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Review

Examining the Drivers to Support Improved Construction and Demolition Waste Management for a Circular Economy: A Comprehensive Review Using a Systematic Approach

Mahmoud Alhawamdeh [1,2,*], Juan A. Ferriz-Papi [2] and Angela Lee [3]

1 Department of Business and Management, Bath Business School, Bath Spa University, Newton St Loe, Bath BA2 9BN, UK
2 Department of Sustainable Built and Natural Environments, School of Science, Engineering and Environment, University of Salford, 43 Crescent, Manchester M5 4WT, UK
3 School of the Built Environment, University College of Estate Management (UK) Horizons, 60 Queens Rd, Reading RG1 4BS, UK
* Correspondence: m.alhawamdeh@bathspa.ac.uk

Abstract: With the rapid pace of global urbanisation, construction demolition waste (CDW) constitutes roughly 36% of the total solid waste deposited in landfill sites worldwide, thereby posing a significant challenge to the sustainability of the construction industry. To address this issue, circular economy strategies are proposed as a solution. This paper systematically analyses 55 research articles published in leading peer-reviewed English-language scholarly journals over the past decade. It aims to identify and categorise drivers for enhanced CDW management by synthesising findings from previous research to support the principles of a circular economy. Utilising a PESTLE model for classification and analysis provides valuable insights into disparities and distinctions among categories, regions, and countries. The resulting analysis yields valuable insights into enablers and trends, with the aim of making a substantial contribution to mitigating the impact of construction activities and thus fostering the establishment of an efficient circular economy within the sector.

Keywords: construction waste; construction and demolition waste; waste management; driver; circular economy; sustainability

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1. Introduction

The problem of waste is significantly concerning for the construction industry. Construction and demolition waste (CDW) originates from various building and infrastructure activities, including new construction, renovation, demolition, and land clearance. A total of 36% of the overall waste produced is attributed to the sector, which equates to between 2.5 and 3.5 billion tonnes on an annual basis [1].

The existing literature highlights several social, economic, and environmental challenges stemming from CDW. Firstly, there is landfill space depletion. The need for landfill space is rapidly increasing in numerous countries, especially in developing nations. For instance, the UK generates about 138 million tonnes of CDW annually, constituting two-thirds of total landfill waste [2]. EU countries produce over 800 million tonnes yearly, comprising 25–30% of total waste [3], while China exceeds 1.5 billion tonnes [4], and the USA reached 569 million tonnes in 2017 [5]. Gulf Cooperation Council countries generate 66 million tonnes annually, accounting for 55% of the total waste [6]. This growing waste generation occupies bigger spaces to be disposed of. Secondly, there is resource depletion. CDW plays a significant role in depleting global natural resources, including non-renewable energy sources and critical materials such as crushed stone, timber, and metal [7]. Construction operations alone consume approximately 35% of global resources, comprising 12% of water, 25% of steel, and exceeding 50% of sand, crushed rock, and gravel [8–10]. Additionally, the construction industry accounts for approximately 36% of global final energy usage, encompassing embodied energy [8].

Thirdly, there is contamination and pollution. Increasing CDW volumes pose significant environmental challenges, with construction activities significantly polluting soil, water, and air. Globally, approximately 33% of CDW is disposed of without restrictions, rising to 93% in developing nations where open dumping prevails [11,12]. Moreover, the construction industry's energy consumption accounts for 11% of global carbon dioxide emissions [8]. Lastly, financial losses occur due to waste generation in construction projects, leading to increased expenses, with approximately 15% of materials (by value) resulting in waste [13–15]. Estimates suggest that the actual cost of waste in construction activities is about 20 times the cost of disposal [16]. Nationally, CDW poses significant economic challenges, with over 20% of municipal budgets and 50% of local government investments allocated to solid waste management in low- and middle-income nations [12].

As an economic paradigm and approach for resource and waste management, a circular economy is designed to reduce waste, foster sustainability, and optimise the use of resources. In a circular economy, to prolong the lifespan of materials and products, they are reused, refurbished, remanufactured, and recycled [17]. The shift towards a circular economy aims to establish a more regenerative and sustainable economic framework, advantageous for both the economy and the environment. A primary challenge is the significant generation of CDW and the considerable consumption of resources, which presents a major obstacle to the sustainability of the construction sector, the country's economy at large, and the global environment [1]. To tackle this issue and align with circular economy principles, various waste management strategies have been devised to reduce waste throughout the lifecycle of construction projects. These strategies include waste collection, reduction, reuse, recycling (3Rs), low-waste technologies (LWTs), and landfill disposal charges [18–20]. However, despite these efforts, statistics on CDW disposal indicate that the industry has yet to achieve a closed-loop circular economy. Key barriers preventing effective CDW management have been identified by a study conducted by Ferriz-Papi JA et al. [21]. Their paper systematically analysed 54 articles published over the past decade, identifying and classifying a total of 59 challenges for successfully attaining circular economy transition in the construction sector. Understanding the drivers of CDW management is also essential. Comparing both barriers and drivers leads to a more comprehensive understanding of the factors at play, supports the development of balanced and effective strategies, fosters continuous improvement, engages stakeholders and decision-makers, and enhances academic research. Analysing existing drivers is therefore crucial to improving CDW management and achieving zero-waste targets.

Many global publications have attempted to identify key effective CDW management enablers for a closed-loop circular economy. The construction industry must engage with a whole variety of stakeholders including regulators responsible for technical standards, investors, the suppliers of materials and products, and the whole industry at large who are often sceptic about the quality of recycled products. Thus, this review paper aims to facilitate the development of appropriate solutions tailored to regional or national levels for implementing circular economy practices in the construction industry. It categorises these drivers using the PESTLE model (political, economic, social, technological, legal, and environmental), exploring their current trends and impacts on aspects like construction methods, technology access, culture, and country development as a means of identifying research trends and gaps for future development.

2. Materials and Methods

A systematic literature review is a robust, objective, and replicable method used to analyse existing research on a specific topic [22]. It serves as a valuable tool aimed at summarising the extant literature to establish the knowledge boundaries of a given subject and identify areas requiring further research. Given the specific context of CDW management, the PRISMA statement is a practical approach particularly useful for systematically reviewing the literature in social sciences studies and for conducting comprehensive reviews in this field [23]. It provides a comprehensive methodological framework and specific guidance on statistical techniques for meta-analysis and approaches for qualitative synthesis. This entails employing systematic literature searches for peer-reviewed material, screening, critical appraisal, metadata extraction, and content analysis. Figure 1 illustrates a simplified diagram outlining the methodological steps, following the PRISMA checklist.

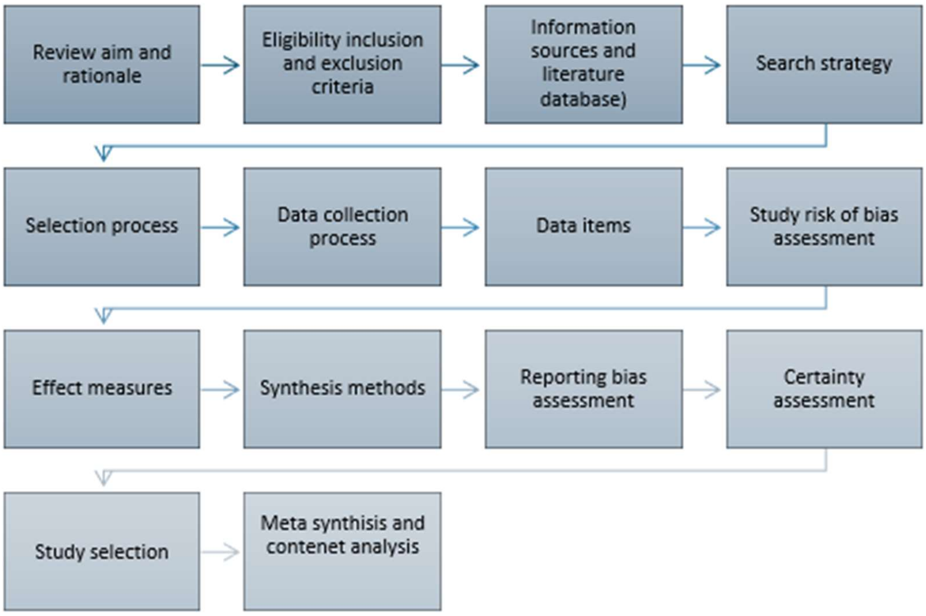

Figure 1. Methodological steps following the PRISMA guidelines for systematic reviews.

