INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

Universidad del País Vasco / Euskal Herriko Unibertsitatea

BILBOKO INGENIARITZA ESKOLA / ESCUELA DE INGENIERÍA DE BILBAO

MÁSTER UNIVERSITARIO EN INGENIERIA INDUSTRIAL

TRABAJO FIN DE MÁSTER

OPTIMIZATION OF A REVERSE SUPPLY CHAIN IN THE CONSTRUCTION SECTOR: A LITERATURE REVIEW

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Curso: 2023-2024

Fecha: Lyon, 21, julio, 2024

Resumen

El sector de la construcción se destaca como uno de los principales contribuyentes al cambio climático, responsable de aproximadamente el 40% de las emisiones anuales de carbono. Ante esta realidad, la adopción de prácticas sostenibles dentro de la industria es imperativa. El reciclaje y la reutilización de residuos de construcción y demolición (C&D) no solo pueden reducir drásticamente el consumo de energía, sino también las emisiones de gases de efecto invernadero. Por ejemplo, en 2013 en India, se estimó una recuperación significativa de materiales C&D, evidenciando el potencial de estas prácticas para disminuir el impacto ambiental.

Integrar los principios de la economía circular (CE) en el sector, especialmente a través de proyectos de deconstrucción, puede ser una vía efectiva para reducir el impacto ambiental. Este enfoque promueve sistemas de producción y consumo circulares, minimizando el uso de materias primas y sus impactos asociados, y proporcionando beneficios socioeconómicos.

La deconstrucción, que prioriza la reutilización y recuperación de recursos, es una solución prometedora para la gestión de residuos en la construcción. No obstante, la gestión de residuos de construcción y demolición a través de modelos matemáticos sigue siendo un área relativamente inexplorada en la literatura científica.

Este trabajo se centra en optimizar las operaciones y la logística de la gestión de residuos de construcción y demolición mediante una revisión de la literatura existente, extendiendo investigaciones previas y proporcionando una base para el desarrollo de herramientas de optimización aplicables a proyectos reales en la región de Gaspésie, Québec, Canadá. A través de esta revisión, se sintetizan los hallazgos recientes y se destacan las tendencias emergentes, proponiendo estrategias accionables para mejorar la gestión de residuos en la construcción y demolición.

Palabras clave: Construcción, renovación y demolición (CRD); economía circular; deconstrucción; planificación; logística; optimización; toma de decisiones.

Summary

The construction sector stands out as one of the main contributors to climate change, responsible for approximately 40% of annual carbon emissions. Given this reality, adopting sustainable practices within the industry is imperative. Recycling and reusing construction and demolition (C&D) waste can not only drastically reduce energy consumption but also greenhouse gas emissions. For instance, in 2013 in India, significant recovery of C&D materials was estimated, demonstrating the potential of these practices to decrease environmental impact.

Integrating the principles of the circular economy (CE) within the sector, especially through deconstruction projects, can be an effective way to reduce environmental impact. This approach promotes circular production and consumption systems, minimizing the use of raw materials and their associated impacts, and providing socioeconomic benefits.

Deconstruction, which prioritizes resource reuse and recovery, is a promising solution for waste management in construction. However, managing

construction and demolition waste through mathematical models remains a relatively unexplored area in scientific literature.

This work focuses on optimizing the operations and logistics of construction and demolition waste management through a review of existing literature, extending previous research, and providing a basis for the development of optimization tools applicable to real projects in the Gaspésie region, Québec, Canada. Through this review, recent findings are synthesized and emerging trends are highlighted, proposing actionable strategies to improve construction and demolition waste management.

Keywords: Construction, renovation, and demolition (CRD); circular economy; deconstruction; planning; logistics; optimization; decision-making.

Laburpena

Eraikuntza sektorea klima-aldaketaren eragile nagusietako bat da, urteroko karbono isurien %40 inguru eragiten baitu. Errealitate honen aurrean, sektore barruan praktika iraunkorrak hartzea ezinbestekoa da. Eraikuntza eta eraispen (C&D) hondakinen birziklatzeak eta berrerabiltzeak ez du soilik energia-kontsumoa drastikoki murrizten, baizik eta berotegi-efektuko gasen isuriak ere bai. Adibidez, 2013an Indian, C&D materialen berreskurapen nabarmena kalkulatu zen, praktika horien ingurumen-inpaktua murrizteko potentziala erakutsiz.

Ekonomia zirkularraren (CE) printzipioak sektorean integratzeak, bereziki deskonposizio proiektuen bidez, ingurumen-inpaktua murrizteko modu eraginkorra izan daiteke. Hurbilketa honek produkzio eta kontsumo sistema zirkularrak sustatzen ditu, lehengaien erabilera eta horiekin lotutako inpaktuak gutxituz, eta onura sozioekonomikoak eskainiz.

