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CAN RISING DEMAND FOR TIMBER IN CONSTRUCTION ACCELERATE DEFORESTATION?

AUTHOR

Eduardo Rojas Briales[1], Simon Flinn[2]

ABSTRACT

Timber, and increasingly Mass Engineered Timber (MET), plays a key role in green building programmes around the world. Its use addresses the UN Sustainable Development Goals, especially SDG 11 – Sustainable Cities and Communities, SDG 13-Climate action, SDG 15-Life on Land and many others that are directly or indirectly linked to forests and construction. Many Life Cycle Assessments (LCAs) recognize the environmental benefits of Mass Engineered Timber in comparison to traditional construction materials such as steel and concrete. The importance of timber in the construction industry has led asset specialists to estimate that over the next 30 years, timber consumption could rise by over 140%. In the EU alone, wood consumption is estimated to be 3.5 times higher than the global average.

Sustainable Forest Management has been fundamental in ensuring both forest resource preservation with the highest possible sustainable supply of forest products and environmental services. 233 million ha of forests globally were under management plans in 2000, increasing to 2.05 billion ha in 2020. Nevertheless, between 1990 and 2020, both growing stock and forest carbon stock at the global scale have fallen, though the rate of loss has declined significantly over the same period. In 2020, the forest and carbon stocks reached an even balance due to reduced tropical deforestation and significant forest recovery in Asia-Pacific, Europe, and North America. Research into forest management (FM) practices has shown that producing the same volume of wood in different ways, may result in substantially different performance regarding biodiversity and other environmental services, including carbon sequestration or rural livelihoods. Therefore, while continuous improvement in FM is beneficial to the timber industry, it is also vital for biodiversity, environmental services, and rural livelihoods.

Finding the balance between demand for forest products and preserving forests through FM will ultimately rely on robust Chain of Custody (CoC) data - informing policy; purchasing strategy; and due diligence, especially if aligned with consistent domestic policies in the areas of tenure, land use and forestry. PEFC's role is to ensure, through certification, that built environment professionals can be confident that they are sourcing timber responsibly and avoiding unsustainable and/or illegal timber or wood products. Technology and specifically blockchain (including the PEFC sponsored Wood-chain Project), will have an important role to play in not only facilitating traceability operations, but also in providing visibility, accountability, and the ability to extend to other enhancements such as carbon credit systems or related to other environmental services.

KEY WORDS

Sustainable Forest Management: Responsible Sourcing: Mass Engineered Timber: Built Environment: Carbon Balance

1 INTRODUCTION

Built environment professionals from around the globe increasingly recognise the importance of timber as a low

[1] Eduardo is Chair of the Board of Directors of PEFC International and Chair of the Spanish Board of MSc. Foresters. He has previously been a Director of the Catalan Forest Owners Association, Associate Professor at the University of Lleida, Head of the forest policy area of the Forest Science and Technology Centre of Catalonia and Vice-Dean of the Life Science Faculty of the Polytechnic University of Valencia, where he is presently a professor in forestry. From 2010-2015 he was Assistant Director-General and Head of the Forestry Department at FAO, UN Commissioner General for Expo Milan in 2015 and co-chair of UNREDD.

[2] Simon is Senior Systems Development Officer with the Soil Association Forestry team, working on digital transformation and business improvement projects of their PEFC and FSC certification systems, for Forest Management, Chain of Custody and Carbon Schemes.

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carbon, renewable and recyclable building material. But some are concerned that this rush to timber could accelerate deforestation.

Forests are a vital natural resource for the planet. It is important that their multiple functions – environmental, social, and economic – are balanced.

The Sustainable Forest Management (SFM) tool has been developed to help maintain this balance. as demand for timber continues to grow, PEFC (Programme for Endorsement of Forest Certification), regularly engages with built environment professionals - architects, contractors, engineers, and their clients - to increase their understanding of SFM and the importance of responsible sourcing,

Sustainability has become integral to all areas of industry and society, and the built environment has become one of the crucial priorities for sustainable change. As life-cycle assessments (LCAs) highlight energy and carbon intensive building materials, namely steel and concrete, the focus has been placed on developing and using carbon neutral alternatives. Mass or Mass Engineered Timber (MET) has been identified through numerous LCAs to be a viable and sustainable building material. It is increasingly being embraced by architects, builders, and engineers around the globe.

However, if the building industry turns toward mass engineered timber (MET) as a less carbon intensive material, will this create a sustainability paradox? As demand for timber grows, what impact will this have upon the global timber supply or the resource that provides it (forests)? Is this rising global demand for timber compatible with sustainable forest management?

2 SUSTAINABLE FOREST MANAGEMENT

In 1713, Carlowitz defined the *Nachhaltigkeit* principle [1] in a time where wood was the main source both of materials and energy, causing restricted availability and frequent signs of exhaustion - important societal challenges. This concept was later operationalised at the end of that century, establishing the starting point for forest science as one of the legacies of the Enlightenment. If wood was a renewable resource, the way to avoid its exhaustion is to know its renewable rate and optimize where and when to extract it. During the 19th and early 20th Centuries, forest science expanded from Central Europe to the rest of the World. The increased use of fossil and mineral materials and their ready availability through the rail network, reduced the potential impact that the increased population and available income (GDP/per capita) would have had potentially for forests.

When Brundtland [2] (1987) presented the key document for the Río 1992 Conference, her inspiration for sustainability was the Carlowitz forest science paradigm[1]. In fact, in the two predominant languages in Central Europe (German and French), the modern term for sustainability is identical to the forest one (Nachhaltigkeit, durabilité). In fact, misunderstanding around that intellectual linkage was caused by the restricted English translation as “sustained yield” if compared to the French, German or even Spanish (persistencia) terms.