As the aim of this paper is to identify drivers for improved CDW management, the selection criteria used was primarily based on the direct relevance to the subject, while also considering studies related to the subject due to their substantial importance. To reduce bias in this process, an objective and transparent approach for research synthesis was adopted, comprising both quantitative and qualitative research papers including journal articles and peer-reviewed conference papers ensuring the quality and reliability of the research. ScienceDirect and Scopus databases, two of the leading citation index organisations, were used for this study. Approximately 99.11% of the journals indexed in Web of Science are also indexed in Scopus, indicating the extensive coverage of Scopus [24]. Consequently, the authors deemed Scopus sufficient for their research due to its significant coverage and its widespread use in previous studies, particularly in systematic reviews across various fields, including construction waste management. The terms 'construction waste management' (CW) and 'construction demolition waste management' (CDW) were used, combined with the terms 'drivers', 'enablers', 'opportunities', and 'practices' to select any papers where they were found in the title, abstract and/or keywords. There was no limit on the country of studies, but only studies written in English were included. This generated 564 papers (as of January 2023).

Thus, in order to limit this wide scope and to focus closely on the drivers of CDW, the search was amended to include those with explicit development on drivers and enablers within the time period of 2013 to 2022. Thus, 196 papers were identified; these were narrowed down following a rapid screening of the titles and abstracts and excluding any review papers as a means to ensure relevance to the timeframe and geographic relevance for the analysis of the metadata. Finally, the full texts of the remaining studies were evaluated based on the inclusion criteria, and any discrepancies were discussed between the authors until a consensus was reached. Notably, some papers could not be accessed, despite the efforts through institutional subscriptions and other available resources, due to restrictions such as a lack of institutional access or unavailability in public repositories.

As a result, 55 papers were identified as suitable for inclusion in this systematic review. A flow diagram illustrating the study selection process is presented in Figure 2.

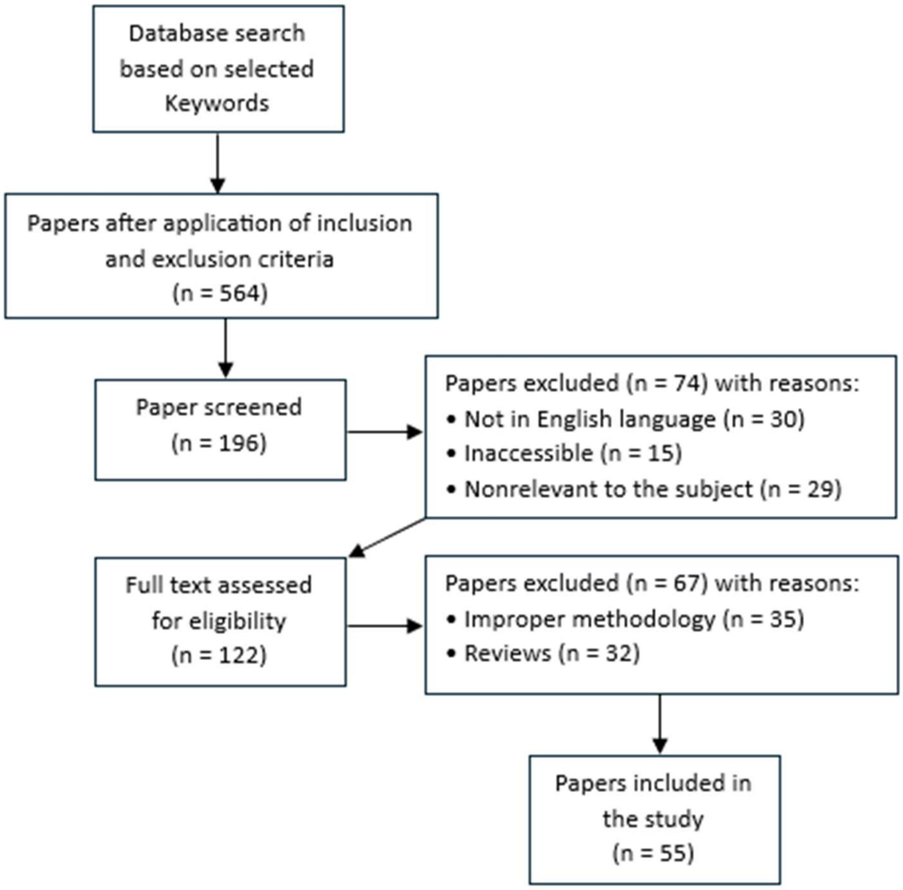

Figure 2. Reporting items diagram for study review process.

3. Results and Discussion

The regression analysis depicted in Figure 3 indicates a low to moderate positive correlation, suggesting an increasing trend in the number of publications related to this topic throughout the review period from 2013 to 2022. Although the significance of this correlation is relatively low, it highlights a growing research interest in this area over time. Notably, the years 2021 and 2022 exhibit the highest number of published papers. A substantial surge is observed in 2021, with a notable increase; 27.3% of the 55 articles reviewed were published in that year alone. In 2020, the European Commission introduced the Construction 2020 strategy and the New Circular Economy Action Plan aimed at stimulating Europe's transition towards a circular economy [25]. Additionally, the second edition of the Global Waste Management Outlook, published by UNEP and the International Solid Waste Association, assesses global waste management trends and strategies for 2020–2024. It has shaped global policies, emphasising the transition to a circular economy and zero-waste strategies [26]. These initiatives collectively created a conducive environment for research and policy development, leading to a marked increase in publications on CDW management by 2021. Another peak is also evident in 2016 and 2017. This surge may be attributed to new waste reduction targets established in the preceding years, such as those set forth in the Paris Agreement of 2015 [27] and the European Waste Framework Directive targets for CDW in 2020, as well as the framework amendment in 2018 [28]. Despite potential disruptions caused by the global COVID-19 pandemic on research output, the overall growth in publications persists.

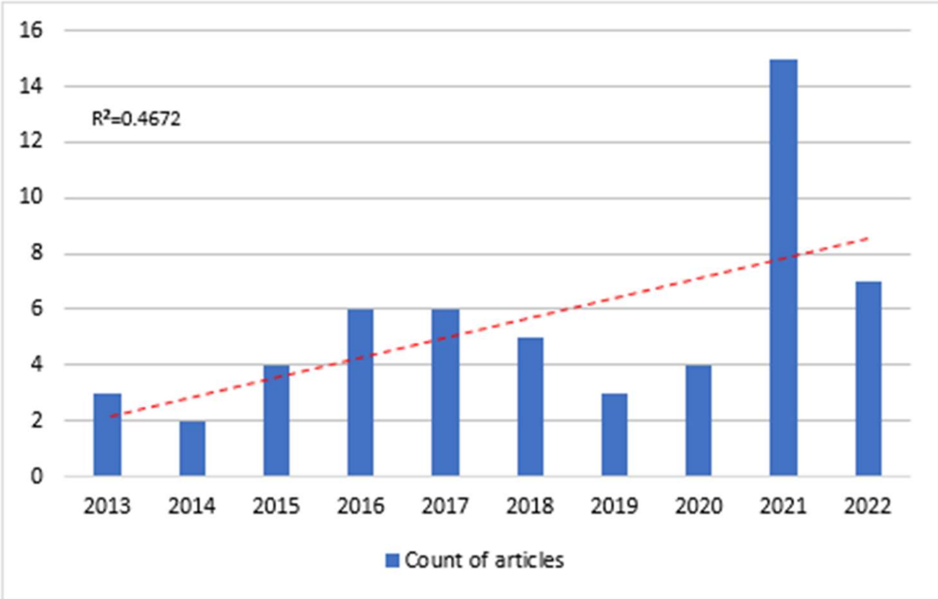

Figure 3. Annual publications trend on CDW from 2013 to 2022.

However, this does not necessarily indicate a universal increase in concern and implementation of improved CDW management practices across the global construction industry. Figure 4 illustrates the distribution of reviewed articles by continent. The geographical location of the papers reviewed in this study is determined by the focus of each paper, specifically the case study or the location where the data were collected. The results revealed that Asia (41%) is the primary source of the reviewed publications. China's contribution to Asian research is remarkable, accounting for 48% of the total articles reviewed. In contrast, no articles were contributed by countries such as India, Indonesia, and Japan despite their robust economies and substantial impact on the Asian economy, especially Japan's highly efficient and innovative construction sector. Consequently, future related research should consider such countries.

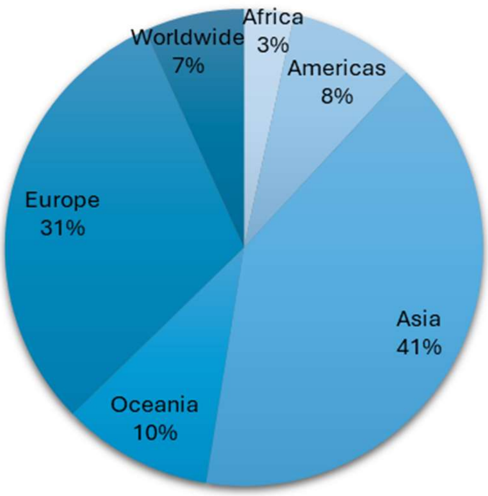

Figure 4. The geographical distribution of the reviewed CDW articles.

