CHEMICAL ENGINEERING TRANSACTIONS
VOL. 122, 2025
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it
Guest Editors: Jeng Shiun Lim, Bohong Wang, Guo Ren Mong, Petar S. Varbanov

ISBN 979-12-81206-23-6; **ISSN** 2283-9216
DOI: 10.3303/CET25122058

The Role of Government in Circular Economy for Timber Waste Management on Construction Sites: A Review

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Timber waste from construction is a serious environmental problem that arises from disposal practices, including landfilling and incineration. While reuse and recycling can be opportunities, timber waste has not been optimally managed due to limited awareness, weak markets, and inadequate support systems. To overcome these challenges, government involvement by creating policies, incentives, and facilities is important in enabling sustainable waste management. The aim of this paper is to examine the role of government in implementing circular economy (CE) principles for timber waste management on construction sites. To achieve this, a systematic literature review (SLR) was conducted, focusing on studies published between 2019 and 2024. The selected articles were analysed to identify common themes and strategies related to both CE practices and the role of government. The review found that CE can significantly reduce timber waste through practices such as recycling, reuse, and material recovery, but its success heavily depends on strong government support through regulations, incentives, and education. The findings highlight the need for a more structured policy approach, public-private partnerships, and increased awareness to promote circular timber management. This study concludes that it is by government action is key to enabling the transition toward sustainable construction practices through effective timber waste management.

1. Introduction

Timber waste in construction is commonly defined as any wood material that is discarded, unused, or deemed unsuitable for its intended purpose during the construction process (Psilovikos, 2023). In Malaysia, more than half of construction contractors opt not to manage timber waste using the 3Rs principle: reduce, reuse, and recycle (Lin et al., 2021). This is further compounded by the contractors' unawareness and poor government promotion of recycling of timber waste (Lin et al., 2021), absence of a credit facility for timber resources, in addition to an unsatisfactory market for reused timber, which further hinders sustainable practice of wastes (Hurst and Halvitagala, 2019). Most timber waste ends up in landfills or is incinerated. In Finland, only about 4 % of timber from construction and demolition waste is recovered as material, while most is incinerated for energy production (Tennakon et al., 2023).

Addressing these constraints requires a shift in direction towards greater sustainability in waste management practices, particularly through the adoption of circular economy processes. The circular economy supports the extension of material life cycles, emphasising methods such as recycling, reuse, and resource recovery (Boros et al., 2024). Yu et al. (2022) observe that the application of Circular Economy (CE) principles can be a viable solution to the environmental issues faced by the construction sector. To succeed with a CE approach, various economic and social stakeholders must cooperate to access a circular material flow and its associated efficiency gains (Liu et al., 2021). The CE model aims to construct a sustainable economic framework by minimising waste, energy loss, and reducing consumption of resources by using methods that retain, postpone, and ultimately terminate the path of the resources (Idris and Bello, 2023). This practice addresses environmental issues and enhances economic resilience by avoiding dependence on limited resources and creating new opportunities for industries (Lahcen et al., 2022). Circular economy practices lead to a more equitable distribution of resources

Paper Received: 8 July 2025; Revised: 5 November 2025; Accepted: 30 November 2025
Please cite this article as: Alfarizi M., Abidin N.I.A., 2025, The Role of Government in Circular Economy for Timber Waste Management on Construction Sites: A Review, Chemical Engineering Transactions, 122, 343-348 DOI:10.3303/CET25122058

and generate employment opportunities (Mashovic et al., 2022) as well as promote economic growth (Gomide et al., 2024).

However, the successful implementation of circular economy strategies typically depends heavily on government involvement. Government involvement can encourage sustainability and convert waste into valuable resources. Regulatory instruments such as extended producer responsibility (EPR) schemes, landfill taxes, and material reuse standards encourage industries to minimise waste generation and prioritise the reuse and recycling of timber (Velenturf et al., 2019). Governments are also pivotal as facilitators by stimulating multi-stakeholder cooperation and inspiring research and innovation in green building (Kirchherr et al., 2017). Without strong institutional frameworks and consistent policy support, the implementation of circular strategies in timber waste management is often limited (Pomponi and Moncaster, 2017). Proactive governance structures are essential for driving systemic change and ensuring the effective transition towards a more circular and resource-efficient construction industry (Ghisellini et al, 2023).