Deskonposizioa, baliabideen berrerabilera eta berreskurapena lehenesten duena, eraikuntzako hondakinak kudeatzeko irtenbide itxaropentsua da. Hala

ere, eraikuntza eta eraispen hondakinak kudeatzea eredu matematikoen bidez arlo nahiko aztertu gabea da zientzia-literaturan.

Lan honek eraikuntza eta eraispen hondakinen kudeaketaren eragiketak eta logistikak optimizatzea du helburu, literaturan dauden azterketen berrikuspen baten bidez, aurreko ikerketak zabaltzen, eta Gaspésie eskualdean, Québec, Kanadan, benetako proiektuetan aplikagarriak diren optimizazio tresnen garapenerako oinarri bat emanez. Berrikuspen honen bidez, azken aurkikuntzak sintetizatzen dira eta joera berriak azpimarratzen dira, eraikuntza eta eraispen hondakinen kudeaketa hobetzeko estrategia bideragarriak proposatuz.

Hitz gakoak: Eraikuntza, berritzea eta eraispena (CRD); ekonomia zirkularra; deskonposizioa; plangintza; logistika; optimizazioa; erabaki-hartzea.

Résumé

Le secteur de la construction est l'un des principaux contributeurs au changement climatique, étant responsable d'environ 40 % des émissions annuelles de carbone. Face à cette réalité, l'adoption de pratiques durables au sein du secteur est impérative. Le recyclage et la réutilisation des déchets de construction et de démolition (C&D) peuvent non seulement réduire considérablement la consommation d'énergie, mais aussi les émissions de gaz à effet de serre. Par exemple, en 2013 en Inde, une récupération significative des matériaux C&D a été estimée, montrant le potentiel de ces pratiques pour réduire l'impact environnemental.

L'intégration des principes de l'économie circulaire (EC) dans le secteur, notamment à travers des projets de déconstruction, peut constituer une voie efficace pour réduire l'impact environnemental. Cette approche favorise des systèmes de production et de consommation circulaires, réduisant l'utilisation des matières premières et leurs impacts associés, tout en offrant des avantages socio-économiques.

La déconstruction, qui privilégie la réutilisation et la récupération des ressources, représente une solution prometteuse pour la gestion des déchets de construction. Cependant, la gestion des déchets de construction et de démolition à travers des modèles mathématiques reste un domaine relativement inexploré dans la littérature scientifique.

Ce travail se concentre sur l'optimisation des opérations et de la logistique de la gestion des déchets de construction et de démolition à travers une revue de la littérature existante, étendant les recherches précédentes et fournissant une base pour le développement d'outils d'optimisation applicables à des projets réels dans la région de Gaspésie, Québec, Canada. À travers cette revue, les résultats récents sont synthétisés et les tendances émergentes sont mises en avant, proposant des stratégies actionnables pour améliorer la gestion des déchets dans la construction et la démolition.

Mots-clés : Construction, rénovation et démolition (CRD) ; économie circulaire ; déconstruction ; planification ; logistique ; optimisation ; prise de décision.

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Acknowledgments

I would like to express my sincere gratitude to the following individuals who have been instrumental in the completion of this project. First and foremost, I am deeply thankful to Julien Fondrevelle, Taha Arbaoui and Tasseda Boukherroub for their invaluable guidance, support, and expertise throughout this research. Their insights and encouragement have significantly contributed to the success of this work.

I also extend my heartfelt thanks to Félix Veillette for their collaborative efforts and essential contributions. Working together has been a rewarding experience, and their involvement has greatly enriched this project.

Furthermore, I am grateful for the opportunity to observe and engage with the project's development process in Gaspésie region in Quebec, Canada. This experience has been both enlightening and inspiring, adding a valuable dimension to my understanding and approach.

Thank you all for your unwavering support and dedication.

1. Introduction

The construction sector is one of the biggest contributors to the climate change worldwide. It is then necessary to adopt sustainable practices and approaches in this domain. There are already studies that highlight the big impact of the sector worldwide. The construction industry is one of the biggest contributors to greenhouse gas (GHG) emissions in the last years, being responsible for about 40% of carbon emissions yearly [1]. It is estimated that on-site recycling of Construction and Demolition (C&D) waste could save more than 92% of energy consumption and about 86% reduction in GHG emissions [2]. In addition, recycling and reuse of C&D waste can offset the demand for primary materials, leading to decreasing energy consumption and reducing GHG emissions. For example, the potential recovery of different materials from C&D waste in India in 2013 included 190.8 million tons/year of soil, sand, and gravel, 164.3 million tons/year of bricks and masonry, and 121.9 million tons/year of concrete [2]. These numbers demonstrate the significant potential for reducing environmental impact through reusing and recycling of C&D waste.