Europe is the second primary source of the reviewed publications (31%), with the UK leading with the highest number of reviewed articles, accounting for 35% of European research output in this field. The European Union is recognised for establishing the Waste Framework Directive, which sets the basic concepts and definitions related to waste management, such as recovery and recycling [28]. Meanwhile, Oceania and the Americas show relatively modest research contributions, representing only 10% and 8% of the total, respectively. Four articles were identified from the USA (i.e., [29–32]), despite the enormous CDW volumes generated by the country, which reached 569 million tonnes in 2017 [5], highlighting an urgent need for CDW management. This is in addition to the United States Environmental Protection Agency's initiatives towards CDW management [33]. Finally, Africa has the least reviewed articles, with 3%. This calls for increased research efforts in these underrepresented countries and continents.

3.1. PESTLE Drivers Classification

A frequency count was conducted for each driver, during the review process, and referenced to the source article. In total, 200 references to drivers were identified across the 55 reviewed papers. These references were categorised into 29 drivers, summarised in Table 1. The drivers were then ranked in ascending order of frequency and categorised using the PESTLE analysis approach (political, economic, social, technological, legal, and environmental). Professor Francis Aguilar is credited with creating the ETPS analysis in 1967 [34]. This strategic tool helps identify the key external factors influencing an organisation and can be applied across various scenarios to assist professionals and senior managers in making strategic decisions. In this study, political and legal drivers were grouped together to streamline the discussion.

Table 1. Classification of drivers based on PESTLE analysis.

Code	Drivers	Article ID	PESTLE Category	Frequency	Rank
D1	Adequate formulation and application of governmental CDW regulations and policies	[32,35–51]	Political/legal	18	1
D2	Training and education about CDW management aspects (causes, types, LWTs, cost savings, environmental impact)	[19,30–32,36,39,40,42,46,49,52–56]	Social	15	2
D3	Provision of innovative low-waste technologies (LWTs)	[29,36,39,42,51,52,54,57–60]	Technological	11	3
D4	Adequate formulation and application of CDW protocols, programmes, and strategies	[32,39,48,53,59–64]	Political/legal	10	4
D5	Commitment of client and contractor by allocating time and money for CDW management	[36,37,39,40,42,43,51,54,65,66]	Economic	10	4
D6	Attitude and behaviour towards CDW management	[35,36,41,42,49,63,65,67,68]	Social	9	6
D7	Data availability about CDW management	[32,37,57,60,62,65,69–71]	Technological	9	6
D8	Adequate and efficient CDW recycling infrastructure	[19,37,42,53,63,65,72,73]	Technological	8	8
D9	CDW landfilling volume restrictions and increased fees	[19,36,44,50,53,68,74]	Political/legal Economic	7	9
D10	Mature market for reused and recycled CDW	[19,30–32,42,52]	Social Economic	6	10
D11	Mandatory requirement for site waste management plans (SWMPs)	[45,66,70,75–77]	Political/legal	6	10
D12	Cooperation and integration between stakeholders in value chain	[31,56,68,77,78]	Social	5	12
D13	Governmental funding and financial support	[35,38,42,50,56]	Economic Political/legal	5	12
D14	Use of waste prediction tools	[66,71,79–81]	Technological	5	12
D15	Adoption of offsite construction	[43,45,53,76]	Technological	4	15
D16	Adoption of waste traceability system	[29,47,55,60]	Technological	4	15
D17	Standardisation of design	[19,59,66,77]	Technological	4	15
D18	Development of environmental standards for design, construction, and demolition activities	[35,50,59,76]	Political/legal Environmental	4	15
D19	Municipality acting as facilitator	[38,42,50,56]	Political/legal	4	15
D20	Establishing business module for CWM practices	[29,52,53,82]	Economic Technological	4	15

Table 1. *Cont.*

Code	Drivers	Article ID	PESTLE Category	Frequency	Rank
D21	Communication and collaboration platforms for development/implementation of circular economy value chains	[29,56,61]	Technological	3	21
D22	Incentivising project teams by offering benefits and awards	[39,54,66]	Economic	3	21
D23	Skills and experience in construction	[36,77,83]	Social	3	21
D24	R&D in circular economy	[39,41,53]	Technological	3	21
D25	Efficient procurement system	[66,74,77]	Economic Technological	3	21
D26	Pressure from environmental organisations/activists	[38,40]	Environmental	2	26
D27	Availability of waste-sharing platforms	[29,73]	Technological	2	26
D28	Mandatory requirement for selective demolition	[56,84]	Political/legal	2	26
D29	Development of integrated environmental and economic management model	[59]	Environmental Economic	1	29
TOTAL				200	

Based on the frequency of the drivers in each category, it is evident that technological drivers are the most cited, accounting for nearly one-third of all references (30.0%), while environmental drivers are represented by just 3.5%. This indicates a remarkable emphasis on technological factors with minimal attention to environmental factors, even though the primary aim of the circular economy is to reduce environmental impact. While all other driver categories share the common goal of improving the transition towards a circular economy, environmental aspects alone do not appear to be strong enough to incentivise the adoption of CDW management among stakeholders.

Notably, in the paper by Ferriz-Papi et al. [21], the environmental parameters included a limited number of barriers. This is expected and natural because the main purpose of the circular economy concept is to reduce the environmental impact of construction industry activities. Therefore, environmental factors are more likely to act as drivers to achieve these concepts rather than as barriers. Nonetheless, certain challenges, such as the risk of increasing the volume of hazardous waste through recycling and the energy consumption required for recycling treatments, can inhibit the willingness to adopt certain CDW management methods. Regarding the technological parameter, it was also identified as the primary category containing the highest number of barriers and was emphasised the most by the papers reviewed according to Ferriz-Papi et al. [21]. Although technological advancements can largely incentivise stakeholders to adopt CDW management methods, challenges such as the availability of technological infrastructure and the complexity or inadequacy of regulatory frameworks and standardised processes can undermine the value and potential of this category in CDW management. This is similar to other categories, including political, legal, economic, and social aspects. Therefore, it is vital that both barriers and drivers are considered when assessing the current uptake of CDW management in the circular economy in order to support the development of balanced and effective strategies and foster continuous improvement.

3.1.1. Political/Legal Drivers

Government regulations and policies, typically utilising a top-down strategy, are central to this category of drivers. Political decisions play a crucial role in creating frameworks for waste production and management by establishing and implementing targets and policies at a broader level. In this regard, the most significant driver (D1) featured in 18 articles [32,35–51] called for 'adequate' governmental CDW regulations and policies. This need was identified in articles whose research was based primarily in developed nations that have national CDW targets (mainly Italy, the UK, China, and Australia) that cited confusion between what is to be considered mandatory and what the guidelines are, particularly in regional and national contexts—and in countries where gaps in regulation need to be addressed such as Pakistan [43], Saudi Arabia [44], South Africa [36], and Vietnam [41].

The need for 'adequate' regulations and policies (D1) is perpetuated in D4, which heralded the need for 'adequate' CDW protocols, programmes, and strategies that could support organisations to conform to any regulatory requirements [32,39,48,53,59–64], as it was often left to individuals/organisations to develop their own implementation solutions. This was deemed a priority in the review papers covering China [(48,59,61,63)]. Notably, 'solutions' that were identified to be essential to support improved management of CDW included site waste management plans (SWMPs) (D11) [45,66,70,75–77] and establishing a business module for CWM practices (D20) [29,52,53,82]. Seven articles went further and stipulated the need for CDW landfilling volume restrictions and increased fees (D9), primarily in China and the UK where landfill space is at a premium [19,36,44,50,53,68,74]. Finally, regulations governing selective demolition (D28) were advocated to increase the lifespan of buildings whereby retrofit or building reuse is favoured over land tenure.

3.1.2. Economical Drivers

Economic drivers are linked to business profitability, highlighting the benefits of adopting CDW management over traditional construction practices and implementing more economical solutions. The most frequently mentioned driver in this category pertains to the commitment of clients and contractors to allocate time and resources for CDW management (D5). Decision-makers involved in construction projects need to ensure adequate provisions for waste management, including the allocation of sufficient time and resources. Specific operations necessary for waste management include supervision and monitoring [45], the segregation of waste [59,66], transportation [37,42], processing/treatment, and disposal [59,64,65]. Financial support was noted as a relevant driver, through national government (D13) and regional government/municipality schemes (D19). These drivers intensify efforts to reduce CDW costs [36,54] and improve recycling rates [71], thereby fostering greater confidence in recovery initiatives and positioning them at the core of numerous case studies [82]. For instance, Adams et al. [52] stress the importance of financial support for considering end-of-life aspects during the design phase, which would significantly contribute to enhanced reuse and recycling activities, especially given the high cost of landfilling in many countries. Indeed, incentivisation at the project level (D22) was deemed critical [39,54,66] as it was noted that the success of any CDW intervention was largely reliant on individual workers' perception of sustainability, particularly as CDW contributes to cost overruns in projects; the client and contractor were noted for the need to make firm resource commitment for CDW management (D5).

