Towards a Sustainable Future: Timber Waste Management in New Zealand's Construction Industry

Dat Tien Doan[1*[0000-0002-5890-0277]] and Ping Sun[1]

[1] Auckland University of Technology, Auckland 1010, New Zealand
dat.doan@aut.ac.nz

Abstract. This research paper provides a comprehensive overview of construction and demolition waste (C&DW) management, specifically emphasising timber waste. Firstly, it assesses timber's environmental and functional advantages in the construction industry. Despite the benefits of timber, the paper identifies significant challenges in managing chromated copper arsenate (CCA)-treated timber waste due to its potentially hazardous impacts. To address these issues, the study proposes enhanced public understanding, innovative timber treatment processes, and effective waste management strategies. The role of stakeholders and policymakers in shaping sustainable waste management practices is also explored, highlighting the importance of implementing site waste management schemes and extended producer responsibility programs. The paper culminates in the presentation of innovative approaches for waste management, encompassing statistical modelling, automation, and systemic carbon reduction strategies. The research concludes with a set of recommendations aimed at promoting sustainable material selection, managing CCA-treated timber, enhancing stakeholder engagement, and adopting lifecycle consideration in material selection.

Keywords: Sustainable Waste Management, CCA-Treated Timber, Timber Treatment.

1 Introduction

The construction sector plays a significant role in environmental issues, primarily through the emission of greenhouse gases [1]. The lifecycle of building materials, from production to demolition, greatly affects global resource usage. The sector is responsible for 40% of carbon dioxide emissions, contributes to landfill waste, and creates airborne particles [2]. Furthermore, the construction industry's dependency on large-scale material extraction results in substantial energy consumption and the release of harmful environmental pollutants [3]. At the end of a building's lifecycle, the demolition process generates a vast amount of material, necessitating recycling or disposal. [2] estimated that construction and demolition (C&D) waste constitutes 13% to 60% of all landfill waste.

In residential construction within New Zealand, timber, steel, and concrete are the primary materials utilised [4]. However, the narrative surrounding timber usage extends beyond single or double-storey buildings. The global adoption of multi-storey timber construction is on the rise, attributed to its manifold advantages [5]. Innovations in technology and the advent of novel timber products have bolstered the popularity of timber as a construction material. Glued laminated timber (glulam), cross-laminated timber (CLT), and laminated veneer lumber (LVL) are particularly popular [6].

In New Zealand, untreated timber is commonly employed in construction. It is frequently repurposed for doors, windows, and structural elements such as beams and walls [7]. Additionally, when combined with other materials, it serves to create composite products such as fibreboard. However, treated wood finds significant use as landfill waste [8]. The use of chromated copper arsenate (CCA) treated substances in the domestic market produces timber that is not recyclable, thereby posing disposal challenges [8].

The evolving demands of New Zealand's building sector necessitate environmentally sustainable construction practices and materials. Reducing the carbon content in materials can reduce the associated carbon emissions during production, construction, and usage [9]. This study aims to examine the benefits of timber usage within the construction industry, focusing on its impacts on climate change and waste management in New Zealand. It advocates for sustainable timber waste management practices to alleviate climate change effects and foster an environmentally conscious built environment. It seeks to answer the following questions:

• What factors contribute to timber's preferred status as a building material in construction?

• What strategies can be implemented to address the current issue of recycling CCA-treated timber?

• How can changes in the attitudes of stakeholders and policymakers significantly affect the management of construction timber waste and facilitate waste reduction?

• How might innovative approaches and technologies revolutionise waste management practices in the construction industry to promote sustainability?

2 Research Methodology

This research employed a systematic literature review methodology involving a comprehensive review of extant publication databases to evaluate scientific publications thoroughly [10]. The adopted approach corresponds with the framework suggested by [11]. This method enables a profound comprehension of pertinent issues by synthesising and summarising previous research, thus promoting transparency for future researchers, reducing bias, and serving as a reliable information source.

The investigation into journal publications associated with timber waste in residential construction within New Zealand necessitated an extensive perusal of the Auckland University of Technology (AUT) databases, Google Scholar, and Scopus. The keywords used are presented in Table 1.