Giving importance to the principles of circular economy (CE) within the sector, particularly through deconstruction projects, presents a viable way towards reducing this environmental impact. By making possible the transition towards circular production and consumption systems, the construction sector could lower its resource consumption, waste generation, and GHG emissions. This change offers an opportunity to minimize the use of raw materials and their associated environmental impacts. In addition, it can contribute to sustainable and profitable alternatives, guiding the efficient use of resources and providing socio-economic benefits including increased gross domestic product and employment opportunities [3].

Deconstruction, as a solution within the construction sector, holds promise for minimizing waste by prioritizing material reuse and resource recovery. Despite its growing recognition within the industry, construction and demolition waste management with mathematical models remains relatively underexplored in scientific literature.

In this literature review, we delve into the realm of optimizing operations and logistics of construction and demolition waste. It is the next step of research following a previous literature review written by Veillette et al. [4]. The investigation extends beyond the theoretical frameworks proposed by previous studies. This study will in the future be used to develop optimization tools for real projects of deconstruction in the Gaspésie region in the province Québec, Canada.

The framework of this review delineates an intricate understanding of the methodologies employed in planning and scheduling deconstruction operations, alongside other topics useful in the domain such as refurbishment, construction waste management among others.

By synthesizing recent research findings, this paper not only encapsulates the current landscape of mathematical optimization models applied to construction and demolition waste management but also sheds light on emerging trends and future research avenues. Through our discussion and conclusion at the end, it delineates key insights and proposes actionable strategies for advancing construction and demolition waste management.

2. Methodology

In this section the methodology used is described. The starting point is the literature review carried out by Veillette et al. (2024) [4]. First the methodology used by the authors is described briefly and then our methodology is presented.

The literature review process of Veillette et al. (2024) [4] began with an analysis of papers referenced in a prior literature review (Boukherroub et al., 2024) [19]. Subsequently, searches were conducted on Google Scholar using various keyword combinations related to waste deconstruction, transport optimization, and deconstruction optimization between May 2023 and August 2023. Then what is called the “snowballing method” was utilized to explore the references of the retrieved articles. Initially, five articles were selected for inclusion in the review. Further articles were recommended by field experts from September 2023 to January 2024, which led to the identification of additional keywords such as waste, optimization, deconstruction, planning, circular economy, and logistics. Synonyms for each keyword were generated resulting in 50 synonyms, of which 19 were used. The review period was set from 2010 onwards based on previous literature. Article searches were conducted on Engineering Village using databases like Compendex, Inespec, and Knovel. Initially, 355 articles were identified using a comprehensive search formula. Filtering based on titles and abstracts, along with subsequent refinements to the search formula, resulted in 18 English-language articles being considered. Following recommendations, synonyms such as selective demolition and selective dismantling were incorporated, leading to the discovery of 27 additional articles. After review, a total of 11 articles were selected for analysis, including those identified in the initial stage.

These 11 articles were the starting point of this new literature review. However, we also tried to look for new articles in other resources with the key words' combinations given in Veillette et al. (2024) [4], but after long research in resource webpages such as Web of Science, it was decided to continue just with the 11 articles and its related articles. Thanks to the google scholar "related articles" tool the new search for new articles began. This approach is known as "Snowballing", and it is the method mostly used for the whole research. As Voicu [14] says in his research: "The "snowball" method implies the identification of an initial set of respondents who will be interviewed and who will be requested at the end of their interview to recommend potential subjects who share similar characteristics and who are relevant for the purpose of the subject survey. Request for referrals shall be initiated by the researcher by means of a phrase such as:" It was a great pleasure to meet you and I really appreciate the time you have so kindly offered. I was wondering if you happen to know other persons who share the same interest/experience as yours and who would be willing to meet me". In this sense a similar approach is used in this method but instead of using people, will be the 11 articles and articles related to them.

From each of the 11 articles the same process was followed:

- First the article itself was looked in google scholar research engine. Once found the "related articles" tool from google scholar was used.
- With all the new articles found, the search for interesting articles for this study began. A first look at the titles was the starting point. For most of the articles, by just reading the title it could be decided whether they were or not interesting. Some of them were just mentioning aspects such as electric vehicles, products, plastics, etc., not related to this study.
- Staying with the articles that looked interesting from the title, the abstract and conclusion was read. In case they remained interesting, deeper

research began, and they were classified in a table that include the following aspects:

- Title of the article
- Authors
- Year of publication
- Topic:
  - Planning and scheduling
  - Building refurbishment
  - Construction waste management
- Decisions: This section presents the main reason the models are aimed for, i.e. which decisions to be made (e.g. the amount of material recycled in the process).
- Country of the case study
- Model type: In this other section the model is briefly explained. It could be multi-objective or mono-objective for example.
- Objective of the model: Could be reducing GHG emissions, increasing the benefits, etc.