3.1.3. Social Drivers

Social drivers pertain to behavioural and cultural aspects, covering a range of human factors within the construction industry. These include training and education (D2) on the causes, types, technologies, and financial/environmental impacts of CDW, which are considered major drivers in the sector [19,30–32,36,39,40,42,46,49,52–56]. This is affirmed in D23, whereby skills and experience were also listed as pertinent to minimising waste from the design, construction, and demolition stages of a project [36,77,83]. Additionally, public awareness and attitudes play a significant role in shaping cultural perspectives towards waste, such as changing perceptions concerning the inevitability of waste generation and providing adequate education on waste recovery [35,36,51,52,68,85].

In social psychology research, it is suggested that an individual's reaction to related situations and objects is influenced by their attitude, which is a neutral and mental state of willingness organised through experience. This state exerts an influence on their behaviour, either directive or dynamic [86]. Of significance, the attitudes of construction stakeholders were identified as the sixth highest ranked driver (D6) and critical for any CDW management practice to be successfully implemented. The acceptance of secondary materials is influenced by the perceived quality, whether low or high, of recycled products [50,63,65], as well as the preference for virgin materials over recycled ones [41,42,59]. Oke et al. [36] emphasise the necessity for citizens' behaviours to change towards consumption patterns. Additionally, it is acknowledged that a willingness to change acts as a significant driver for the adoption of CDW management methods. According to Tirado et al. [55] and Galvez–Martos et al. [84], improvements in waste management in construction are highly achieved through the utilisation of existing technology, coupled with a commitment to waste reduction.

A marketplace for reused and recycled CDW is needed to mature (D10) as, unfortunately, the construction industry is lagging, and stigma still prevails in the use of recycled materials in buildings, largely due to health and safety, and the lack of reliability/predictability [and costs] involved. Finally, cooperation and integration among stakeholders (D12) are crucial, potentially facilitated by an efficient corporation among governmental bodies, policymakers, and enterprises [38,77,78], communication and collaboration platforms across the entire circular economy value chain (D21; [56]), or through a waste-sharing platform (D27; [29]).

3.1.4. Technological Drivers

Technological drivers relate to the accessibility of infrastructure, tools, and innovative processes for CDW management. A number of modern methods of construction (MMC) were identified as drivers in the review articles; MMC is a term used to describe innovative construction processes, techniques, and technologies that differ from traditional onsite construction methods, typically including offsite and/or digital solutions to design and construct buildings in a more efficient, sustainable, and cost-effective manner. Low-waste technologies (LWTs) were identified as the third highest-ranked factor (D3) with 11 articles [29,36,39,42,51,52,54,57–60]; LWTs are seen to optimise resource consumption to ensure waste minimisation [20]. However, authors are yet to agree if MMC is a component of LWTs or vice versa (see Table 2). A key MMC technology listed as a driver was offsite construction (D15; [43,45,53,76]), particularly in countries such as Ethiopia [76] and Pakistan [43] where uptake is limited.

Table 2. Types of LWTs.

Types of LWTs	References
Soft technologies (i.e., information and communication technologies)	[87–90]
Hard technologies (i.e., innovative construction tools and equipment)	[20,91,92]
Modern methods of construction (MMC, i.e., offsite construction, BIM, 3D printing)	[91,93,94]

A waste traceability system was also put forward (D16), and whilst clearly not a novel idea, there is an inherent need in the construction sector to ensure accountability and responsibility as well as data availability on CDW management (D7); a waste sharing platform (D27); and/or waste prediction tools (D14). These approaches could perhaps be encapsulated in the need for more R&D in the circular economy (D24), which was only featured in articles published from Australia, Spain, and Vietnam [39,41,53], a surprising fact given the global need for improved practice. Adequate and efficient CDW recycling infrastructure (D8), coupled with a marketplace for reused and recycled CDW materials (D10) were identified as other technological drivers (see also social factors). Improved access to waste treatment facilities equipped with modern innovative technologies, especially in remote areas, could significantly enhance waste recovery targets and divert CDW from landfills. Additionally, in situations where waste disposal as an end-of-pipe solution is the only available option, the presence of engineered landfill infrastructure allows for secure final waste disposal, thereby minimising environmental impacts [29,42,44,64].

3.1.5. Environmental Drivers

Whilst the authors have only categorised three primary environmental drivers in this review, D18, D26, and D29, it must be noted that the premises of all drivers stem from the need to address environmental sustainability. CDW generates several significant environmental issues, including reduced landfill capacity due to the growing volume of disposed waste, substantial consumption of resources, contamination and pollution leading to severe health problems, and an increased consumption of energy for the transportation of waste and the production of new materials to replace the discarded ones [11,95,96]. Consequently, the effective management of CDW is becoming increasingly crucial to safeguard the natural ecosystem and public health. Two articles noted the increasing pressure from environmental organisations/activists (D26) as a strong driver [38,40], particularly from a diminishing landfill space, the overmining of raw materials, and general pollution and contamination perspectives. Many construction stakeholders do not prioritise environmental issues in the management of CDW. According to Serpell et al. [85], small- and medium-sized enterprises focus solely on cost considerations, neglecting the social and environmental pillars of sustainability in waste reduction. In contrast, large organisations address all three pillars of sustainability due to the requirement for sustainable projects by clients and the necessity of accountability reporting.

Notably, it was suggested by article [59] that an integrated environmental and economic management model was needed to address CDW globally so as to make any inroads on the circular economy challenge (D29). Whilst this was only cited by one review article [59], it is reasonable to suggest a clear link between this driver and D18 and D17 which call for design environmental standards.

3.2. Drivers Analysis by Geographic Region

It can be observed that some of the identified drivers (Table 1) appear more frequently in articles published in particular continents and countries than in others (Figure 5). Drivers focusing on the improvement of waste management regulations, policies, and environmental performance are pressuring issues in Europe (D1, D9, D11, D13, D19, D26, D28). This can be attributed to the fact that the foundation and basic fundamentals of managing CDW are well developed in most European countries; therefore, the focus would be stronger to ensure an adequate and efficient application of these fundamentals to achieve better performance in CDW management. This is in addition to seeking further advancement in the application of offsite construction (D15) and selective demolition techniques (D28).

On the other hand, personal factors including construction skills, experience, and behaviour towards CDW management are more dominant in Asia (D5, D6, D23), with China alone covering around 20% of the total number of selected articles for this review. Enhancing the construction practices of the supply chain (D17, D25), the development of efficient recycling infrastructures (D8), and improvements in CDW management practices from basic waste classification, sorting, and quantification [37] to further developments of waste data management (D7) are also identified as a major concern in Asia.

Low representativity in the articles reviewed was noticeable from the Americas, for which reason they are analysed together. The most relevant drivers for this continent are D2, D10, D16, D26, and D27. The only published papers found are from the USA, Columbia, and Costa Rica. The need for training and education on CDW (D2) aspects is evident in all previous countries [30–32,40]. However, the papers published in the USA also reflect on other drivers such as establishing business models and sharing platforms for CWM practices (D21, D27). These drivers are considered significant to countries that are advanced in solid waste management like the USA [29].