In the process to the Rio Conference 1992, four environmental conventions were negotiated (Climate Change, Biodiversity, Desertification and Forests). While the first three reached broad consensus and entered into force during the decade, the forest convention was not agreed, but negotiations were kept open until they were institutionalised in the form of the UN Forum on Forests, as a time bound setting, extended twice in 2006 and 2015.

In the absence of a convention, many formerly non legally binding documents have been approved since Rio, starting with the Rio Forest Principles (known officially as the Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forests), established that while forests are essential to economic progress, sustainable development and management should be the guiding principles that nations should follow.

An intensive process was conducted during the rest of the decade with the International Panel/Forum on Forests agreeing 300 proposals for action in the expectation of a later agreement on a convention that failed to materialise. It became obvious that sustainable forest management could not be further defined at a global scale, because of strong regional and climatic differences, other than the basic principles and the structure of criteria and indicators (C&I). However, nine regional processes started that decade to agree on criteria and indicators for sustainable forest management and were agreed at regional scale.

For the European region, including the countries of the former Soviet Union, the framework of the 1990 Ministerial Conference on Protection of Forests held in Strasburg, was agreed as the basis for the regional Criteria and Indicators. The following Ministerial Conference held in 1993 in Helsinki, first agreed on a regional definition for sustainability in forestry: "The stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems." [3]. On that basis, the Criteria were agreed during the same

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conference while the indicators during the following one held in Lisbon in 1998.

At a global scale, the pressure for action, especially around deforestation, grew as the aspiration for a global convention on forests remained unfulfilled as two major players in the OECD and G-7, plus China, USA and Brazil, were clearly opposed to the convention on forests. The demand for alternative solutions in the absence of a convention grew. The eNGO community proposed consideration of the important growth in ISO certification during this period, as a solution to address the failure of states suffering deforestation, to establish sustainable forest management certification mechanisms.

The application of forest certification was first introduced by the Forest Stewardship Council (FSC) in 1994 driven by WWF, as a direct response to the Rio Forest Principles. Certification soon became accepted across the globe, and by 1999, 10 million hectares of forest were certified to FSC standards and the first book was printed on FSC-certified paper [4].

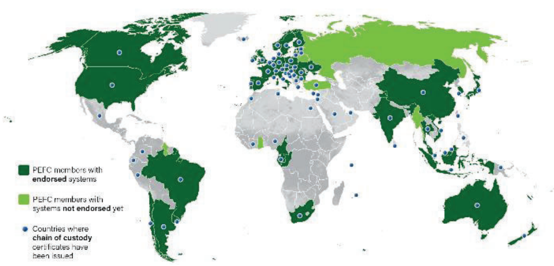

Figure 1: Map of global PEFC certified forest area [13]

PEFC was founded in 1999 by the national forestry organisations of 11 European countries, responding to demand from small and family forest owners who encountered considerable difficulties accessing certification through existing schemes, especially because of audit costs. Later, PEFC expanded beyond Europe to include other regional or national existing certification schemes such as SFI in North America and Responsible Wood, Australia.

PEFC "endorses national forest certifications systems developed through multi-stakeholder processes and tailored to local priorities and conditions."[5] Its standards are oriented to the Criteria & Indicators agreed at regional level by governments in formal processes. PEFC firmly believes that forest certification functions most effectively when the impetus, intent and influence come from local and national organisations, through bottom-up processes.

By December 2022, 288,154,245[6] hectares of Forest area were managed and conformed to PEFC's Internationally accepted sustainability bench marks – 71% of all certified forests globally are certified to PEFC. This has allowed more than 20,000 companies to achieve chain of custody certification in more than 70 countries. PEFC now has 55 national members with 48 endorsed national certification systems.

It should be noted that wood regrows in a reasonable time frame (100 years on average), and that it continues to store carbon when used in long term uses like buildings. Additionally, it requires much less energy to harvest and process than conventional building materials.

Wood used in construction globally is more than 95% coniferous and sourced from boreal and temperate forests, where no deforestation has recently been recorded. FAO has repeatedly confirmed that less than 10% of deforestation is linked to wood use being the primary cause (>80%) agriculture[7]. 50% of the global wood use is for energy, mostly in the countries of the global south and this is the main cause of forest degradation, especially in the dryland forests of Sub-Saharan Africa; a problem exacerbated by unclear land tenure rights.

2.1 BENEFITS OF SUSTAINABLE FOREST MANAGEMENT

The benefits of sustainable forest management are numerous and complex. Marchi et al[8] describe five key performance indicators of SFM – Economics, Ergonomics, Environment, People and Society and Quality optimisation. And these five indicators can be used to understand the complex web of benefits and relationships, including air quality, cost optimisation, energy consumption, health, training, etc. They argue that SFM leads to resource optimisation in forest operations; the promotion of timber as an environmentally renewable and sustainable material; the ability of forest owners to adapt and influence climate change; reducing the impacts of harvesting; and finally promotes workers' rights, thereby improving conditions and safety.