Finally, 9 articles were chosen, they will be studied in the next section and next it is shown the tables mentioned before [Table 1].

Table 1. Information of the articles

Reference	Year	Country	Topic	Decision	Model	Objective	Snowballed article
[5]	2020	France	Planning and scheduling	Finding an optimal set of trade-offs between economic performance, deadlines, and environmental impact to choose the right option	Multi-objective	4 Objectives: costs, deadlines, recovery rate and GHG emissions	[5]
[6]	2022	N/A	Planning and scheduling	Visualize and understand current problems associated with BR C&D waste management and thereby strategically intervene to reduce the carbon emissions	First model and sub-models for different purposes, multiobjetive, integrated SD-LCA causal loop model	Evaluate the carbon emissions of the life cycle, and several submodels to evaluation those carbon emissions under different circumstances	[16]

[7]	2020	Canada	Network design	Design eco-efficient reverse logistics network	Two-stage stochastic model	Maximize the expected profit and minimize landfilling activities to give more incentive for materials recycling	[17]
[8]	2018	Canada	Network design	Determine the location and the capacities of the sorting facilities to ensure compliance with the new regulation and prevent the wood from being massively landfilled	Mixed-integer linear programming model (MILP)	Balance supply source's locations, the available quantity of recycled wood at the collection sites, and the various quality grades of the collected wood.	[17]
[9]	2021	Hong Kong	Planning and scheduling	Calculate cost and evaluate the impact of uncertainties on the cost parameters	multi-stage network-based model	minimize the overall cost for the reverse logistics management of inert construction waste across its entire life cycle	[17]
[10]	2016	India	Planning and scheduling	Calculate the revenue	multi-objective linear programming problem with two	minimize the exploitation on the environment and find a means for recycling the waste into environment friendly building materials, maximize revenue	[15]

					inequality and two equality constraints		
[11]	2011	China	Planning and scheduling	Analyze the cost–benefit of this process using a system dynamics approach	System dynamics approach	Net benefit	[16]
[12]	2021	Germany	Planning and scheduling	Investigate the economic impacts and consequences of recycling concrete from building demolition in a closed loop material cycle. Information on the number and location of installed sorting screens and defines the material flows	Bi-objective mixed-integer linear optimisation model	Economic objective function minimises the total costs of the recycling network, the circularity objective function minimises the amount of primary natural aggregates required for concrete manufacturing.	[18]

				within a comprehensive regional recycling network.			
[13]	2021	Poland	Planning and scheduling	Help demolition companies with a better waste management.	Multi-objective	Choose the best variant of works organization and machinery selection.	[15]

3. Articles resumes

3.1. Article 1: Quéheille, E., TAILLANDIER, F., & SAIYOURI, N. Optimization tool of waste management in building deconstruction with environmental criteria.

The document presents a multi-objective optimization model for waste management in building demolition, focusing on deconstruction practices and their environmental impact. An optimization algorithm was developed considering four objectives: costs, deadlines, recovery rate, and greenhouse gas emissions. This algorithm was tested in a real case study and demonstrated efficiency in finding an optimal set of trade-offs between economic performance, deadlines, and environmental impact. There was also a meeting with the author of the article from which it was concluded that the genetic algorithm has a great impact in solving this kind of problem. This kind of algorithm is inspired by natural selection.

Deconstruction, compared to classic demolition, facilitates waste recycling by allowing on-site sorting. In addition, the various types of variables used in the model are detailed, including decision variables, knowledge variables, and building variables. Decision variables include demolition type, resources, container types, and waste treatment methods, shaping the strategy with 77 variables that affect waste sorting efficiency. Knowledge variables are constant and encompass removal efficiencies, daily costs, waste transport and treatment costs, recovery rates, and GHG emission factors, helping calculate demolition duration and cost based on professional experience and local treatment plant characteristics. Building variables are specific to each case, covering floor area, waste type and amount, and constraints like limited access. Up to forty waste types are managed, with on-site reuse and worker limits assessed using building documents and inspection reports. It is mentioned that the optimization problem is complex, and a metaheuristic search algorithm was used to find optimal solutions in the Pareto sense.

In a real case study, 20 optimal solutions were found in less than 3 minutes, and the results were compared for decision-making. It is concluded that the proposed model is a significant advantage for demolition studies as it allows for waste management planning and optimization of costs and deadlines. In addition, it is suggested that the model could be adapted to other contexts and could be improved by including Life Cycle Assessment to consider broader environmental impacts.

3.2. Article 2: Ma, W., Hao, J. L., Zhang, C., Guo, F., & Di Sarno, L. (2022). System dynamics-life cycle assessment causal loop model for evaluating the carbon emissions of building refurbishment construction and demolition waste. Waste and Biomass Valorization, 13(9), 4099-4113.