This research focuses on the government's role in enabling the sustainability of construction timber waste management through the circular economy. It focuses on creating a more resilient and environmentally friendly approach to using timber efficiently and effectively. Through detailed analysis, the research provides valuable guidance for industry stakeholders and policymakers to achieve sustainable development goals and ensure the long-term viability of timber resources. The goal is to inspire a shift toward optimised timber utilisation and prioritised environmental sustainability, offering a clear roadmap for a more sustainable construction.

2. Methodology

The research process in this study consisted of three main stages, as illustrated in Figure 1. The first stage of this process begins with data collection. The Scopus database was used as the primary data source for retrieving pertinent literature. This stage involves identifying articles related to the role of government in the circular economy for timber waste management on construction sites. Keywords such as "stakeholder", "government role", "government policies", "circular economy", "timber or wood", "waste management", "construction" and "construction site" were used in searches, some of which were conducted randomly. The search period was limited to 2019–2024, with all the retrieved publications written in English, a global language frequently used for communication.

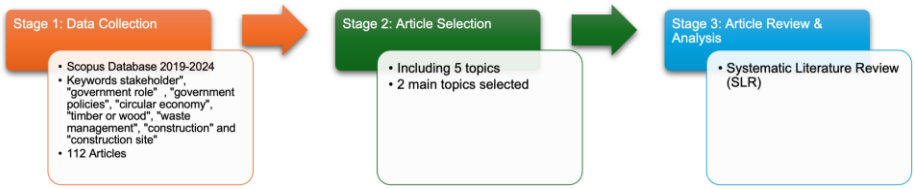

Figure 1: Research process of the study

From the first stage, 112 relevant articles were selected based on their contributions to timber waste management, circular economy, and government involvement. These articles were then used in the data collection process to support the foundation of the present research. Table 1 highlights the key research topics concerning the role of the government in the circular economy for timber waste management in construction, identifying five key topics in 112 research articles:

Table 1: Key research topics concerning the role of government in CE for timber waste management on construction sites

No.	Key Research Topics	Number of Article(s)
1	circular economy for timber waste management on construction	3 Articles
2	circular economy for timber/wood waste management on construction	20 Articles
3	stakeholder in circular economy for timber/wood waste management on construction	79 Articles
4	government in circular economy for timber/wood waste management on construction	2 Articles
5	policy in circular economy for timber/wood waste management on construction	8 Articles
Total		112 Articles

After reviewing 112 articles that focus on a shared topic, two main topics were identified for detailed analysis in the results and discussions. The two main topics are (1) circular economy for timber/wood waste management in construction, and (2) government in the circular economy for timber/wood waste management in construction. Last stage, Systematic Literature Review (SLR) was used for reviewing and analysing articles in this study. A deep understanding of relevant studies through data analysis of SLR is useful for policymakers.

3. Results and Discussions

Understanding how scholarly work is distributed across journals focused on the circular economy and timber waste management is crucial. Table 2 presents the main journals, the number of articles published in each research theme, and their estimated citation counts based on the reviewed articles.

Table 2: Key journal publishing research on CE for timber waste management on construction sites

Key Research Topics	Key Journals Publishing	Number of Article(s)	Total Citations
1	Journal of Cleaner Production, Sustainability	3 Articles	52
2	Journal of Cleaner Production, Sustainability, Resources, Conservation & Recycling	20 Articles	312
3	Sustainability, Renewable and Sustainable Energy Reviews	79 Articles	648
4	Sustainability, Environmental Science & Policy	2 Articles	18
5	Journal of Environmental Management, Waste Management	8 Articles	94

The table highlights key publication venues across five research topics. The Journal of Cleaner Production and Sustainability are the most frequently cited and published journals, emphasising their importance in timber waste management and the circular economy. The high citation count for Renewable and Sustainable Energy Reviews reflects increasing academic interest in stakeholder roles within circular construction. Government involvement remains a relevant stakeholder topic and continues to be a topic of discussion.