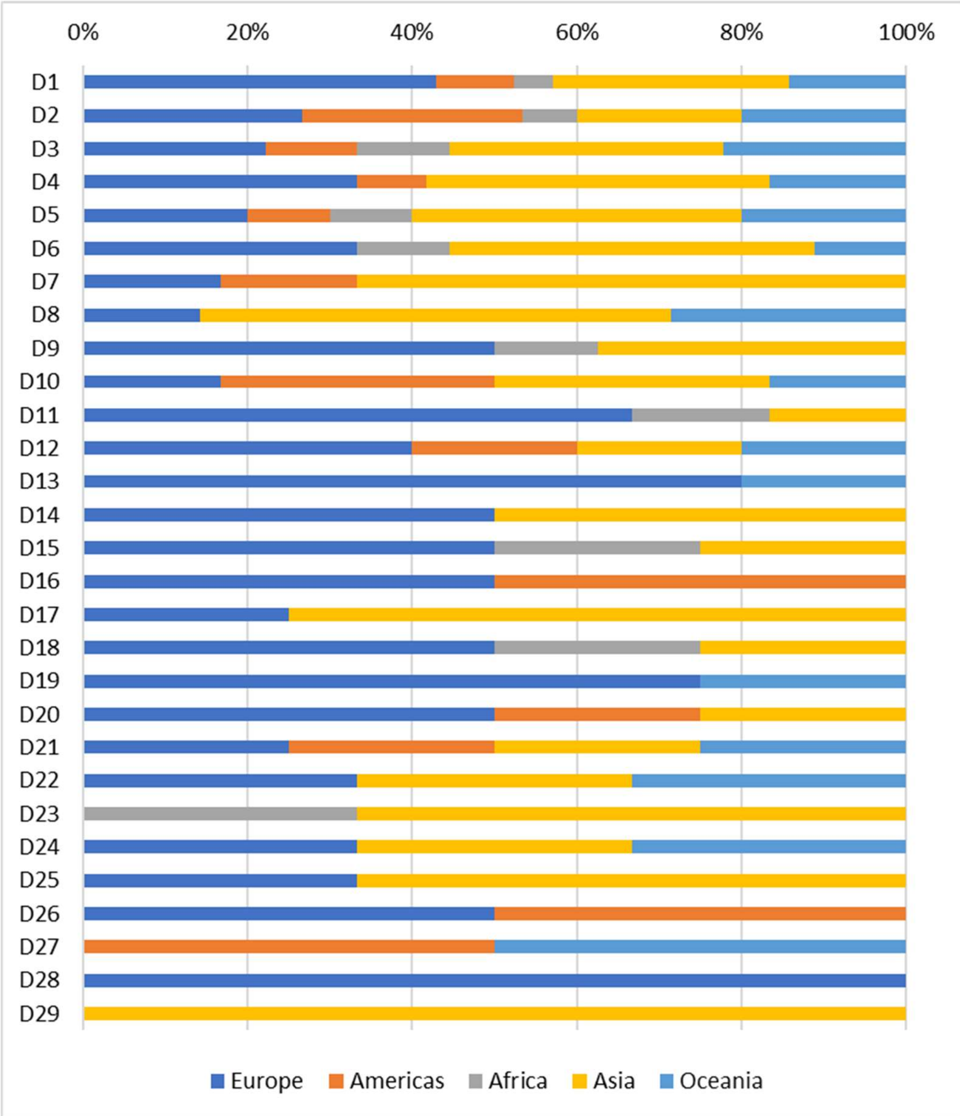

Figure 5. Distribution of drivers per continent.

Regarding Oceania, and considering their small continent size, their representativity in this analysis is substantial. The most relevant drivers that can be identified for this continent are D1–D5, and D8, although other drivers are present as well but with less frequency of occurrence. Making a comparison between Europe and Oceania, it can be observed that they largely follow a similar pattern, with many repeated drivers identified. The notable exception is the need to establish adequate recycling infrastructure (D8) which has a higher relevance than in Oceania; other drivers involving LWTs, stakeholders' commitment in CDW, collaboration platforms, benefits and incentives, and R&D in CDW management (D3, D5, D21, D22, D24) are at the same level of urgency in both continents. Finally, Africa has the shortest representation in this analysis, with only 5%. This continent is present in D1, D2, D3, D5, D6, D9, D11, D15, D18 and D23. The drivers identified are about adequate policies and regulation, innovation, training, stakeholders' commitment, and skills and behaviours.

3.3. Drivers Analysis by Timeframe

Figure 6 demonstrates the nature of the identified drivers in this systematic review during the past decade, from 2013 to 2022. This figure enables the ease of comparison between the article survey years for each of the drivers: the warmer colours (i.e., red, orange, and yellow) represent articles published from 2013, and the colder colours (i.e., green, blue, and black) highlight publications that were published more recently. Thus, it can be observed that in the last 5 years of this analysis timeframe, an increased focus has been placed on the majority of drivers, with a larger prevalence in 2021 and 2022 publications. This matches the growing concern with regard to the need for a circular economy in the construction industry and improved CDW management and recovery during the past few years.

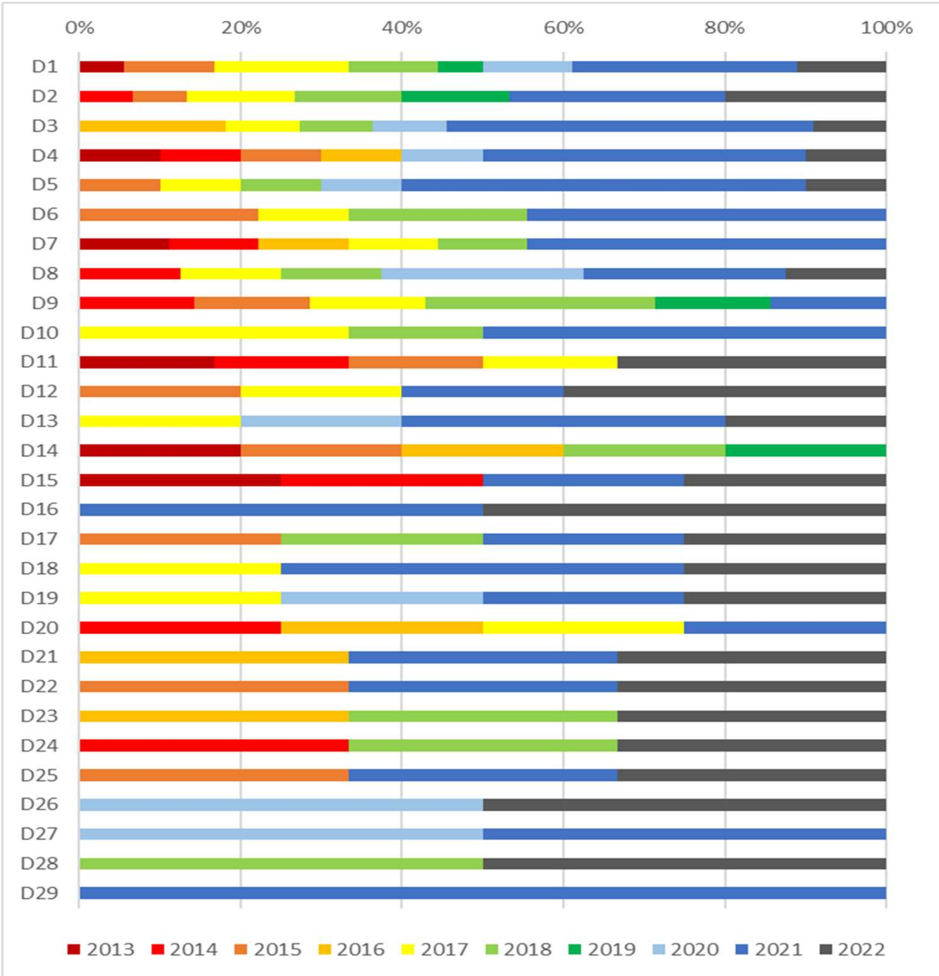

Figure 6. Distribution of drivers per year of publication.

Arguably, there have been different published regulations and policies that have influenced the implementation of a circular economy worldwide in the last decade. This includes, but is not limited to, the Paris Agreement in 2015 [27]; the amendment of the European Waste Framework Directive in 2019 [28]; the new European Circular Economy Action Plan in 2020 [25]; and the zero-waste targets and strategies arising in different countries. These events have largely contributed to the increased attention to a circular economy in the construction sector as in other sectors, by bringing new climate change agreements and goals to the regional and international plane.

Notably, following these policy milestones, three main period intervals can be identified according to the data in Figure 6. The first interval (2013–2015) involved drivers focusing on the establishment of strategies, plans, and protocols as a baseline for attaining a circular economy in construction (D4, D11, D14, D15). The second interval (2016–2019) required advanced solutions such as the creation of new business models, collaboration platforms, and waste prediction tools and putting more emphasis on the development of circular product markets and recycling infrastructure (D8, D10, D14, D20, D21). The final interval (2020–2022), however, involved most of the drivers identified in this paper indicating a globalisation of the circular economy concern. Many waste management aspects are now being considered from a multi-lateral and multi-disciplinary perspective, with evidence of clear interaction and collaboration between countries of different backgrounds and development levels [47,60,61,69,72,84]. More concern is placed on aspects such as the innovation and improvement of existing infrastructure and management procedures, the development of policies and regulations, collaboration and communication, government support, etc.

4. Conclusions

A structured review and meta-analysis of drivers were performed to support circular economy improvements in the construction industry. A total of 55 scientific articles were selected from all countries corresponding to the period of 2013–2022. The analysis of the annual publications trend showed a growing interest in this matter, with 27.3% of articles published in 2021 alone despite any impact the COVID-19 pandemic may have had on the number of articles published during that year.

Most of the articles reviewed were from Europe (31.0%) and Asia (41.0%), with China, the UK, and Australia being the most prolific countries. On the other hand, there were very few articles published on studies in Africa and South America. This suggests many possibilities for that reason such as a lack of priority of CDW in that continent, or even the reduced amount of research in general developed in those countries. Many other factors can have an impact on this, like less urbanised areas, or even the selection criteria for this study (e.g., this research could be written in other languages). Further analysis would be needed to understand these factors and the impact they can have in the development of research around CDW management.