2.1.1 Biodiversity

Forests are the most diverse ecosystems on the planet. 80% of Earth's land animals and plants live in forests. Biodiversity provides natural pollination, fertilisation, and seed pollination. Biodiversity benefits in several ways from SFM. SFM promotes the UNFCCC Warsaw framework REDD+ activities - the reduction in emissions from deforestation and forest degradation plus conservation and enhancement of forest carbon stocks. SFM practices such as reduced impact harvesting, fire management, reforestation and restoration have had a direct effect in halting bio-diversity loss [9]. An example of this impact has been measured in Sabah, Borneo where vertebrate diversity is greater in SFM forests than conventionally managed forests[10]. In fact, several publications have confirmed that locally managed forests, often by indigenous communities in the tropics, show better performance (e.g., on forest fires), than protected areas, state managed or concessions).[11]

2.1.2 Carbon Storage

Forests are also nature's best form of carbon capture and storage. Well managed forests remain carbon sinks while at the same time, contributing to economic development. Figure 2 below shows how SFM maintains a steady carbon sink through harvesting.

Figure 2: Patchwork of Emissions and removals from Forest Harvesting, source Harris et al [12]

The PAFC Congo Basin project is endorsed by PEFC. The Republic of Congo, Cameroon and Gabon have jointly developed a regional forest certification system. The PAFC Congo Basin project is "the first to contain two new requirements linked to current climate issues: the mapping of the carbon stock in a forest, and a greenhouse gas (GHG) emissions assessment linked to forestry operations. Born during the standard development process, the innovative requirements are a response to the new expectations that companies and forests owners are facing." [13]

EU forests alone currently provide a net sink of 300 million tonnes of CO^2, around 10% of the EU's greenhouse gas emissions.[14] It has been estimated that reduced-impact logging in tropical forests, could reduce between 29% and 50% of net carbon emissions from tropical deforestation and land use changes whilst supplying 45% of global roundwood timber demand[15]

2.1.3 Water

Forested catchments supply 75% of fresh water, and millions of people from around the world depend on high-quality, fresh flowing, forest water. Forest trees absorb water through their roots from the ground in a process known as evapo-transpiration – a key element of the global water cycle.

2.1.4 Products & Energy

Sustainable forests deliver sustainable products; from raw materials transformed into books, packaging, and buildings, to pharmaceuticals, textiles, and personal care goods. Forests that are managed sustainably need not be finite but continue to provide sources of income to forest owners, sawmills, factories, and business within the supply chain.

Energy from forests is recognised as the single most important resource, providing 9% of the global total of primary energy supply and above 60% of the total renewable one, especially in Sub Saharan Africa. In fact, it is astonishing to note the marginal recent and present attention paid to forest-based biomass when comparing it to its historical and present contribution to renewable energy supply.

2.1.5 Social

The livelihoods 1.6 billion people worldwide have some impact from forests, including 60 million indigenous people who are fully dependent on them. In developing countries, forest-based enterprises provide about 13–35% of all rural, non-farm employment; equivalent to 17 million formal sector and 30 million informal sector jobs[16].

Sustainable Forest management is focussed on ensuring not only that forest workers' rights and safety are respected, but also those of workers along the supply chain, through chain of custody certification.

It is a core value of SFM, that cultural values and traditions are respected, protecting indigenous people and their cultural, social, and spiritual mores.

2.2 TIMBER CERTIFICATION

Timber certification allows organisations, businesses, and consumers to have a direct link to and impact on SFM. There are a range of reasons for different organisations to certify their forests and/or choose to specify certified material. According to Zubizarreta et al [17] in a case study on forest certification in Spain, the two main certification drivers for forests and companies are accessing new markets and improving corporate image. However, fundamentally, the value of forestry certification only works if it is understood and recognised by consumers and therefore affects consumption behaviour.

Certified products can bring economic benefits as materials can add premiums to prices. Zanchini et al [18] analysed customer behaviour and forestry certification, through a consumer study. They demonstrated that while price was the main attribute affecting consumer choice, the second most important, was the presence of recognised forest certification labels such as PEFC and FSC. Consumers will not only choose to make an ethical purchase, but will also perceive labels to have an added value[18].

Certified products can help companies penetrate new markets. The European and UK Timber Regulations, United States Lacey Act, and the Japanese Clean Wood act, have all placed legislative barriers on the trading of timber. Adopting SFM practices through certification allows companies around the world to find new and valuable customers. The positive effects on biodiversity protection and development, may also be used for

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political advantage or to demonstrate corporate values [19].

Owari et al [20] identified that companies adopting forestry certification gained recognition from environmentally sensitive customers; better retention of existing customers; improved public reputation; and increased customer satisfaction.

PEFC through its partners, makes SFM certification available to 750,000 forest owners globally and chain of custody certification to more than 20,000 companies. PEFC SFM certification respects ecological, social, and cultural frameworks, while improving economic values. It supports healthy forest ecosystems, while securing livelihoods for workers and local communities.

Chain of custody certification enables companies and consumers to identify products from responsibly sourced raw material. It provides confidence that products are legal and from a verifiable supply chain. It allows organisations to demonstrate their commitment to, and business leadership on, sustainability.

3 SUSTAINABLE BUILDING MATERIALS

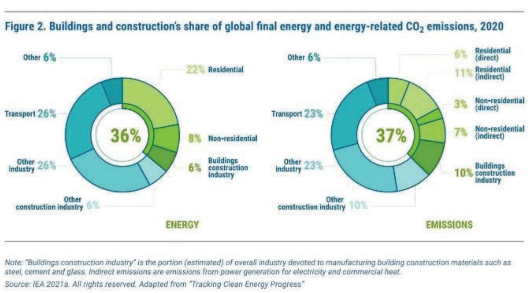

Figure 3: Graph taken from the 2021 UN Global status report for buildings and construction. [21]

Although building operations and construction industry together accounted for up to 37% of the global CO^2 emissions, much of this comes directly or indirectly from fossil fuels. Figure 3, from the UN Global Status Report for Buildings and Construction, shows that this sector used 36% of the global energy resource in 2020. Whilst there has been a shift away from the direct use of coal and oil for energy to electricity, the high dependency of electrical generation on fossil fuels, has contributed to an increase in emissions from the buildings and construction sector. Governments and institutions globally have unsurprisingly turned their attention towards sustainable buildings, construction, and maintenance. Inger Andersen, Executive Director of the UN Environment Programme states "Rising emissions in the buildings and construction sector emphasize the urgent need for a triple strategy to aggressively reduce energy demand in the built environment, decarbonize the power sector and implement materials strategies that reduce lifecycle carbon emissions" [21]. Additionally high insulation performance, earthquake resistance and recyclability should be recalled in this context.

