Sustainability performance of construction waste management policies by 2050: A comparative study of China and Australia

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1. Introduction

China and Australia present contrasting contexts for construction waste management, with China's construction boom generating massive waste streams but facing challenges in achieving high recycling rates (Aslam et al., 2020; Hao et al., 2024), and Australia emphasizing policy-driven approaches to improve waste recovery. Despite advancements in both nations, there remains a gap in systematically evaluating how policies impact long-term sustainability. This study addresses this gap by employing integrated methodologies to explore the influence of policy scenarios on construction waste management systems in the two countries by 2050.

This study choose two most representative cities in each country: Suzhou in China and Brisbane in Australia. Suzhou in China and Brisbane in Australia were chosen as the two representative cities for this study due to their contrasting yet significant roles in construction and demolition waste management within their respective countries. Suzhou, a rapidly developing economic hub with a booming construction industry, faces challenges related to high waste volumes and urbanization, making it a key city for examining construction waste management practices in China. Brisbane, as a mature urban center in Australia, has well-established sustainability policies and waste management practices, offering a different set of challenges focused on recycling and environmental impact reduction. These cities provide an ideal comparative context, allowing the study to explore the influence of diverse policy environments and urbanization stages on construction waste management outcomes, while also ensuring data availability for rigorous analysis.

2. Material and methods

2.1 System dynamics

System dynamics modeling involved the development of a causal loop diagram and stock-and-flow model to represent the dynamics of construction waste management systems in both China and Australia (Zhao et al., 2024). The model captures key variables such as waste generation rates, recycling rates, policy incentives, economic costs, and environmental impacts, providing a comprehensive view of the system's behavior.

After the development of the system dynamics model and before simulating the scenarios, the model should be validated to ensure its feasibility and reliability through validity test, sensitivity test, extreme condition test, and dimension consistency test (Pinha & Sagawa, 2020). Historical data from government reports, academic studies, and industry statistics were utilized to calibrate and validate the model, ensuring that it accurately reflects the real-world dynamics and can predict the outcomes of various policy scenarios. By varying different policy variables, the overall construction waste and the associated carbon emissions can be calculated by 2050 through scenario simulations.

2.2 Multi-objective optimization

The sustainability performance of construction waste management policies is evaluated from three perspectives: environment, economy, and society (Aslam et al., 2020; Visentin et al., 2020). A multi-objective optimization framework was designed to identify optimal policy scenarios that balance environmental, economic, and social objectives in construction waste management (Ooi et al., 2021; Wu et al., 2022). The objectives include minimizing greenhouse gas emissions, maximizing economic benefits, and enhancing social performance in waste management practices.

The three perspectives can be comprehensively evaluated using a multi-objective model by calculating a sustainability index (Han et al., 2024). A higher sustainability index indicates better sustainability performance in construction waste management. This approach enables stakeholders to quantitatively assess and compare different management strategies, facilitating more informed decision-making.

3. Results and Discussion

The preliminary findings reveal notable differences in the effectiveness of construction waste management policies between China and Australia. In China, stricter enforcement of recycling mandates has been instrumental in significantly improving material recovery rates. Complementing this regulatory approach,

substantial investments in advanced recycling technologies have enhanced the efficiency of waste processing and contributed to notable reductions in carbon footprints. However, regional disparities in policy implementation and recycling infrastructure pose challenges to achieving nationwide consistency in construction waste management outcomes.

Although their strategies differ, both nations gain significantly from integrating circular economy principles into their construction waste management frameworks. These principles promote material reuse, recycling, and recovery, aligning with global sustainability objectives. Notably, Australia's policy-driven approach demonstrates a greater ability to navigate multi-objective trade-offs, effectively balancing environmental, economic, and social priorities. This adaptability highlights the critical role of strong governance and collaborative stakeholder efforts, offering valuable insights for shaping future global construction waste management strategies.

4. Conclusion

This study employs an integrated approach combining system dynamics and multi-objective optimization to evaluate the sustainability performance of construction waste management practices under various policies in China and Australia, focusing on the representative cities of Brisbane and Suzhou. This study underscores the importance of dynamic and integrated approaches to policy evaluation in CWM systems. By combining system dynamics and multi-objective optimization, it offers a comprehensive framework for predicting long-term policy impacts. Policymakers in China and Australia can leverage these insights to refine their strategies, focusing on collaborative efforts, advanced technologies, and public engagement to achieve sustainable construction waste management by 2050.

Looking ahead to 2050, the study emphasizes the critical role of circular economy principles in fostering material reuse, recycling, and recovery. By integrating these principles, both countries can significantly contribute to global sustainability goals, reduce carbon footprints, and transition toward more resilient and resource-efficient construction industries. These findings not only provide actionable recommendations for China and Australia but also offer a framework for other nations seeking to advance sustainable construction waste management practices and align with global environmental objectives.

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