In total, 29 drivers were identified through a frequency analysis of the selected articles and were classified and grouped according to PESTLE analysis (political, economic, social, technological, legal, and environmental), discussing similarities and differences between continents, regions, and countries. The five most repeated drivers were the following:

- D1—adequate formulation and application of government CDW regulations and policies
- D2—training and education about CDW management aspects (causes, types, LWTs, cost savings, environmental impact)
- D3—provision of innovative low-waste technologies (LWTs)
- D4—adequate formulation and application of CDW protocols, programmes, and strategies
- D5—commitment of client and contractor by allocating time and money for CDW management

Different drivers could be recognised as associated with the CDW management practices of some countries and regions and also associated with different levels of development. For example, an improvement of awareness, behaviours, and skills are more considered in Asia together with efficient recycling infrastructures, whereas in Europe there are more considerations about the improvement of political strategies and legal aspects, management procedures, and pressure from environmental organisations. An evolution of the circular economy in construction was distinguished in the period of 2013–2022: initial steps identifying inadequacies, needs, and potential solutions, demanding more guidance and tools for CDW management (2013–2015); the requirement of specialism, the creation of new business models, and the consideration of the full supply chain (2016–2019); and the globalisation of the circular economy concern, involving a multi-lateral and interdisciplinary perspective (2020–2022).

It is evident of the need to move forward towards a more circular and sustainable production system. The construction industry's contribution is paramount to achieving zero-waste targets by 2050. A more regulated, (digitally) connected, collaborative, and skilled sector is demanded, considering the full supply chain in the whole life cycle of construction projects and the waste value chain, which seem to be the steps that will be able to transform the construction industry towards a circular system.

A limitation of this systematic review was the exclusion of papers not written in English. This language restriction might have led to the omission of some relevant research conducted in non-English-speaking regions. Additionally, the review was limited to studies published between 2013 and 2022. While this timeframe captures recent developments, as this past decade has seen increased attention to the circular economy in construction (as discussed in the Section 1), it might have excluded important earlier research; therefore, future research could extend the timeframe of the review. Furthermore, the process of reading, analysing, and abstracting data from the selected papers, despite following a systematic approach, inherently involves some degree of subjective interpretation.

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References

1. ISWA. 2015 ISWA Annual Report. 2015. Available online: https://www.iswa.org/annual-reports (accessed on 28 July 2023).
2. DEFRA. UK Statistics on Waste. Available online: https://www.gov.uk/government/statistics/uk-waste-data/uk-statistics-on-waste (accessed on 28 July 2023).
3. Deloitte. Study on Resource Efficient Use of Mixed Wastes Improving Management of Construction and Demolition Waste—Final Report. 2017. Available online: https://ec.europa.eu/environment/pdf/waste/studies/CDW_Final_Report.pdf (accessed on 29 July 2023).
4. Chang, Y.; Li, X.; Masanet, E.; Zhang, L.; Huang, Z.; Ries, R. Unlocking the green opportunity for prefabricated buildings and construction in China. *Resour. Conserv. Recycl.* **2018**, *139*, 259–261. [CrossRef]
5. EPA. Advancing Sustainable Materials Management: 2017 Fact Sheet. 2017. Available online: https://www.epa.gov/sites/default/files/2019-11/documents/2017_facts_and_figures_fact_sheet_final.pdf (accessed on 29 July 2023).
6. Ouda, O.K.M.; Peterson, H.P.; Rehan, M.; Sadef, Y.; Alghazo, J.M.; Nizami, A.S. A Case Study of Sustainable Construction Waste Management in Saudi Arabia. *Waste Biomass Valorization* **2018**, *9*, 2541–2555. [CrossRef]
7. Akenji, L.; Bengtsson, M.; Emily Briggs Chiu, A.; Daconto, G.; Fadeeva, Z. *Sustainable Consumption and Production: A HANDBOOK for Policymakers*; Briggs, E., Ed.; Global Edition; UNEP: Nairobi, Kenya, 2015; 212p.
8. IEA; UNEP. *2019 Global Status Report for Buildings and Construction: Towards a Zero-Emissions, Efficient and Resilient Buildings and Construction Sector*; International Energy Agency: Hamburg, Germany, 2019. Available online: https://www.unep.org/resources/publication/2019-global-status-report-buildings-and-construction-sector (accessed on 29 July 2023).
9. UNEP; IRP. Global Resources Outlook 2019 Natural Resources for the Future We Want. 2019. Available online: https://wedocs.unep.org/handle/20.500.11822/27517 (accessed on 29 July 2023).
10. UNEP. Sand and Sustainability: Finding New Solutions for Environmental Governance of Global Sand Resources. 2019. Available online: https://wedocs.unep.org/handle/20.500.11822/28163 (accessed on 29 July 2023).
11. Ferronato, N.; Torretta, V.; Ragazzi, M.; Rada, E.C. Waste Mismanagement in Developing Countries: A Case Study of Environmental Contamination. *UPB Sci. Bull. Ser. D* **2017**, *79*, 185–196.
12. World Bank. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. 2018. Available online: https://openknowledge.worldbank.org/bitstream/handle/10986/30317/9781464813290.pdf?sequence=12&isAllowed=y (accessed on 29 July 2023).
13. WRAP. Achieving Good Practice Waste Minimisation and Management Guidance for Construction Clients, Design Teams and Contractors. Available online: https://www.eauc.org.uk/file_uploads/wrap2.pdf (accessed on 29 July 2023).
14. Mahpour, A.; Mortaheb, M.M. Financial-Based Incentive Plan to Reduce Construction Waste. *J. Constr. Eng. Manag.* **2018**, *144*, 4018029. [CrossRef]
15. Hao, J.; Yuan, H.; Liu, J.; Chin, C.S.; Lu, W. A model for assessing the economic performance of construction waste reduction. *J. Clean. Prod.* **2019**, *232*, 427–440. [CrossRef]