Cross-laminated timber (CLT) and glulam are both examples that provide an exciting glimpse into the possibilies for engineered wood. Commonly made from PEFC-certified spruce, pine, fir and larch from European and North American forests, they can reduce the carbon impact of steel and concrete.

As a lightweight building material, timber can provide time and cost savings due to reduced foundation work as the structural loads required with CLT are small compared to those from concrete and steel.

CLT and glulam are prefabricated within a precision, factory-controlled environment, using accurate data from BIM modelling and CNC processes. Openings can also be pre-cut or routed in the factory for windows, doors, or services, facilitating quick and easy installation. This means that it is easier to timetable the construction critical path and eliminate site delays, while improving working conditions and reducing on-site accidents.

The drive to improve the sustainability of buildings has caused wood to be substituted in place of materials such as steel and cement, which all have higher carbon emissions. The manufacture of concrete and steel each contribute about 5% of global emissions. MET is a material specifically engineered to deliver high strength ratings for the construction industry. It is formed by gluing together strands or panels of wood to create outstanding strength.

The structural properties that MET products offer as a sustainable alternative have been widely recognized, and resulted in the 2021 International Building Code allowing the use of wood in buildings up to 18 storeys[22]. Indeed, Zanchini et al state "several recent studies have shown that substituting MET for steel and concrete in mid-rise buildings can reduce the emissions associated with manufacturing, transporting, and installing building materials by 13%-26.5%."[18]

The Mjøstårnet building in Brumunddal, Norway is a testament to the properties and potential of both CLT and Glulam. Standing at 85.3 metres tall, the 18 storey MET development contains a hotel, restaurants, offices and apartments [23]. As they are substantially lighter, such buildings necessitate specialist engineering to overcome challenges including fire safety, and resistance to the extremities of nature such as earthquakes. However, the entire building meets Eurocode 5 and can withstand extensive fire. It is thought that similar buildings can reduce emissions from material production by up to 85%, while timber absorbs CO^2 from the atmosphere. Additionally, a higher timber use would reduce sand and concrete demand in the construction

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sector reducing the impact of river sand drain or open pit limestone mines.

3.1 LIFECYCLE ASSESSMENTS

Many life-cycle assessments of MET have provided evidence of its excellent environmental credentials. Duan [24] et al found that the average embodied energy of MET construction is 23% higher than that of reinforced concrete alternatives, and the average embodied greenhouse gas emissions of reinforced concrete buildings are 42.68% higher than that of MET alternatives. They concluded that "mass timber buildings generally have lower GHG [greenhouse gas] and life cycle primary energy than RC [reinforced concrete] and steel buildings, indicating that the use of mass timber to substitute conventional materials could help mitigate climate change and promote sustainable construction."

Nevertheless, within the circular economy, caution does need to be applied when considering the environmental benefits of MET. Hart and Pomponi reason that while re-use of structural steel is possible, it is "hindered by current regulations and a poor financial case". Structural timber provides a similar challenge including the fact that "engineered structural timber is typically a composite of organic and mineral substances that may be impossible to separate in a controlled way. [25]"

In a study published in 2020, Chen et al used the Athena life-cycle impact assessment for buildings to compare those using concrete and CLT. The team followed the scope, adapted and shown in figure 3, following the EN15978 guidelines but going beyond the building life cycle to look at recycle and recovery of materials.

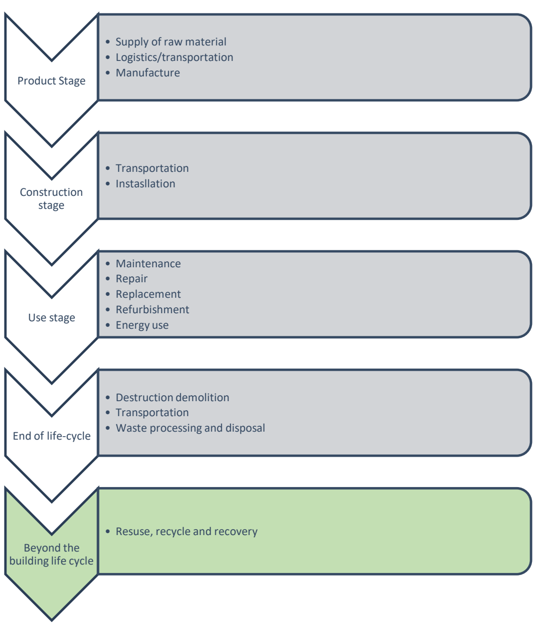

Figure 4: Adapted from an assessment system boundary from Zhongija Chen et al [26]

The study showed that the total of greenhouse gas emissions, shown in figure 5 below, from mass-timber buildings walls and floor were reduced from 50% to 80% between mass timber buildings and reinforced concrete buildings.