Table 1. Keywords

How (OR/AND)	Where (OR/AND)	What (OR/AND)	When (OR/AND)
Timber waste	New Zealand	Residential	Design
Timber recycles	Global	Housing	Production
Timber reuse		Building	Manufacturing
Timber reduces			Construction
Timber recover			End-of-life
Timber regenerate			
Timber management			

The articles were methodically categorised and filtered to facilitate a detailed comparison, thereby aiding in identifying critical factors influencing the efficiency of construction waste management. This also supported the establishment of quality control for construction waste management through public policies and legislation. Initially, a total of 784 articles were identified. These underwent rigorous screening to exclude those not pertinent to the engineering field, written in languages other than English, or lacking clarity in their relevance. As a result, a total of 41 articles were meticulously selected for inclusion in the study.

3 Findings

3.1 Benefits of Using Timber in Construction

A study analysing the demand for timber-based products and their substitutes in the German construction sector, performed by [12], indicated the critical need to promote timber usage in the industry. The study calculated the elasticities of demand in relation to the price of timber and its alternatives. [12] further highlighted numerous advantages of timber, such as fire resistance, durability, stability, and sound insulation. Beyond its functional qualities, timber is also associated with health benefits, aesthetic appeal, and minimal ecological impact, making it an optimal choice for residential construction. [13] demonstrated that replacing concrete or steel with CLT could yield a carbon emission reduction of 40%. Furthermore, CLT is recognised for its high strength-to-weight ratio, ease of installation, and pleasing aesthetics. According to [14], CLT buildings offer superior overheating resistance compared to their concrete counterparts during the summer months.

[15] compared energy consumption and operation in a typical three-storey office building constructed with three different materials. The findings revealed that timber buildings possess lower embodied energy than those built with concrete and steel. Similarly, [16] suggested that CLT, as a construction material, could deliver performance at par or even superior to that of steel, brick, and concrete systems. [17] applied a material flow analysis model to forecast the material intensity in the EU-28 in the forthcoming years. The findings proposed that timber and straw are optimal for

carbon storage in European edifices, particularly during the critical period of climate change and shortage of non-renewable resources [18].

[19] evaluated timber's potential as a construction material, utilising both quantitative impact assessment and participatory retrospective analysis. The findings showed an ongoing preference for timber due to its user-friendliness, rapid construction, standardisation, and cost-effectiveness, making it a popular choice among consumers. The study also predicted that technical enhancements in recycling systems could enable complete recycling and reuse of waste wood post-2050. [1] administered an Unanswered Questions and Future Challenges questionnaire to 757 panellists from the Ministry of Wood Construction and Forestry. The results revealed that a majority (57%) of Austrian millennials have a favourable attitude towards timber construction.

3.2 CCA Treated Timber

In New Zealand, CCA-treated timber is widely used in the construction industry due to its impressive resistance to insects, fungi, and water damage, achieved via the application of specific preservatives, particularly copper, chromium, and arsenic [20]. CCA timber preservatives are compounds of arsenic, copper, chromium substances, oxides, or salts, typically used for vacuum pressure treatment of timber and are commercially accessible. Their principal role is to protect timber products from pests such as timber-destroying insects, marine borers, and decay fungi [21]. CCA treatment has been prevalent in preserving timber in New Zealand since 1955. However, CCA-treated timber is recognised as potentially hazardous globally and is prohibited in countries such as Germany, Sweden, Japan, and Indonesia [22].

In New Zealand, the use of CCA preservatives is authorised in specified hazard categories. Timber is extensively employed for residential applications, including decking, playground equipment, and garden furniture. These uses are categorised as hazardous due to exposure to weather, above and below ground, or fresh water. For these applications, the arsenic content in treated timber ranges from 0.11 to 0.22% [21]. Australia and New Zealand are the two leading consumers of CCA-treated timber worldwide.

Unsustainable processing and modification techniques often undermine the green resource credentials of timber. In both New Zealand and Australia, timber is frequently treated with CCA to deter termites and mosquitoes, resulting in inseparable mixtures and composites that are non-reusable or non-recyclable. The literature analysis suggests the following three key solutions to mitigate the adverse impacts of CCA:

Public Perception

Enhancing the public's understanding of CCA-treated timber could facilitate improved categorisation of discarded materials [21]. High levels of arsenic have been identified in the ash of treated and untreated timber, highlighting the need to caution against disposing of treated wood in organic bins. Timber waste is frequently discarded in organic containers or included in demolition consignments from municipal contractors.

Timber Treatment

In the process of recycling timber waste, it is crucial to separate treated timber from untreated timber. Various extraction methods can render treated timber safe for disposal or recycling without intricate filtration systems. These methods include biological extraction, steam exposure extraction, wood liquefaction, chemical extraction, and electro-dialytic, see Table 2 [23].