The article presents an integrated System Dynamics (SD) and Life Cycle Assessment (LCA) model to assess carbon emissions from construction and demolition (C&D) waste in the building renovation (BR) process. The study identifies the complexity in managing BR C&D waste and proposes a causal loop model to evaluate carbon emissions. Five causal loops are identified, including a general model to assess carbon emissions in the life cycle of BR C&D waste, and sub-models to assess emissions at different stages of the BR process. Results demonstrate how interactions among factors influence carbon emissions and how the model can assist decision-makers in understanding current issues and making strategic interventions to reduce carbon emissions in the life cycle of BR C&D waste.

The study highlights promoting building renovation as a green alternative to demolition and new construction, along with the increase in C&D waste associated with renovation and its impact on carbon emissions. In addition, it underscores the importance of assessing carbon emissions throughout the entire life cycle of BR C&D waste. The integrated SD-LCA model provides a platform for visualizing and understanding the complex interactions and environmental impacts associated with BR C&D waste. Findings are valuable for decision-makers in waste management and sustainable building development.

The study is relevant to the construction industry and waste management, emphasizing the importance of considering carbon emissions in managing BR C&D waste. Furthermore, the proposed model provides a basis for future research on mitigating carbon emissions through evaluating different scenarios. Overall, the article presents an innovative approach that integrates System Dynamics and Life Cycle Assessment to address a complex and relevant issue in construction and demolition waste management.

3.3. Article 3: Trochu, J., Chaabane, A., & Ouhimmou, M. (2020). A carbon-constrained stochastic model for eco-efficient reverse logistics network design under environmental regulations in the CRD industry. Journal of Cleaner Production, 245, 118818.

The article addresses the design of a reverse logistics network for recycling wood waste from the construction, renovation, and demolition (CRD) industry in the province of Quebec, Canada. The proposed optimization model aims to maximize expected profits and minimize landfill activities, considering uncertainty in the quantity and quality of collected materials. A sampling average approximation method and the ε-constraint method were used to solve the model. The results highlight the importance of source separation to control the impact of uncertainty, both from an economic and environmental perspective. The need to evaluate the interaction between environmental policies to avoid conflicting objectives is revealed. The experiments also indicated that setting recycling targets for materials can be challenging for local authorities in an uncertain environment. Therefore, it is suggested that conducting a sensitivity analysis on legislative parameters could be the focus of another study. This would provide valuable insights for governments before implementing recycling targets in specific areas, potentially impacting the effectiveness of reverse logistics operations. The proposed model was applied to the case of wood waste recycling in the CRD industry in Quebec, yielding efficient Pareto solutions that balance economic gains with environmental constraints.

The model considers uncertainty in the quantity and quality of collected materials, as well as the costs and emissions associated with transportation, processing, and landfilling. Two main objectives are identified: maximizing profits from the sale of recycled materials and minimizing the total amount of materials sent to landfills. The ε-constraint approach was applied to obtain optimal Pareto solutions, balancing economic objectives with environmental constraints.

The proposed model offers a comprehensive perspective on the design of the reverse logistics network for wood waste recycling in the CRD industry in Quebec, providing valuable insights for strategic decision-making that balance economic considerations with environmental ones. The results provide a clear insight into the importance of addressing uncertainty in the design of the reverse logistics network and the need to consider interactions between environmental policies to achieve desired efficiency in waste recycling.

3.4. Article 4: Trochu, J., Chaabane, A., & Ouhimmou, M. (2018). Reverse logistics network redesign under uncertainty for wood waste in the CRD industry. Resources, Conservation and Recycling, 128, 32-47.

The study tackles the problem of redesigning the reverse logistics network for recycled wood material from the Construction, Renovation, and Demolition (CRD) industry in the province of Quebec, Canada. The problem is set up as a Mixed Integer Linear Programming (MILP) model to minimize the total cost of the wood recycling process collected from CRD sites. Important uncertain factors are considered, such as the locations of the supply sources, the available amount of recycled wood at collection sites, and the different grades of collected wood quality.

Scenario-based analysis shows that adjusting the reverse logistics network leads to reduced wood recycling costs due to improved efficiency of sorting facilities and achieved economies of scale under new policy. This research could benefit local authorities by offering valuable insights into the anticipated impact of environmental policies targeting recycled wood material from the CRD industry. This understanding could help prevent illegal dumping and cross-border landfilling under the new regulations. Furthermore, it is demonstrated that obtaining precise information about the supply source locations and the expected amount of wood recovered from sorting facilities is crucial to ensure a more efficient redesign of the reverse logistics network.

