycling the wood products they contain (Hill et al. 2020).

Whilst the average lifespan of buildings in Finland is known, the factors affecting this are less well understood. Moreover, holistic knowledge of the means and capacity of extending the longevity of the buildings is insufficient. The aim of the ongoing study reported in this paper is, therefore, to generate a better understanding of, and new knowledge about, the lifespan of wood buildings and to propose ways in which their longevity can be extended. Moreover, this can support and promote new, durable, wood construction. These actions will help extend the carbon storage of wood-based building products, reduce the need for primary resources, and so help mitigate climate change. We report preliminary results from this study.

Methodology

To investigate the factors that affect both the longevity of wooden buildings and the reasons for their demolition, we utilised a qualitative approach comprising desk research tasks and interviews, collecting data through a literature search and semi-structured interviews with relevant actors. A snowballing approach was used to identify additional interviewees from the initial interviews. Interviews are still ongoing and have included discussion with experts and researchers from the following disciplines: Forest management and politics, forest bioeconomy, legislation, business and society, building economics, wood architecture, vernacular architecture, wood construction, wood science and technology, indoor air quality, and building inspection and conservation. Additionally, participatory observation in events, seminars and meetings was used to complement our understanding.
To undertake the analysis, we adopted a process approach, shown schematically in Fig.1, that creates analytical constructs from the different events in the lifetime of a wooden building as the primary units of analysis, and maps the underlying factors affecting building longevity within these units. The phases included in the process are Forests, Circumstances, Preparatory, Design, Construction, Maintenance and Beyond. This approach was complemented using an iterative research process and systems thinking to ensure a holistic viewpoint.

Results and discussion

The results suggest that factors relevant to the longevity of wooden buildings can be broadly divided into two categories; The first comprises factors that are relevant before the building process begins and the second are factors that are relevant after the start of the building process. The first category includes phases 1-3 in Fig. 1 (*Forests, Circumstances & Preparatory*) and the second, phases 4-7 (*Design, Construction, Maintenance,* and *Beyond*).

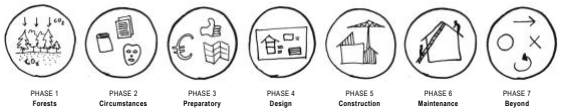

Figure 1. The phases of the wood building process that are being investigated.

Phases 1-3: Before the building process begins

Throughout all phases, it seems crucial to change the mindset and alter the emphasis of the wood building process. Currently, wood buildings are mainly thought of as 'temporary' (albeit some decades), whereas we could consider them to be 'practically permanent' (some centuries) or, in some cases temporary with the permanent use of the material through cascading supported by e.g., design for disassembly. We should plan and understand the life span of the buildings accordingly.

Phase 1: Forests – global resilience and the origin of materials

From our interviews and background research, clearly wood should be used for buildings to help mitigate climate change (e.g., Churkina et al 2020) and reduce resource extraction, yet at the same time, forests should be preserved for the resilience of the planet. To achieve this, we should make efficient use of the wood extracted from the forest, and the wood that is harvested should be directed towards longer-lasting, higher-value products. This finding is not new; EASAC (2017), for instance, stated that since "*using wood in durable commodities and construction allows carbon to be stored over long periods, these uses should be stimulated*". Forestry practices should be developed; accordingly, longer rotations and more continuous cover, with focus on quality.

Finland has a growing domestic market for wood building and so the emphasis on wood production should be shifted towards quality rather than quantity. By harvesting less and creating more value from what we take from the forests, we could generate new employment in the more labour-intensive wood building products sector. This has economic potential and may favourably influence the future know-how of Finland.

Our findings suggest that a shift in the product line is the first part of the change, and the second is the efficient, holistic use of the materials harvested. By using the whole tree and side streams more efficiently and directing them to higher value products, ensuring the longevity and maintainability of these 'products' and cascading the material multiple times, we can reduce the pressure on primary resources and create a healthier wood life cycle chain. This will also help maintain a livable planet by protecting the forest carbon store, most of which is in the ground (Pan et al, 2011), maintaining active carbon sinks now, when we most need them, and help recover and save the remaining biodiversity. All this contributes to resilience of the forests and the planetary system.

Phase 2: Circumstances – cultural and legislation impact

Legislation and policy guidelines appear to have a significant impact on the longevity of buildings. Additionally, attitudes and cultural aspects, like habits and customs, seem to have an influence.

Both in the EU and at national level there are strong incentives to prolong building lives in connection with sustainable building practices, the green transition and climate change mitigation. Laws and guidelines have already addressed this issue, and both the EU circular economy strategies (European Commission 2020) and the Finnish Building Act 2023 (YmVM 27/2022) address building durability and longevity. Within the legislation some of the main factors having an influence are: supporting the different roles of the forest and material use, supporting adaptability and resilience within the city structure, setting and supervising goals for longevity, and requiring reasoning and possible compensation for demolition.