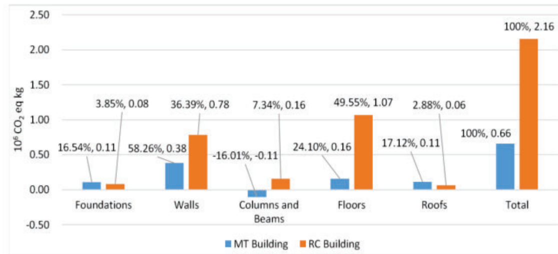

Figure 5: From Chen et al[26]. A comparison of global warming impact.

4 DEMAND FOR TIMBER AND FOREST PROTECTION

In pursuit of cleaner, sustainable building materials, the growth and promotion of MET as a potential solution might seem somewhat incompatible with forestry conservation. This should not be of concern, as Churkina et al state[27] "although global mass timber production has increased rapidly in recent years, it still constitutes a small fraction of total global wood consumption (less than 1% global softwood lumber consumption)". Still, this understates the prediction that by 2034 North American 16.3 million cubic metres of MET panels would be required, meaning that "manufacturers would need to boost their current capacities by a factor of nearly 40 to meet those demand projections." [28]

Academic research has recently focused on unravelling this apparent paradox. The Global Mass Timber Impact Assessment (GMTIA) is a collaborative research programme, commissioned by The Nature Conservancy which focuses on five phases of work[29] which are:

- Whole-building Life Cycle Assessment
- Regional demand assessments
- Global Trade Modelling
- Regional forest modelling
- Integration and communication.

The aim of the project will be to capture those impacts of MET which are not normally captured by traditional life-cycle assessments. This will include examining the effects of MET demand on forest carbon stock; understanding the implications for biodiversity; whether there is an increase or decrease on embodied carbon (transportation, harvest, production); carbon storage in wood products; and end of life cycle of MET.

Higher demand supposes higher prices and incentives to preserve and manage forests according to the best standards. The dynamic nature of forests is frequently

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overlooked when the risk of deforestation is considered as a trade off against increasing demand. Through clear tenure and rule of law and with land use planning as a prerequisite, increased demand does not negatively affect forests.

4.1 FORESTRY IMPACT

The critical phases of the GMTIA will officially report in 2023. Still, in a 2021 related study about the effects on global forests as a result of the increased demand for MET, Nepal et al [22] identified four key findings:

- That increase in MET demand will lead to price inflation for products using MET. The price inflation will correlate directly with timber demand.
- Conversely the levels of product prices directly effects "production, consumption and trade of forest products in a country and accordingly alter its timber harvest, forest growth and forest stock level."
- The increased demand for MET will lead to increased competition for softwood, reducing consumption for less valuable present uses.

Moreover,

- They found that with sustainable forest management "most of the projected depletion in aggregate forest stock due to mass timber-induced increases in removals will be replaced by biological forest growth occurring over time, suggesting relatively smaller impacts on forest stock at aggregate national, regional, and global levels."[22]

In their projection, there is negligible effect of increased MET demand in a model which assumes sustainable forest management practices – "that is, mass timber-induced increases in demand for timber and harvest activities do not lead to deforestation." [22]

Therefore, if wood for MET is sourced solely from sustainably certified forests with well managed stock levels, the effects of price inflation and substitution, will ensure that demand has no negative effect upon forest stocks.

In a recent example published in 2022, Comnick et al [30] examined the increasing consumption of MET in the USA against the timber supply. They arrived at the following conclusion:

- The current rate of harvesting and consumption of softwood in the United States is currently 56% that of growth.
- The most aggressive estimate for increase in MET demand by 2035 would amount to a 17% increase in current softwood consumption.
- This most optimistic of MET growth rate would still only represent a consumption of 68% of growth, or 82% of lowest projected growth estimates.

The sustainable benefits of MET cannot be realized in the material alone, it must be accompanied by ensuring the raw products come from certified forests. As Mark Wishnie, Director of Forestry and Wood Products at the Nature Conservancy states, "We must ensure that mass timber drives sustainable forestry management, otherwise all of these benefits are lost"[31]

The study by Chen et al[26] referenced in 3.1 above, demonstrated that if forests continue to be renewed after logging, there will be a continual offset of greenhouse gas emissions. In the study they demonstrated significant impact on carbon out of a MET building, estimating a saving of 150,000 ton of CO^2 when compared to a reinforced concrete equivalent. It is this measurable benefit which will help drive the promotion of SFM and ensure that sustainable MET continues to be preferred.

Ultimately though, the popularity of MET is not only attributable to its durability and versatility as a construction material. One of the primary recognized motivations for adopting MET is its sustainability credentials, and the associated benefits that this brings along the commercial supply chain. Therefore, while sustainability prompts customers to demand this material, it is sustainability which will surely determine how the raw material is sourced. As certification will ensure that MET continues to be recognised as environmentally responsible choice, then sustainable forest management practices demanded by certification will ensure that demand does not exceed sustainable supply.

Increased demand for higher value uses like construction would suppose an additional incentive to increase rotations, to improve degraded stands, to prioritize valuable species, to implement quality driven thinnings or to expand forests by planting and paying more attention to forest management by local actors than was the case in the past when wood prices were lower.

4.2 PEFC AND SUSTAINABLE TIMBER

While PEFC supports the advancement of mass engineered wood as the future of architecture and construction, this can only be positive for ecological progress if underpinned by certification. In the long run, in comparison to concrete, steel, cement and glass, buildings made with engineered wood from sustainably managed forests require less energy and emit less carbon.

"PEFC-certified timber, whether it is solid wood or engineered wood such as CLT and glulam, comes from a

PEFC-certified forest – a forest managed sustainably in line with strict international requirements.