3.1 Circular Economy for Timber/Wood Waste Management on Construction

The generation of timber waste originates from construction activities, causing environmental damage. For example, large amounts of wood are left as off-cuts when timber is sawn and machined to create structural elements. These offcuts are typically discarded, resulting in significant waste (Muthumala et al., 2019). Other wastes include wood that is spoiled during transportation or material handling that does not meet the intended quality, often being wasted rather than recycled (Lin et al., 2021). Traditional waste management, mostly in the form of landfilling, remains prevalent within the construction sector. While simple, landfilling wood waste leads to resource depletion (Lin et al., 2021), greenhouse gas emissions (Agha and Ayob, 2022) and environmental degradation (Siddiqua et al., 2022). Recycling and reusing wood waste can potentially lead to the creation of new products and materials and, hence, reduce the consumption of virgin resources (Lazaridou et al., 2021) and environmental degradation (Neykov et al., 2020). For instance, wood waste and sawdust can be remanufactured into engineered wood products or as materials for new building purposes (Olaiya et al., 2023). Recycling wood products, such as used pallets and construction waste bonded with cementitious materials, offers various applications in construction and is a practical solution for the industry (Gigar et al., 2023). Converting sawdust into hydrochar through hydrothermal carbonisation (HTC) is another promising method. This method has shown both technical and economic viability, with a 17.4 % return on equity over 20 years (Vallejo et al., 2023). These advances highlight the potential of Circular Economy (CE) strategies in managing timber waste, offering environmental and economic advantages, particularly when supported by suitable policies and market systems.

The use of CE principle in construction promotes three significant sustainable outcomes: intensified utilisation of renewable resources, optimised material recovery processes, and significant minimisation of waste generation, as well as reductions in landfill dependency (Boros et al., 2024). Due to the rising demand for construction material, material shortages, and growing environmental concerns (Almusaed et al., 2024), resource-efficient construction has gained recognition at different levels globally, ranging from governmental action to industrial initiatives and academic research (Hossain et al., 2020). Hence, the circular economy aims to reduce and recycle Construction & Demolition (C&D) waste, promoting a new design philosophy, such as deconstruction design and increased material efficiency (Salleh et al., 2022). By minimising reliance on limited resources, it also creates new business ventures, improves economic resilience, and promotes environmental sustainability (Khan and Mihaisi, 2023). CE has emerged as a modern and realistic methodology in the building industry to address the objectives of sustainability, particularly in the areas of resource preservation and waste minimisation (Idris and Bello, 2023). By promoting a closed-loop system, the CE aims to decouple economic

growth from resource consumption, moving towards a greener future (Drager et al., 2022). The concept closely aligns with the Sustainable Development Goals (SDGs), specifically Target 12.5, which aims to prevent waste generation through reduction, recycling, and reuse (Ezema et al., 2023).

3.2 Government in Circular Economy for Timber/Wood Waste Management on Construction

Mohammed et al. (2022) emphasise that government support through regulations and standards plays an instrumental role in encouraging the construction sector to become more sustainable. Such policies can range from offering financial incentives to establishing regulatory frameworks that require the reduction, reuse, and recycling of waste (Mohammed et al., 2022), as well as repurposing waste as a material for combustion to generate renewable energy (Lin et al., 2021). Although specific laws, regulations, and policies exist to safeguard recyclable waste at construction sites, it is equally essential to develop an effective system for monitoring the disposal or recycling of wood waste (Umar et al., 2021). For example, the Solid Waste and Public Cleansing Management Act 2007 (Act 672) requires developers and contractors to implement waste management practices that focus on waste segregation and recycling (Na'im et al., 2022). This law is part of a broader initiative aimed at reducing landfill waste and promoting sustainable development (Ibrahim et al., 2022). Niu et al. (2021) also emphasise the importance of standardised criteria to assess the reuse of wood, highlighting the need to address subjectivity in evaluation processes.