Table 2. CCA extraction methods

Extraction methods	Notes
Biological	A technically viable solution with the potential to extract almost 100% of CCA components, but not effective in terms of time and cost
Steam exposure	This method is not practical from either an economic or technical standpoint, as it fails to achieve more than 90% extraction
Wood liquefaction	Up to 85% of the CCA components can be eliminated, but further research is required
Chemical	A complex and time-consuming process that requires substantial resources; this method needs further research
Electro-dialytic	Similar to the steam exposure method, this method is not a viable extraction solution, either economically or technically

[23] identified that treated CCA waste timber could be recycled into wood plastic composites (WPC). They further investigated the potential use of WPC in construction and its long-term conservation in the construction industry within a circular life cycle. [24] suggested that timber residue could serve as an emerging fuel source based on assumptions and input data from timber waste landfilling. This residue could be directly burnt as a heating fuel or combined with coal and other fuels. It also generates fewer air pollutants than traditional fossil fuels. Timber pellets, in particular, hold the potential for heat provision in industries such as cement manufacturing and power generation.

Management of CCA-Treated Timber

In addition to the previously mentioned treatments and recycling methods for CCA, [23] outlined various management strategies for CCA-treated timber. These strategies include substituting treated timber with alternative materials such as brick, untreated cedar, and teak; utilising 3D scanning to collate wood parameter information for material integration, thus reducing the need for excessive CCA wood system development and design; and minimising the use of treated timber during the design process. Applying WPC could also decrease the construction industry's reliance on raw materials, including treated wood, thereby reducing the volume of treated timber waste.

Regarding waste management, while landfills need substantial space and present the risk of leaching, incineration can generate energy but sacrifices carbon storage. Thermal treatments offer a comprehensive solution but require technical support and can be time-consuming. Therefore, clear prioritisation is necessary to identify the most suitable option for the future.

3.3 Roles of Stakeholders and Policymakers in Timber Waste Management

[25] observed diverging opinions on the necessity for companies to implement C&DW management. However, it is pivotal to consider various sustainability assessments before developing a C&DW system. Several methods exist for creating C&DW systems, aiding in determining their environmental impact. Focusing on key areas such as waste materials and metal composition is crucial to achieve tangible improvements in environmental performance. Gathering information on sectors such as wood scrap can drive progress towards meeting national C&D waste recycling targets.

[26] argued that councils across New Zealand should consider site waste management schemes as crucial for enhancing resource efficiency in the construction industry. Their research examined the global implementation of these schemes and their successful application in Auckland. Key success factors in Auckland included council-led schemes, stakeholder consultation, legal enforcement of site waste management schemes, phased implementation, template processes, minimising bureaucratic requirements, and engagement with the waste and construction industry during development.

[22] explored the most effective processes for treating timber waste and identifying the responsible producers of treated timber. It would be advantageous for New Zealand timber producers to establish a voluntary Extended Producer Responsibility (EPR) scheme. EPR is increasingly adopted worldwide. New Zealand is considering an EPR scheme for waste-treated timber, which would inevitably require legislation. Before enacting such legislation, timber producers should establish a voluntary environmental responsibility programme. Forestry companies, wood manufacturers, and chemical processors should collectively assess each other's treatment procedures to determine responsibility for treated timber more effectively. Suitable solutions such as carbon sequestration, energy production, or circular thinking can be discussed and selected accordingly.

3.4 Innovative Approaches to Timber Waste Management

Recent research presents innovative strategies for construction waste management. [27] introduced a statistical model to predict waste generation in residential construction. By enhancing the accuracy of waste forecasting, this model could improve the construction planning phase, leading to more sustainable design choices and efficient material utilisation. Future studies could expand upon this research by incorporating diverse datasets, qualitative measurements, and extending the scope to various building types and sizes.

Automation and data extraction methods also emerge as potential solutions. [28]'s script, developed for the Revit BIM database, streamlines the process of collecting precise material data. This tool can track the use of recycled or reused materials and components, offering a pathway towards a more circular economy in the construction industry.

[29] presented a systemic perspective with their Urban Equilibrium (UE) approach. By considering buildings as carbon pools to counterbalance urban greenhouse gas emissions, the UE approach underscores the role of sustainable design choices in waste management and carbon reduction. The study's suggestion of promoting timber use in urban development serves as a case in point, highlighting the environmental benefits of intelligent material selection.

[30] focused on the crucial role of material selection in managing construction waste. Their study distinguishes the divergent carbon emissions of light timber and steel framing houses, demonstrating how the recyclability and sustainability of materials can innovatively reduce the environmental impact of construction. While the recyclability of steel offers an advantage, the potential of sustainably sourced timber to function as a carbon pool presents a novel approach to waste management.