This means that forest owners manage their forest in a way that provides a good supply of timber and other forest products, while at the same time ensuring that the forest will be around for generations to come.

Certification matters. It not only demonstrates that wood used in construction is sourced sustainably, but that a positive choice has been made to design and build with a future for healthy forests in mind." [32]

PEFC-certified timber and engineered wood products for the construction industry are available globally, with a steadily increasing range of global suppliers. Furthermore, construction projects can also obtain PEFC Project Chain of Custody certification to demonstrate excellence in responsible sourcing. The impact of certification is not only crucial for the preservation of our forests, but also demonstrates the integrity and innovation of companies that choose to specify these materials.

While recognizing the benefits of timber in construction, PEFC is committed to supporting its certificate holders. PEFC is currently working with online product platform 2050 Materials [32] to help drive generational change in choosing certified forest-base products at all stages of a construction project. The platform will be a user-friendly way to find PEFC-certified suppliers,

5 THE FUTURE OF SUSTAINABLE FOREST MANAGEMENT AND CHAIN OF CUSTODY

The future of sound forest management and sustainable timber products undoubtedly lie within the effectiveness of chain of custody procedures, monitored by certification bodies. PEFC wants to ensure that customers throughout the chain of custody can have full confidence in the procedures that protect the authenticity and integrity of sustainable products. As highlighted earlier, the growth in use of MET products within the construction industry will result in increased scrutiny of both forest management and chain of custody practices. The benefits of MET as a sustainable, low carbon alternative to traditional building materials can only be assured by demanding certification audits throughout the supply chain.

An efficient chain of custody process relies on a rigorous monitoring of critical control points such as observing processes around segregation of timber and processing of timber products. Ensuring that personnel along the chain understand the importance of PEFC principles is crucial and that possibility of tampering and fraud is minimised; PEFC recognises that efficiency within this process can only come from ongoing innovation in chain of custody processes.

5.1 BLOCKCHAIN AND RFID

The success and efficiency in balancing timber demand with sustainable forest practices is likely to rely on PEFC, certification bodies and certificate holders adapting to new technology. Figorilli et al[33], for example, showed how the use of blockchain technology can be used to record the traceability of a finished product. The use of Radio Frequency Identification RFID might be able to reduce the information gaps in critical control points such as logistics. This could help certificate holders optimize valuable operational factors such as time, materials, and costs.

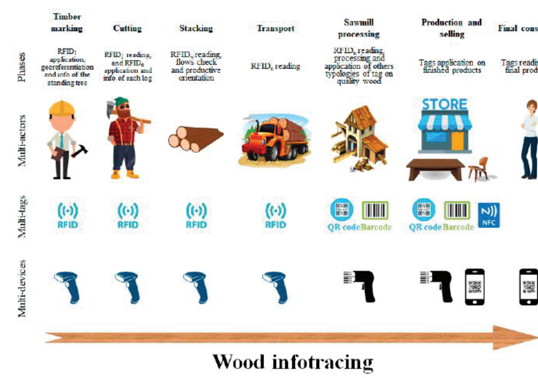

Figure 6: Figorelli et al [33]

Figorelli et al showed the potential of this technology by tagging and monitoring the progress of chestnut trees felled in Cardinale, Italy. After the trees were felled and cut, RFID tags were inserted into each of the logs. The progress of the logs could be monitored through to the sawmill where they were processed into boards and marked with a QR code. They then demonstrated that a final consumer product could be created and tagged allowing the consumer to know exactly where the tree was felled. It is perhaps this final step that might prove the most powerful aspect of blockchain technology, giving information to the consumer such as exactly where the tree was felled and how far the timber has travelled. This would certainly ensure that a premium could be applied to blockchain timber and timber products.

PEFC is committed to exploring the value of technology in improving the strength of traceability within the chain of custody. To this end, PEFC International funded a project with Italian and French partners in 2019, known as the Wood-chain project[34]. The project was designed to test the application of blockchain technology for forestry and wood applications.

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The project's specific goal was to explore blockchain in the creation of secure, dependable data chains that could improve the efficiency and accuracy of forest management certification.

5.2 FUTURE GROWTH OF SUSTAINABLE FOREST MANAGEMENT

The future growth of responsible forest management and the security of MET as a sustainable resource relies on careful and adaptable sustainable forestry policy making. Daigneault et al [35], in 2022 released a study on the relationship between the global forest carbon sink and timber demand. They concluded that in areas where SFM is applied "strengthening forest product markets, expanding forest areas and boosting forest productivity can…be successful climate mitigation strategies".

Future growth of SFM can only happen with continued investment in training and certification training. PEFC are committed to investing in innovation and technology to ensure that the growth in SFM continues:

- PEFC UK [36] have developed an online certification application, a forestry tool to assist group managers and small to medium-sized woodland owners participle in forest certification.
- PEFC Italy[37] are working with the Foundation Euro-Mediterranean Center on Climate Change on digital projects that use tree sensors to help forest owners monitor the health of their forests. This will help provide certification bodies with valuable-pre audit data, thereby boosting efficiency.
- PEFC Spain [38] are also involved in a similar project, which will use GIS technology and remote systems to monitor SFMs.

6 CONCLUSIONS

This paper set out to examine the relationship between increased consumption of mass engineered timber and its supply through sustainable forest management, as well as the potential risk of increased deforestation. Some of the latest available studies and research have been reviewed to ascertain whether a positive or negative correlation has been confirmed. Firstly, SFM was summarised from conception at the 1992 Rio Summit, before looking at the rewards it provides, and the tools used to help deliver it, via certification. It also examined the drivers behind the rush to mass engineered timber in the built environment and the evidence supporting its sustainability claims. The potentially paradoxical paradigm behind the growth and values of SFM and MET was then compared, and the available evidence reviewed.