The study emphasizes the importance of considering uncertainty in the locations of collection sites, the amount of recycled material, and the quality of recycled wood in the reverse logistics network design. In addition, it highlights the need to strategically adjust sorting facilities and treatment capacity to minimize transportation distances and make the option of dumping construction materials less attractive. The results show that relocating or expanding some sorting facilities near supply sources can reduce the total costs of the reverse logistics network and improve the efficiency of construction material recycling.

3.5. Article 5: Ahmed, R. R., & Zhang, X. (2021). Multi-stage network-based two-type cost minimization for the reverse logistics management of inert construction waste. Waste Management, 120, 805-819.

In this study, a cost minimization model for managing inert construction waste, which includes debris, rubble, earth, and concrete, throughout its lifecycle is presented, using a multi-level network approach. The model employs a dual-cost type approach, dividing the total cost into Facility-Based Costs (FBC) and Non-Facility-Based Costs (NFBC), being type I and II respectively.

Type-I cost, or facility-based costing, encompasses costs incurred at waste generation points like construction sites, public fill facilities, recycling facilities, and landfills. It includes six components: fixed cost for opening a facility, operation cost for processing waste, handling charge for loading and unloading within the facility, green tax associated with landfill disposal, storage cost for holding waste at public fill and recycling facilities, and subsidies from the government to promote green practices.

Type-II cost, or non-facility-based costing, includes four components within a reverse logistics value chain: transportation cost for moving waste between facilities, logistic operator cost related to worker wages, environmental cost for carbon emissions from shipping waste, and collection cost tied to vehicular movement for collecting waste.

Mixed Integer Linear Programming (MILP) was applied to formulate the problem using LINGO software. A case study in Hong Kong was conducted to validate the model, resulting in a 24% reduction in total cost compared to the base case. In addition, a scenario-based sensitivity analysis was performed to assess the impact of uncertainties in cost parameters. The study revealed that the majority of the total cost stems from the NFBC component, indicating its significance in defining the reverse logistics network.

3.6. Article 6: Sobotka, A., & Sagan, I. (2021). Decision support system for managing concrete demolition waste. Resources, Conservation and Recycling, 169, 105570.

The paper proposes a decision support system (DSS) for managing concrete demolition waste, focusing on various technological and organizational solutions. The DSS evaluates different strategies based on economic, environmental, and social criteria and provides a ranked list of solutions to help stakeholders choose the most advantageous option. The system considers various factors such as technology costs, recycling efficiency, and environmental impacts, aiming to optimize the management of concrete demolition waste. The DSS facilitates decision-making by providing a structured approach to evaluating different waste management alternatives and their associated benefits and drawbacks.

The study highlights the importance of integrating economic, environmental, and social considerations into waste management decision-making. The DSS approach allows for a comprehensive assessment of various waste management strategies, considering the complex interplay of different factors. The results show that the DSS can effectively guide stakeholders in selecting the most suitable waste management solutions, improving the overall efficiency and sustainability of concrete demolition waste management.

In summary, the proposed DSS provides a valuable tool for managing concrete demolition waste by evaluating and ranking different strategies based on multiple criteria. The study underscores the need for decision support tools in waste management and emphasizes the role of comprehensive assessment in achieving sustainable and effective waste management practices.

3.7. Article 7: Ghosh, S., Bhattacharyya, R., & Mukherjee, A. (2016). Optimization model for maximizing revenue from construction and demolition waste recycling: A case study from India. Resources, Conservation and Recycling, 113, 41-50.

The article presents an optimization model to maximize revenue from construction and demolition (C&D) waste recycling in India. The model, based on real data from demolition sites, focuses on quantifying and maximizing revenue while addressing environmental concerns. The study highlights the importance of recycling C&D waste to achieve economic gains and environmental protection. The model provides an intuitive and simple approach to optimizing C&D waste recycling, aiming to improve the overall efficiency and profitability of the recycling process.

A case study in India demonstrated the practical application of the model, showing significant potential for revenue generation from C&D waste recycling. The model's simplicity and effectiveness make it a valuable tool for stakeholders in the construction and demolition industry. The study emphasizes the need for data-driven models to optimize waste management practices and enhance sustainability.

3.8. Article 8: Tsydenova, O., & Bengtsson, M. (2021). Economic analysis of concrete recycling networks: A case study of the Swedish concrete recycling industry. Resources, Conservation and Recycling, 167, 105306.

The article explores the economic aspects of concrete recycling networks, focusing on the Swedish concrete recycling industry. The study examines the economic viability of recycling concrete using various policy measures and network configurations. The results indicate that manufacturing concrete with recycled aggregates can be economically viable, particularly in regions without local supplies of primary natural aggregates. The study underscores the role of policy and economic analysis in enhancing recycling efficiency and promoting sustainable practices in the concrete industry.