In Australia, various government initiatives have been launched to enhance recycling efforts and reduce waste, which are crucial for fostering a circular economy, as highlighted by Halog et al. (2021). Similarly, in Hungary, the application of CE principles in the construction sector has been guided by aligning national policies with EU directives, resulting in improved recovery rates for construction and demolition waste (Buruzs and Kozma, 2023). This example demonstrates how structured regulatory frameworks and government oversight can speed up the adoption of circular timber waste practices. The implementation of Extended Producer Responsibility (EPR) schemes, which require producers to be responsible for their products throughout their entire lifecycle, promotes the development of more durable and recyclable products and is another effective regulatory approach (Kartiko, 2023). The fight against illegal logging and the promotion of sustainable timber practices in the United States is strengthened through the Lacey Act, which mandates that wood products entering the U.S. be legally sourced, thereby decreasing waste resulting from illegal logging. Policies in Brazil aim at the sustainable utilisation and management of timber, focusing on minimising waste from logging and processing. These regulations include guidelines for timber management under sustainable forestry to reduce waste and increase timber utilisation. The Brazilian government recognises the need to incorporate environmental considerations into timber management to achieve sustainability goals (Liu et al., 2021). In Ghana, legal enforcement regulations and export bans play a crucial role in controlling the timber trade and effectively reducing waste. These policies play a crucial role in regulating logging practices and minimising timber waste during production (Kombat and Chen, 2022). Recognising the significant impact of economic and environmental policies on timber management, the Ghanaian government has endeavoured to integrate waste management into its overall policy framework to promote sustainability.

Currently, the National Solid Waste Management Department and the Solid Waste and Public Cleansing Management Corporation Malaysia (SWCorp) oversee the regulation of recycling in construction waste, including wood (Lee, 2023). These regulations support the conversion of timber waste into boards and reusable materials, helping to reduce landfill waste and improve resource utilisation. However, their effectiveness is often hindered by inconsistent enforcement and low public participation in recycling efforts (Razali and Choong, 2019). In the 12th Malaysia Plan (2021-2025), Malaysia aims to transition from a conventional linear economy model to a sustainable circular economy model (Malaysia 12th Economic Planning Unit, 2021). The involvement role of the Government is necessary to control the unsustainable urban development process (Mohammed et al, 2020). Furthermore, the use of recycled materials is crucial in supporting construction projects (Adeyemi et al., 2017). However, in Malaysia, government policies addressing waste material management seemed to be of low priority at the time (Lee et al., 2023). These findings underscore the crucial role of the government in successfully implementing circular economy principles. The government should address the importance of timber waste management systems in Malaysia and increase contractors' awareness of timber recycling so that they can practice this timber management system on their construction sites (Ramanathan, 2023)

4. Conclusions

This study examines how timber waste from construction sites can be better managed using circular economy (CE) principles, with a focus on the government's role. Government support is crucial for the implementation of the circular economy. The establishment of recycling infrastructure, financial assistance, and clear laws are all ways that governments may assist. According to the study, effective timber waste management strategies have been developed in countries such as Australia and the EU through supportive regulations. Although objectives

have been established, awareness and enforcement remain lacking in Malaysia. Governments should strengthen legislation, support the construction of recycling facilities, provide incentives to companies that reduce waste, increase industry and public awareness, and better monitor waste statistics to facilitate improvements. Future research should focus on evaluating specific policy tools, exploring stakeholder behaviour, and examining the use of digital technologies to improve timber reuse and tracking. Comparative studies between regions could also offer insights into best practices and implementation challenges.

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