MET promises to provide architects, engineers, towns, cities, and their inhabitants with a building material that could potentially diminish the harmful by-products of steel and concrete and their implicit consequences in the form of mines and increasing sand extraction. In both cases, they can either not be recycled (concrete) or require high energy inputs to be recycled (steel). And while these MET materials are in their relative infancy, the benefits in terms of reduced carbon emissions and LCAs are promising. Ultimately, timber is a natural, renewable, and precious resource that contributes to the livelihoods of an estimated 33 million people employed in the forestry sector globally. Where mining provides income to very limited areas, sustainable forestry provides income to extensive disadvantaged areas of the world that cover 40% of the terrestrial area. This is currently the single most significant income they receive for preserving the global forests and their key contributions in terms of environmental services like climate, erosion, water, or biodiversity.

Evidence reviewed shows that the growth in MET can aid and strengthen the growth of Forests if SFM practices are adhered to and monitored through certification and labelling.

PEFC and other forestry certification bodies have an important role to play in helping to ensure that, MET can deliver global benefits in a sustainable way. By improving and developing access to forestry certification, PEFC can give forest owners, and wood product suppliers, the benefits of certified products, while ensuring that sustainable forestry practices continue.

Through continued investment in innovation and research, PEFC can continue its contribution to SFM practices globally. MET can contribute to the health and growth of forests globally, but only if it is responsibly sourced. It is therefore crucial that certification schemes such as PEFC's, encourage MET manufacturers to source their raw materials from certified forests. If they do, then the full potential LCA and reduced carbon benefits of timber as a construction material can be realised.

REFERENCES

[1] F. J. Schmithüsen, 'Three hundred years of applied sustainability in forestry', 2013, doi: 10.3929/ETHZ-A-009955604.
[2] F. O. for S. D. ARE, '1987: Brundtland Report'. https://www.are.admin.ch/are/en/home/medien-und-publikationen/publikationen/nachhaltige-entwicklung/brundtland-report.html (accessed Feb. 27, 2023).
[3] 'FOREST EUROPE | Publications'. https://foresteurope.org/publications/ (accessed Feb. 05, 2023).
[4] 'Our History', *fsc.org*. https://fsc.org/en/our-history (accessed Feb. 11, 2023).
[5] 'What is PEFC?' https://www.pefc.org/discover-pefc/what-is-pefc (accessed Feb. 05, 2023).
[6] 'Facts and figures'. https://www.pefc.org/discover-pefc/facts-and-figures (accessed Feb. 05, 2023).
[7] 'COP26: Agricultural expansion drives almost 90 percent of global deforestation', *Newsroom*. https://www.fao.org/newsroom/detail/cop26-agricultural-expansion-drives-almost-90-percent-of-global-deforestation/en (accessed Feb. 27, 2023).
[8] E. Marchi *et al.*, 'Sustainable Forest Operations (SFO): A new paradigm in a changing world and climate', *Sci. Total Environ.*, vol. 634, pp. 1385–1397, Sep. 2018, doi: 10.1016/j.scitotenv.2018.04.084.
[9] J. A. Parrotta, C. Wildburger, and S. Mansourian, Eds., *Understanding relationships between biodiversity, carbon, forests and people: the key to achieving REDD+ objectives ; a global assessment report ; prepared by the global forest expert panel on biodiversity, forest management and REDD+*. Vienna: International Union of Forest Research Organizations (IUFRO), 2012.
[10] N. Imai *et al.*, 'Co-Benefits of Sustainable Forest Management in Biodiversity Conservation and Carbon Sequestration', *PloS One*, vol. 4, p. e8267, Dec. 2009, doi: 10.1371/journal.pone.0008267.
[11] Nawari, Rifardi, Nofrizal, E. H. Halim, Suwondo, and T. Warningsih, 'An Indigenous Based Forest Management for Achieving Sustainable Development Goals: Reducing CO_2 Emissions in Pelalawan District, Indonesia', presented at the 3rd Annual Conference of Education and Social Sciences (ACCESS 2021), Dec. 2022, pp. 293–302. doi: 10.2991/978-2-494069-21-3_32.
[12] 'Climate change: Are forests carbon sinks or carbon sources?', *World Economic Forum*, Feb. 12, 2021. https://www.weforum.org/agenda/2021/02/forests-climate-change-carbon-absorb-environment-earth-trees/ (accessed Feb. 06, 2023).
[13] 'Carbon stock and emissions mapping: PAFC leads the way'. https://www.pefc.org/news/carbon-stock-and-emissions-mapping-pafc-leads-the-way (accessed Feb. 06, 2023).
[14] 'How has the forest-based carbon sink and stock evolved in the European Union? | European Forest Institute'. https://efi.int/forestquestions/q16 (accessed Feb. 27, 2023).
[15] N. Sasaki *et al.*, 'Sustainable Management of Tropical Forests Can Reduce Carbon Emissions and Stabilize Timber Production', *Front. Environ. Sci.*, vol. 4, 2016, Accessed: Feb. 06, 2023. [Online]. Available: https://www.frontiersin.org/articles/10.3389/fenvs.2016.00050
[16] 'The state of the World's forests 2022'. https://www.fao.org/3/cb9360en/online/cb9360en.html (accessed Feb. 27, 2023).
[17] M. Zubizarreta, G. Arana-Landín, and J. Cuadrado, 'Forest certification in Spain: Analysis of certification drivers', *J. Clean. Prod.*, vol. 294, p. 126267, Apr. 2021, doi: 10.1016/j.jclepro.2021.126267.
[18] R. Zanchini, S. Blanc, L. Pippinato, F. Poratelli, S. Bruzzese, and F. Brun, 'Enhancing wood products through ENplus, FSC and PEFC certifications: Which attributes do consumers value the most?', *For. Policy Econ.*, vol. 142, p. 102782, 2022.
[19] H. Paluš, M. Krahulcová, and J. Parobek, 'Assessment of forest certification as a tool to support forest ecosystem services', *Forests*, vol. 12, no. 3, p. 300, 2021.
[20] T. Owari, H. Juslin, A. Rummukainen, and T. Yoshimura, 'Strategies, functions and benefits of forest certification in wood products marketing: Perspectives of Finnish suppliers', *For. Policy Econ.*, vol. 9, no. 4, pp. 380–391, Dec. 2006, doi: 10.1016/j.forpol.2005.10.005.
[21] '2021 Global Status Report for Buildings and Construction | Globalabc'. https://globalabc.org/resources/publications/2021-global-status-report-buildings-and-construction (accessed Feb. 11, 2023).
[22] P. Nepal, C. M. T. Johnston, and I. Ganguly, 'Effects on Global Forests and Wood Product Markets of Increased Demand for Mass Timber', *Sustainability*, vol. 13, no. 24, p. 13943, Dec. 2021, doi: 10.3390/su132413943.
[23] 'The World's Tallest Timber-Framed Building Finally Opens Its Doors | Architectural Digest'. https://www.architecturaldigest.com/story/worlds-tallest-timber-framed-building-finally-opens-doors (accessed Feb. 11, 2023).
[24] 'Life cycle assessment of mass timber construction: A review | Elsevier Enhanced Reader'.
[25] J. Hart and F. Pomponi, 'More Timber in Construction: Unanswered Questions and Future Challenges', *Sustainability*, vol. 12, no. 8, p. 3473, Apr. 2020, doi: 10.3390/su12083473.
[26] Z. Chen, H. Gu, R. D. Bergman, and S. Liang, 'Comparative Life-Cycle Assessment of a High-Rise Mass Timber Building with an Equivalent Reinforced Concrete Alternative Using the Athena