16. Osmani, M. Construction Waste. In *Waste*; Academic Press: Cambridge, MA, USA, 2011; pp. 207–218.
17. World Economic Forum. What Is the Circular Economy and Why Does It Matter That It Is Shrinking? 14 June 2022. Available online: https://www.weforum.org/agenda/2022/06/what-is-the-circular-economy/ (accessed on 7 July 2023).
18. Alhawamdeh, M.; Lee, A. Construction Waste Minimisation: A Narrative Review. *Int. J. Environ. Sustain.* **2021**, *18*, 1. [CrossRef]
19. Huang, B.; Wang, X.; Kua, H.; Geng, Y.; Bleischwitz, R.; Ren, J. Construction and demolition waste management in China through the 3R principle. *Resour. Conserv. Recycl.* **2018**, *129*, 36–44. [CrossRef]
20. Zhang, X.; Wu, Y.; Shen, L. Application of low waste technologies for design and construction: A case study in Hong Kong. *Renew. Sustain. Energy Rev.* **2012**, *16*, 2973–2979. [CrossRef]
21. Ferriz-Papi, J.A.; Lee, A.; Alhawamdeh, M. Examining the Challenges for Circular Economy Implementation in Construction and Demolition Waste Management: A Comprehensive Review Using Systematic Methods. *Buildings* **2024**, *14*, 1237. [CrossRef]
22. Levy, Y.; Ellis, T.J. Informing Science Journal A Systems Approach to Conduct an Effective Literature Review in Support of Information Systems Research. *Inf. Sci. J.* **2006**, *9*, 181–212.
23. Peters, M.D.; Godfrey, C.M.; Khalil, H.; McInerney, P.; Parker, D.; Soares, C.B. Guidance for conducting systematic scoping reviews. *JBI Evid. Implement.* **2015**, *13*, 141–146. [CrossRef] [PubMed]
24. Singh, V.K.; Singh, P.; Karmakar, M.; Leta, J.; Mayr, P. The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis. *Scientometrics* **2021**, *126*, 5113–5142. [CrossRef]
25. European Commission. Circular Economy Action Plan. Available online: https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en (accessed on 30 July 2023).
26. United Nations Environment Programme, International Solid Waste Association. *Global Waste Management Outlook 2024—Beyond an age of waste: Turning Rubbish into a Resource*; United Nations Environment Programme: Nairobi, Kenya, 2024. Available online: https://wedocs.unep.org/20.500.11822/44939 (accessed on 13 May 2024).
27. UN Climate Change. The Paris Agreement Related News Related Documents Related Links What is the Paris Agreement? Available online: https://unfccc.int/process-and-meetings/the-paris-agreement (accessed on 30 July 2023).
28. European Commission. European Waste Framework Directive. 2019. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32019D1004&qid=1690732569938 (accessed on 30 July 2023).
29. Guerra, B.C.; Shahi, S.; Mollaei, A.; Skaf, N.; Weber, O.; Leite, F.; Haas, C. Circular economy applications in the construction industry: A global scan of trends and opportunities. *J. Clean. Prod.* **2021**, *324*, 129125. [CrossRef]
30. Guerra, B.C.; Bakchan, A.; Leite, F.; Faust, K.M. BIM-based automated construction waste estimation algorithms: The case of concrete and drywall waste streams. *Waste Manag.* **2019**, *87*, 825–832. [CrossRef] [PubMed]
31. Abarca-Guerrero, L.; Leandro-Hernandez, A.G. Material management practices for construction waste reduction. *WIT Trans. Ecol. Environ.* **2017**, *223*, 551–557.
32. Guerra, B.C.; Leite, F. Circular economy in the construction industry: An overview of United States stakeholders' awareness, major challenges, and enablers. *Resour. Conserv. Recycl.* **2021**, *170*, 105617. [CrossRef]
33. EPA. *Sustainable Management of Construction and Demolition Materials*; US EPA: Washington, DC, USA, 2023. Available online: https://www.epa.gov/smm/sustainable-management-construction-and-demolition-materials (accessed on 7 July 2023).
34. Aguilar, F.J. Scanning the Business Environment. Available online: https://lccn.loc.gov/67011688 (accessed on 13 May 2024).
35. Cristiano, S.; Ghisellini, P.; D'Ambrosio, G.; Xue, J.; Nesticò, A.; Gonella, F.; Ulgiati, S. Construction and demolition waste in the Metropolitan City of Naples, Italy: State of the art, circular design, and sustainable planning opportunities. *J. Clean. Prod.* **2021**, *293*, 125856. [CrossRef]
36. Oke, A.; Aigbavboa, C.; Aghimien, D.; Currie, N. Construction Professionals Perception of Solid Waste Management in the South African Construction Industry. In *Advances in Human Factors, Sustainable Urban Planning and Infrastructure*; Charytonowicz, J., Falcão, C., Eds.; Springer: Berlin/Heidelberg, Germany, 2019; pp. 496–505.
37. Yuan, H. Barriers and countermeasures for managing construction and demolition waste: A case of Shenzhen in China. *J. Clean. Prod.* **2017**, *157*, 84–93. [CrossRef]
38. Ghaffar, S.H.; Burman, M.; Braimah, N. Pathways to circular construction: An integrated management of construction and demolition waste for resource recovery. *J. Clean. Prod.* **2020**, *244*, 118710. [CrossRef]
39. Shooshtarian, S.; Hosseini, M.R.; Kocaturk, T.; Arnel, T.; Garofano, N.T. Circular economy in the Australian AEC industry: Investigation of barriers and enablers. *Build. Res. Inf.* **2023**, *51*, 56–68. [CrossRef]
40. Torres-Guevara, L.E.; Prieto-Sandoval, V.; Mejia-Villa, A. Success Drivers for Implementing Circular Economy: A Case Study from the Building Sector in Colombia. *Sustainability* **2021**, *13*, 1350. [CrossRef]
41. Van Tuan, N.; Kien, T.T.; Huyen, D.T.T.; Nga, T.T.V.; Giang, N.H.; Dung, N.T.; Isobe, Y.; Ishigaki, T.; Kawamoto, K. Current status of construction and demolition waste management in Vietnam: Challenges and opportunities. *Int. J. GEOMATE* **2018**, *15*, 23–29. [CrossRef]
42. Shooshtarian, S.; Caldera, S.; Maqsood, T.; Ryley, T.; Khalfan, M. An investigation into challenges and opportunities in the Australian construction and demolition waste management system. *Eng. Constr. Archit. Manag.* **2022**, *29*, 4313–4330. [CrossRef]
43. Khan, A.R.; Ditta, A.; Mehmood, M.S.; MaoSheng, Z.; Natalia, M. Determinants and implications of environmental practices for waste management and the minimization in the construction industry: A case study of Pakistan. *Environ. Sci. Pollut. Res.* **2021**, *28*, 58221–58231. [CrossRef] [PubMed]

44. Blaisi, N.I. Construction and demolition waste management in Saudi Arabia: Current practice and roadmap for sustainable management. *J. Clean. Prod.* **2019**, *221*, 167–175. [CrossRef]
45. Saez, P.V.; Merino, M.d.R.; González, A.S.-A.; Porras-Amores, C. Best practice measures assessment for construction and demolition waste management in building constructions. *Resour. Conserv. Recycl.* **2013**, *75*, 52–62. [CrossRef]
46. Crawford, R.H.; Mathur, D.; Gerritsen, R. Barriers to Improving the Environmental Performance of Construction Waste Management in Remote Communities. *Procedia Eng.* **2017**, *196*, 830–837. [CrossRef]
47. Giorgi, S.; Lavagna, M.; Wang, K.; Osmani, M.; Liu, G.; Campioli, A. Drivers and barriers towards circular economy in the building sector: Stakeholder interviews and analysis of five European countries policies and practices. *J. Clean. Prod.* **2022**, *336*, 130395. [CrossRef]
48. Wu, H.; Duan, H.; Wang, J.; Wang, T.; Wang, X. Quantification of carbon emission of construction waste by using streamlined LCA: A case study of Shenzhen, China. *J. Mater. Cycles Waste Manag.* **2015**, *17*, 637–645. [CrossRef]
49. Li, J.; Tam, V.W.Y.; Zuo, J.; Zhu, J. Designers' attitude and behaviour towards construction waste minimization by design: A study in Shenzhen, China. *Resour. Conserv. Recycl.* **2015**, *105*, 29–35. [CrossRef]
50. Ajayi, S.O.; Oyedele, L.O. Policy imperatives for diverting construction waste from landfill: Experts' recommendations for UK policy expansion. *J. Clean. Prod.* **2017**, *147*, 57–65. [CrossRef]
51. Pellegrini, L.; Campi, S.; Locatelli, M.; Pattini, G.; Di Giuda, G.M.; Tagliabue, L.C. Digital Transition and Waste Management in Architecture, Engineering, Construction, and Operations Industry. *Front. Energy Res.* **2020**, *8*, 576462. [CrossRef]
52. Adams, K.T.; Osmani, M.; Thorpe, T.; Thornback, J. Circular economy in construction: Current awareness, challenges and enablers. *Proc. Inst. Civil. Eng. Waste Resour. Manag.* **2017**, *170*, 15–24. [CrossRef]
53. Gangolells, M.; Casals, M.; Forcada, N.; Macarulla, M. Analysis of the implementation of effective waste management practices in construction projects and sites. *Resour. Conserv. Recycl.* **2014**, *93*, 99–111. [CrossRef]
54. Alhawamdeh, M.; Lee, A. A behavioral framework for construction waste minimization: The case of Jordan. *Int. J. Environ. Sustain.* **2021**, *17*, 9–32. [CrossRef]
55. Tirado, R.; Aublet, A.; Laurenceau, S.; Habert, G. Challenges and Opportunities for Circular Economy Promotion in the Building Sector. *Sustainability* **2022**, *14*, 1569. [CrossRef]
56. Christensen, T.B.; Johansen, M.R.; Buchard, M.V.; Glarborg, C.N. Closing the material loops for construction and demolition waste: The circular economy on the island Bornholm, Denmark. *Resour. Conserv. Recycl. Adv.* **2022**, *15*, 200104. [CrossRef]
57. Luscuere, L.M. Materials Passports: Optimising value recovery from materials. *Proc. Inst. Civil. Eng. Waste Resour. Manag.* **2017**, *170*, 25–28. [CrossRef]
58. Won, J.; Cheng, J.C.P.; Lee, G. Quantification of construction waste prevented by BIM-based design validation: Case studies in South Korea. *Waste Manag.* **2016**, *49*, 170–180. [CrossRef]
59. Wang, G.; Krzywda, D.; Kondrashev, S.; Vorona-Slivinskaya, L. Recycling and Upcycling in the Practice of Waste Management of Construction Giants. *Sustainability* **2021**, *13*, 640. [CrossRef]
60. zu Castell-Rüdenhausen, M.; Wahlström, M.; Astrup, T.F.; Jensen, C.; Oberender, A.; Johansson, P.; Waerner, E.R. Policies as Drivers for Circular Economy in the Construction Sector in the Nordics. *Sustainability* **2021**, *13*, 9350. [CrossRef]
61. Tam, V.W.Y.; Lu, W. Construction Waste Management Profiles, Practices, and Performance: A Cross-Jurisdictional Analysis in Four Countries. *Sustainability* **2016**, *8*, 190. [CrossRef]
62. Noor, R.N.H.R.M.; Ridzuan, A.R.M.; Endut, I.R.; Noordin, B.; Shehu, Z.; Ghani, A.H.A. The quantification of local construction waste for the current construction waste management practices: A case study in Klang Valley. In Proceedings of the 2013 IEEE Business Engineering and Industrial Applications Colloquium (BEIAC), Langkawi, Malaysia, 7–9 April 2013; pp. 183–188.
63. Bao, Z.; Lu, W. Developing efficient circularity for construction and demolition waste management in fast emerging economies: Lessons learned from Shenzhen, China. *Sci. Total Environ.* **2020**, *724*, 138264. [CrossRef] [PubMed]
64. Condotta, M.; Zatta, E. Reuse of building elements in the architectural practice and the European regulatory context: Inconsistencies and possible improvements. *J. Clean. Prod.* **2021**, *318*, 128413. [CrossRef]
65. Torgautov, B.; Zhanabayev, A.; Tleuken, A.; Turkyilmaz, A.; Mustafa, M.; Karaca, F. Circular Economy: Challenges and Opportunities in the Construction Sector of Kazakhstan. *Buildings* **2021**, *11*, 501. [CrossRef]
66. Ajayi, S.O.; Oyedele, L.O.; Bilal, M.; Akinade, O.O.; Alaka, H.A.; Owolabi, H.A.; Kadiri, K.O. Waste effectiveness of the construction industry: Understanding the impediments and requisites for improvements. *Resour. Conserv. Recycl.* **2015**, *102*, 101–112. [CrossRef]
67. Ramos, M.; Martinho, G. Influence of construction company size on the determining factors for construction and demolition waste management. *Waste Manag.* **2021**, *136*, 295–302. [CrossRef] [PubMed]
68. AAjayi, S.O.; Oyedele, L.O.; Akinade, O.O.; Bilal, M.; Owolabi, H.A.; Alaka, H.A.; Kadiri, K.O. Reducing waste to landfill: A need for cultural change in the UK construction industry. *J. Build. Eng.* **2016**, *5*, 185–193. [CrossRef]
69. Shojaei, A.; Ketabi, R.; Razkenari, M.; Hakim, H.; Wang, J. Enabling a circular economy in the built environment sector through blockchain technology. *J. Clean. Prod.* **2021**, *294*, 126352. [CrossRef]
70. Saez, P.V.; de Guzman Baez, A.; Navarro, J.G.; del Rio Merino, M. Redefining construction and demolition waste management systems: Best practices on civil engineering works. *Balt. J. Road Bridge Eng.* **2014**, *9*, 171. [CrossRef]
71. Lu, W.; Webster, C.; Peng, Y.; Chen, X.; Chen, K. Big data in construction waste management: Prospects and challenges. *Detritus* **2018**, *4*, 129–139. [CrossRef]