The analysis highlights the importance of considering economic factors in the design and operation of concrete recycling networks. Policy measures and economic incentives can significantly impact the effectiveness of recycling efforts and the overall sustainability of the concrete industry. The findings provide valuable insights for policymakers and industry stakeholders seeking to improve recycling practices and reduce environmental impacts.

4. Literature review analysis

Quéheille et al. (2020) [5] developed a multi-objective optimization model for managing waste in building deconstruction, emphasizing the benefits of deconstruction over traditional demolition. This model integrates a genetic algorithm to balance four key objectives: costs, deadlines, recovery rates, and greenhouse gas emissions. The algorithm's efficiency was demonstrated in a real case study, showcasing its ability to find optimal trade-offs between economic performance, deadlines, and environmental impact. This aligns with Ma et al. (2022) [6], who introduced a combined System Dynamics (SD) and Life Cycle Assessment (LCA) model to evaluate carbon emissions from C&D waste during building refurbishment. Both studies highlight the need for comprehensive models that integrate various objectives and impacts to optimize waste management processes. Also, Quéheille et al.'s [5] model demonstrated the efficiency of finding cost-effective and environmentally friendly solutions in less than 3 minutes during a case study.

Trochu et al. (2020, 2018) [7][8] extended this approach by focusing on the design and optimization of reverse logistics networks for wood waste recycling from the CRD industry. Their models addressed uncertainties in the quantity and quality of collected materials, using methods like sampling average approximation and the ε-constraint method to solve optimization problems. Similarly, Ahmed and Zhang (2021) [9] developed a multi-stage network-based model for managing inert construction waste, such as debris, rubble, earth, and concrete. Their model employed a dual-cost type approach, dividing the total cost into Facility-Based Costs (FBC) and Non-Facility-Based Costs (NFBC). Type-I cost, or facility-based costing, includes expenses at waste generation points like construction sites, public fill facilities, recycling facilities, and landfills. It encompasses six components: the fixed cost for opening a facility, operation cost for processing waste, handling charge for loading and unloading within the facility, green tax for landfill disposal, storage cost at public fill and recycling facilities, and government subsidies to promote green practices. Type-II cost, or non-facility-based costing, involves four components within a reverse logistics value chain: transportation cost for moving waste between facilities, logistic operator cost related to worker wages, environmental cost for carbon emissions from shipping waste, and collection cost tied to vehicular movement for collecting waste. All three studies emphasize the complexity of reverse logistics network design and the need to balance economic and environmental considerations, addressing uncertainties to achieve optimal solutions.

The importance of lifecycle perspective is evident in Ma et al. (2022) [6] and Yuan et al. (2011) [11], who utilized system dynamics models to perform cost-benefit analyses of C&D waste management. These studies consider the dynamic nature of waste management, simulating interactions over time to understand long-term impacts. Yuan et al. (2011) [11] specifically used a system dynamics approach to evaluate different regulatory scenarios, showing how higher landfill fees could incentivize better waste management practices. This focus on lifecycle and dynamic modelling is crucial for developing effective strategies that minimize environmental impacts while maximizing economic benefits.

Economic and environmental benefits of optimized waste management practices are further highlighted in Quéheille et al. (2020) [5] and Tsydenova et al. (2021) [12]. Tsydenova et al. [12] explored the economic viability of concrete recycling networks, proposing policy measures to enhance recycling efficiency. They found that manufacturing concrete with recycled aggregates is economically viable in areas without local supplies of primary natural aggregates, emphasizing the role of policy and economic analysis in waste management strategies.

Ghosh et al. (2016) [10] developed an optimization model to quantify and maximize revenue from C&D waste recycling in India, addressing both economic gains and environmental protection. The model, based on practical data from demolition sites, aimed to provide an intuitive and simple way to optimize C&D waste recycling. This practical approach is mirrored in Ahmed and Zhang (2021) [9], who validated their model through a case study in Hong Kong, achieving a significant reduction in total costs. Both studies underscore the importance of data-driven models in optimizing waste management practices and enhancing sustainability.

Sobotka and Sagan (2021) [13] developed a decision support system (DSS) for managing concrete demolition waste, evaluating various technological and organizational solutions based on economic, environmental, and social criteria. Their DSS provides a ranked list of variants, helping stakeholders select the most advantageous waste management strategy. This decision-making support is like the practical applications demonstrated in Ahmed and Zhang (2021) [9], where a scenario-based sensitivity analysis was performed to assess the impact of uncertainties in cost parameters. Both studies emphasize the role of decision support tools in optimizing waste management practices and improving sustainability in the construction industry.