Whilst wood has long been the main building material for detached houses (Nasiri et al. 2021), attitudes towards constructing apartment blocks and public buildings from wood have changed and are now more positive. Circumstances also seem to now be more positive towards continuous cover forestry that could emphasise quality over quantity and the production of building scale wood instead of smaller scale wood for fibre. Nevertheless, there also seems to be doubt about using wood for new purposes e.g., wood building, because of threats related to the forest carbon store, carbon sink and biodiversity – issues that would need to be tackled to ease this doubt.

Existing habits and practices seem to hinder changes to building practices.

Phase 3: Preparatory – influence of building decisions

Considering preparing for building, urban planning and building economics are the two main factors investigated so far. The green transition connects both these categories, and it seems that a clear economic plan to transition to a carbon neutral society is needed.

It has been noted by interviewees that urban planning as well as the city structure and density can affect obsolescence and, moreover, flexibility i.e., the adaptability of the buildings and spatial functions, can affect the decision to demolish or not.

Regarding building economics, it seems that key issues affecting longevity include redundancy – the need for the building, the profit motive, e.g., constructing more floor area on a given plot, spatial obsolescence, and perceived risks. These issues were raised by several interviewees and seemed to apply irrespective of the building material, and be closely connected to political decisions, the location of the building, and banking practices. Wood buildings are still perceived to be more expensive, although it seems that they can command a small premium due to demand. Insurance costs do not seem to have a significant influence. Further, the share of renovation practices in the building market is growing (37% in 2021), whilst the share of new building is decreasing (45% in 2021), renovation having larger housing share in housing in 2021. The RT (The Finnish Building Industry) estimates that to achieve green transition, a huge possibility for the country according to them, the renovation construction should double. The shift towards renovation and maintenance would contribute directly to the longevity of buildings and is necessary to prolong building lives (RT 2023).

Phases 4–7: After starting the building process

In general, it seems that we need to start to design and build permanence or 'thoughtful temporality', with repurposing of building materials in mind. We should emphasise design and building for resilience, adaptability, and a changing climate, preparing for unexpected situations, extreme conditions, and increased moisture, or heat related issues (Lü et al., 2018). For this, according to a number of interviewees, more specialised professionals, greater knowledge and expertise and more examples of resilient wooden buildings are needed.

Phase 4: Design – contemplating impact

The design mindset and design decisions affect longevity. When designing for permanence, all structures should be easy to maintain and designs should be resilient considering unanticipated faults, some of which will eventually arise. The structures and maintenance of the building should also be understandable for users, with simplicity and accessibility of the structure being one means to achieve this. Moreover, known risks to structures should be avoided, by e.g., ensuring that they can dry readily, and that future risks, such as coping with changing weather conditions, are carefully considered.

To avoid obsolescence design for flexibility, repurposing, disassembly, and relocation or reuse are important tools.

Phase 5: Construction – building to last

The building construction mindset can also affect the permanence of a building or building elements. High quality work and building for ease of maintenance and the replacement of materials, are important. Additionally, it is important to avoid moisture damage at the construction stage. In the worst case, building guidelines or instructions risk hindering the wood building process. As noted earlier, more examples of resilient long-lasting wood construction are needed.

Phase 6: Maintenance – sustaining the longevity

By increasing longevity and growing the (wooden) building stock, the role of maintenance and renovation will become more important. All buildings need maintenance, and the focus should be on 'lighter' continual maintenance instead of neglect and major renovations; over-renovating should be avoided. However, some building typologies not well designed for maintenance, may present challenges in maintaining them, and may need larger renovations instead. When renovating, adequate expertise and professionals educated and specialised in wood building maintenance are crucial; a lack of both, according to several interviewees, exists.

Understanding buildings is important to avoid the risk that renovation might even compromise building longevity. In wood building it is important to use materials that are suitable for the building, and to understand e.g., the role of the attic and cellar on airflow in current building structures. According to some interviewees, creating living spaces in these spaces may present risks. Forthcoming energy renovation requirements were regarded by several interviewees to be possible risk factors, both for the structures of wooden buildings, if overdone, and affecting the decision to demolish if it was deemed uneconomic to renovate an older building. Additionally, regular condition examination of buildings is recommended.

Phase 7: Beyond – permanence, reuse and demolition choices

When does a building come to the end of its life? Does it? To promote longevity, we need to see the value in existing buildings and have the motivation to preserve them; to value the historical layers, the time and materials contained in the building. Sometimes *we* also need to adapt to the buildings.

The most important lifetime decision of a building is avoiding uselessness. If the building has no function the motivation to maintain it decreases. Thus, proper maintenance and keeping the building in use, healthy and functional is essential. Understanding the building and its maintenance needs are, therefore, extremely important. Additionally, the adaptability of the building and that of the city plan directly affects building longevity.

Conclusions

We present the preliminary results of an ongoing investigation into the factors affecting the longevity of wooden buildings. Employing a systemic approach and considering all the phases in the lifetime of a wooden building, we identify some of the main issues that affect this. Well before building construction begins, the quality and availability of the raw material, the legislative and regulatory environment, all have an effect. Design decisions and the current mindset, along with the construction itself, and subsequent maintenance also dictate longevity. Perhaps the biggest question of all is what does building longevity mean? This is a question we aim to address in our future work.

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