[4] expanded upon this idea in their lifecycle analysis of building materials. This study innovatively maps out the carbon footprint of each material over its lifecycle, providing a broad perspective on their environmental impacts. It emphasises the need for construction industry stakeholders to shift their focus from merely the immediate use of materials to their long-term environmental implications. While the recyclability of steel offers clear benefits, the sustainable sourcing of timber materials can lead to a similar, if not more significant, reduction in a project's carbon footprint.

In summary, these innovative strategies highlight the intersection of construction waste management with other domains such as statistical modelling, automation, and systemic carbon reduction. By adopting a multi-faceted and forward-thinking approach to material selection, it is possible to revolutionise waste management practices in the construction industry, bringing us closer to a sustainable future in this sector.

The key findings of the research are summarised in Fig. 1.

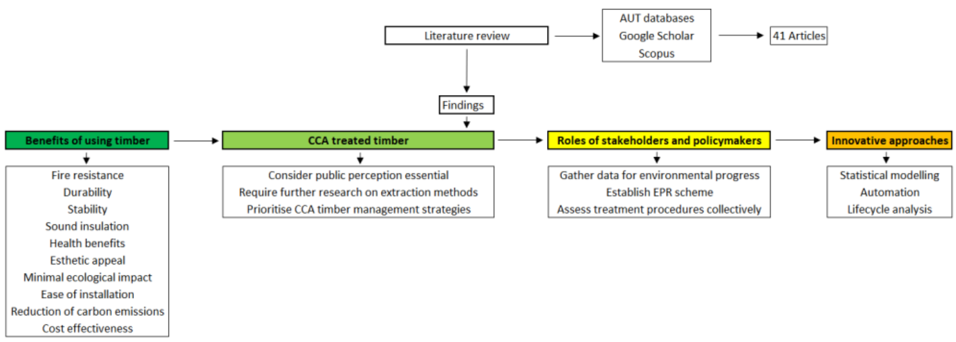

Fig. 1. Research findings

4 Conclusion

The construction industry plays a critical role in shaping the world's environmental trajectory. This research paper has addressed a lacuna in the existing literature concerning the sustainable management of construction waste, focusing primarily on timber, a much-favoured building material. Through a comprehensive literature review, the paper scrutinised the benefits of timber, the challenges posed by CCA-treated timber, the impact of stakeholders and policymakers on timber waste management, and the innovative approaches to waste management.

The findings highlighted numerous advantages of timber, including its durability, insulation properties, aesthetic appeal, and positive environmental impact. The potential of timber to act as a carbon sink emerged as a compelling solution to offset urban greenhouse gas emissions. CLT stood out for its significant reduction in carbon emissions compared to traditional materials like concrete and steel.

Nonetheless, the paper also revealed the challenges inherent in managing CCA-treated timber waste due to its potentially hazardous effects. Consequently, a deeper understanding, alternative treatment processes, and effective management strategies were proposed to alleviate these issues. Further, stakeholders and policymakers were recognised as instrumental in managing construction waste. Their roles range from implementing waste management schemes to establishing voluntary environmental responsibility programmes. Innovative strategies such as statistical modelling, automation, and systemic carbon reduction also emerged as potential solutions for managing construction waste.

Based on the findings, the following recommendations are made:

• Sustainable Material Selection: Prioritising timber in construction can dramatically lower carbon emissions whilst offering practical benefits such as fire resistance and ease of installation. Industry professionals and policymakers are urged to promote the increased use of sustainable timber in construction projects.

• Improved Management of CCA-Treated Timber: Stakeholders should investigate alternative timber treatments and advanced recycling processes to manage CCA-treated timber waste sustainably. Furthermore, public education is crucial to enhance the proper classification and disposal of treated timber.

• Policy and Stakeholder Engagement: Policymakers should introduce legislation to encourage the reduction of CCA-treated timber use, while the construction and forestry industries should actively participate in waste reduction strategies. Implementing EPR schemes could hold timber producers accountable for the waste they generate.

• Promotion of Innovative Strategies: Embracing technological advancements, such as statistical modelling and automation, can streamline waste management practices and promote efficient resource use. Construction industry stakeholders should invest in these innovative strategies to enhance waste reduction and recycling.

• Lifecycle Consideration: Stakeholders should adopt a lifecycle perspective when selecting materials to understand their long-term environmental impacts fully. Focusing on immediate use, recyclability, and end-of-life disposal can significantly reduce construction waste.

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