5. Discussion and conclusion

Construction and demolition (C&D) waste management is a multifaceted challenge that requires integrated approaches. Across the articles analyzed, optimization models emerge as essential tools for tackling this complexity. These models, often incorporating metaheuristic search algorithms or mixed-integer linear programming, enable decision-makers to balance various objectives such as cost reduction, meeting deadlines, maximizing recycling rates, and minimizing environmental impacts. They offer a systematic way to navigate the trade-offs inherent in waste management decisions.

Environmental considerations play a prominent role in these optimization efforts. Models integrating System Dynamics and Life Cycle Assessment shed light on the carbon emissions associated with construction and demolition activities. By evaluating the environmental consequences of different waste management strategies, these models provide valuable insights for policymakers and industry stakeholders seeking to mitigate the environmental footprint of construction-related activities.

A recurring theme in the articles is the importance of different kinds of waste separation in the whole process' management efficiency. Effective separation of waste materials on site facilitates recycling and minimizes the volume of waste destined for landfills. This emphasis underscores the significance of on-site practices in shaping the overall effectiveness of waste management strategies. Moreover, it is mentioned the importance of uncertainty in the whole process. One solution for this problem would be the mentioned before, be as precise as possible when separating in every state.

Furthermore, waste management policies, such as landfill fees and regulatory frameworks, emerge as critical drivers influencing waste management practices and economic viability. Optimization models and decision support systems (DSSs) prove instrumental in evaluating the implications of different policy scenarios, providing valuable guidance for policymakers and industry practitioners navigating regulatory landscapes.

DSSs are highlighted as powerful tools for aiding stakeholders in waste management decision-making processes. By synthesizing diverse criteria and generating ranked lists of optimal solutions, a DSS can enable decision-makers to navigate the complexity of waste management challenges and select strategies aligned with their objectives and constraints.

However, through this literature review we realized that most of the articles just focus on economic and environmental aspects, but none of them show importance to the human aspect. Managing the employees in the right way in deconstruction projects is also needed to benefit the total sustainable approach, also it could help the companies working in the field be able to organize better their working power.

Overall, the articles underscore the importance of adopting integrated, data-driven approaches to optimize construction and demolition waste management. By considering economic, environmental, and social objectives simultaneously, these approaches contribute to sustainable development efforts by minimizing waste generation, promoting recycling, and reducing environmental impact.

6. Personal contribution

Embarking on the literature review project has been a transformative experience that has significantly broadened my horizons and introduced me to the intricate and fascinating world of research. Prior to this project, my understanding of academic research was rudimentary at best. However, through the course of this undertaking, I have acquired a profound appreciation for the meticulous and systematic processes that underpin scholarly inquiry.

One of the most eye-opening aspects of this project was delving into the topic of waste generation during building demolitions and the subsequent waste management practices. Before this, I had little awareness of the complexities and the profound environmental impact associated with construction and demolition waste (CDW). Through extensive reading and analysis, I have come to understand the significant challenges that arise from the generation of these residues. The environmental repercussions are vast, encompassing issues such as resource depletion, landfill overflow, and the release of harmful substances into the ecosystem. This newfound knowledge has underscored the urgency and importance of developing more sustainable waste management practices and has sparked a personal interest in environmental preservation and sustainability.

Moreover, this project has significantly honed my research skills. I have learned how to efficiently search for articles and bibliography, utilizing various databases and academic resources. This process has taught me how to discern credible sources from less reliable ones and to approach each piece of literature with a critical eye. Analyzing and synthesizing information from multiple sources has improved my ability to construct well-founded arguments and to present information in a coherent and persuasive manner. This critical analysis skill is invaluable and will undoubtedly serve me well in future academic and professional endeavors.

A particularly enriching part of this experience was gaining an understanding of optimization methods. Before embarking on this project, optimization techniques were an area I was entirely unfamiliar with. However, as I delved deeper into the literature, I began to appreciate the critical role that optimization plays in developing efficient and effective waste management strategies. Learning about various optimization models and their applications has been intellectually stimulating and has broadened my technical skill set, allowing me to contribute more meaningfully to discussions on improving CDW management.

The collaborative aspect of the project, involving professors and students from France and Canada, added a unique and invaluable dimension to my learning experience. Working in a multicultural team has not only enhanced my understanding of the global nature of the waste management problem but also taught me the importance of diverse perspectives in tackling complex issues. Collaborating with individuals from different cultural and academic backgrounds has improved my communication skills and highlighted the value of teamwork and international cooperation in research.

In conclusion, this literature review project has been challenging yet immensely rewarding. It has provided me with a comprehensive understanding of the environmental impact of demolition waste and the critical need for effective waste management strategies. I have gained significant research skills, including literature search, critical analysis, and the application of optimization methods. The experience has also enriched my ability to work collaboratively in a multicultural setting, preparing me for future academic and professional challenges. This project has not only expanded my knowledge but also ignited a passion for research and environmental sustainability that I am eager to pursue further.

7. References

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