https://doi.org/10.52202/069179-0545

Impact Estimator for Buildings', *Sustainability*, vol. 12, no. 11, Art. no. 11, Jan. 2020, doi: 10.3390/su12114708.
[27] G. Churkina and A. Organschi, 'Will a Transition to Timber Construction Cool the Climate?', *Sustainability*, vol. 14, no. 7, Art. no. 7, Jan. 2022, doi: 10.3390/su14074271.
[28] 'A new report predicts significant demand growth for mass timber components', *Building Design + Construction*, Jul. 05, 2020. https://www.bdcnetwork.com/new-report-predicts-significant-demand-growth-mass-timber-components (accessed Feb. 06, 2023).
[29] R. Pasternack *et al.*, 'What Is the Impact of Mass Timber Utilization on Climate and Forests?', *Sustainability*, vol. 14, no. 2, Art. no. 2, Jan. 2022, doi: 10.3390/su14020758.
[30] J. Comnick, L. Rogers, and K. Wheiler, 'Increasing Mass Timber Consumption in the U.S. and Sustainable Timber Supply', *Sustainability*, vol. 14, no. 1, Art. no. 1, Jan. 2022, doi: 10.3390/su14010381.
[31] 'As Mass Timber Takes Off, How Green Is This New Building Material?', *Yale E360*. https://e360.yale.edu/features/as-mass-timber-takes-off-how-green-is-this-new-building-material (accessed Feb. 07, 2023).
[32] 'Designing the future with sustainable timber'. https://www.pefc.org/what-we-do/our-collective-impact/our-campaigns/designing-the-future-with-sustainable-timber (accessed Feb. 06, 2023).
[33] S. Figorilli *et al.*, 'A Blockchain Implementation Prototype for the Electronic Open Source Traceability of Wood along the Whole Supply Chain', *Sensors*, vol. 18, no. 9, Art. no. 9, Sep. 2018, doi: 10.3390/s18093133.
[34] P. Italy, 'Wood-chain: the technology for strengthening traceability and PEFC certification', *MedForest*, Apr. 26, 2019. https://medforest.net/2019/04/26/wood-chain-project-the-technology-for-strengthening-traceability-and-pefc-certification/ (accessed Feb. 04, 2023).
[35] A. Daigneault *et al.*, 'How the future of the global forest sink depends on timber demand, forest management, and carbon policies', *Glob. Environ. Change*, vol. 76, p. 102582, Sep. 2022, doi: 10.1016/j.gloenvcha.2022.102582.
[36] 'PEFC Forest Certification Checklist – PEFC UK Forest Certification Online Tool'. https://forestrytool.pefc.co.uk/ (accessed Feb. 12, 2023).
[37] 'Fostering tree monitoring technologies to support climate adaptation and mitigation'. https://www.pefc.org/what-we-do/our-collective-impact/our-projects/fostering-tree-monitoring-technologies-to-support-climate-adaptation-and-mitigation (accessed Feb. 12, 2023).
[38] 'Using technology to make certification more accessible to smallholders'. https://www.pefc.org/what-we-do/our-collective-impact/our-projects/using-technology-to-make-certification-more-accessible-to-smallholders (accessed Feb. 12, 2023).