72. Oluleye, B.I.; Chan, D.W.M.; Saka, A.B.; Olawumi, T.O. Circular economy research on building construction and demolition waste: A review of current trends and future research directions. *J. Clean. Prod.* **2022**, *357*, 131927. [CrossRef]
73. Low, J.K.; Wallis, S.L.; Hernandez, G.; Cerqueira, I.S.; Steinhorn, G.; Berry, T.A. Encouraging Circular Waste Economies for the New Zealand Construction Industry: Opportunities and Barriers. *Front. Sustain. Cities* **2020**, *2*, 35. [CrossRef]
74. Umar, U.A.; Shafiq, N.; Ahmad, F.A. A case study on the effective implementation of the reuse and recycling of construction & demolition waste management practices in Malaysia. *Ain Shams Eng. J.* **2021**, *12*, 283–291.
75. Ajayi, S.O.; Oyedele, L.O.; Bilal, M.; Akinade, O.O.; Alaka, H.A.; Owolabi, H.A. Critical management practices influencing on-site waste minimization in construction projects. *Waste Manag.* **2017**, *59*, 330–339. [CrossRef] [PubMed]
76. Tafesse, S.; Girma, Y.E.; Dessalegn, E. Analysis of the socio-economic and environmental impacts of construction waste and management practices. *Heliyon* **2022**, *8*, e09169. [CrossRef] [PubMed]
77. Wuni, I.Y.; Shen, G.Q. Developing critical success factors for integrating circular economy into modular construction projects in Hong Kong. *Sustain. Prod. Consum.* **2022**, *29*, 574–587. [CrossRef]
78. Kabirifar, K.; Mojtahedi, M.; Changxin Wang, C.; Tam, V.W.Y. Effective construction and demolition waste management assessment through waste management hierarchy; a case of Australian large construction companies. *J. Clean. Prod.* **2021**, *312*, 127790. [CrossRef]
79. Akinade, O.O.; Oyedele, L.O. Integrating construction supply chains within a circular economy: An ANFIS-based waste analytics system (A-WAS). *J. Clean. Prod.* **2019**, *229*, 863–873. [CrossRef]
80. Cheng, J.C.P.; Ma, L.Y.H. A BIM-based system for demolition and renovation waste estimation and planning. *Waste Manag.* **2013**, *33*, 1539–1551. [CrossRef]
81. Bernardo, M.; Gomes, M.C.; de Brito, J. Demolition waste generation for development of a regional management chain model. *Waste Manag.* **2016**, *49*, 156–169. [CrossRef] [PubMed]
82. Ding, Z.; Yi, G.; Tam, V.W.Y.; Huang, T. A system dynamics-based environmental performance simulation of construction waste reduction management in China. *Waste Manag.* **2016**, *51*, 130–141. [CrossRef] [PubMed]
83. Rahmat, A.S.; Noor, H.R.N.R.M.; Endut, I.R.; Ridzuan, R.A.M. The practice of construction waste management in Pulau Pinang. *AIP Conf. Proc.* **2016**, *1774*, 030018.
84. Gálvez-Martos, J.L.; Styles, D.; Schoenberger, H.; Zeschmar-Lahl, B. Construction and demolition waste best management practice in Europe. *Resour. Conserv. Recycl.* **2018**, *136*, 166–178. [CrossRef]
85. Serpell, A.; Kort, J.; Vera, S. Awareness, actions, drivers and barriers of sustainable construction in Chile. *Technol. Econ. Dev. Econ.* **2013**, *19*, 272–288. [CrossRef]
86. Davies, J.; Foxall, G.R.; Pallister, J. Beyond the Intention–Behaviour Mythology: An Integrated Model of Recycling. *Mark. Theory* **2002**, *2*, 29–113. [CrossRef]
87. Nikakhtar, A.; Hosseini, A.A.; Wong, K.Y.; Zavichi, A. Application of lean construction principles to reduce construction process waste using computer simulation: A case study. *Int. J. Serv. Oper. Manag.* **2015**, *20*, 461–480. [CrossRef]
88. María, M.R.; Nicolás, M.; Amparo, V.M. The Role of Information Technologies to Address Data Handling in Construction Project Management. *J. Comput. Civil Eng.* **2016**, *30*, 04015064.
89. Liu, Z.; Osmani, M.; Demian, P.; Baldwin, A. A BIM-aided construction waste minimisation framework. *Autom. Constr.* **2015**, *59*, 1–23. [CrossRef]
90. Won, J.; Cheng, J.C.P. Identifying potential opportunities of building information modeling for construction and demolition waste management and minimization. *Autom. Constr.* **2017**, *79*, 3–18. [CrossRef]
91. Martin, L.; Perry, F. Chapter 11—Sustainable Construction Technology Adoption. In *Sustainable Construction Technologies*; Tam, V.W.Y., Le, K.N., Eds.; Butterworth-Heinemann: Waltham, MA, USA, 2019; pp. 299–316. Available online: https://www.sciencedirect.com/science/article/pii/B9780128117491000092 (accessed on 13 May 2024).
92. Pan, M.; Linner, T.; Pan, W.; Cheng, H.; Bock, T. A framework of indicators for assessing construction automation and robotics in the sustainability context. *J. Clean. Prod.* **2018**, *182*, 82–95. [CrossRef]
93. Tam, V.W.Y.; Fung, I.W.H.; Sing, M.C.P.; Ogunlana, S.O. Best practice of prefabrication implementation in the Hong Kong public and private sectors. *J. Clean. Prod.* **2015**, *109*, 216–231. [CrossRef]
94. Mesároš, P.; Mandičák, T. Factors affecting the use of modern methods and materials in construction. *IOP Conf. Ser. Mater. Sci. Eng.* **2015**, *71*, 012053. [CrossRef]
95. Wang, J.; Wu, H.; Tam, V.W.Y.; Zuo, J. Considering life-cycle environmental impacts and society's willingness for optimizing construction and demolition waste management fee: An empirical study of China. *J. Clean. Prod.* **2019**, *206*, 1004–1014. [CrossRef]
96. Wang, T.; Wang, J.; Wu, P.; Wang, J.; He, Q.; Wang, X. Estimating the environmental costs and benefits of demolition waste using life cycle assessment and willingness-to-pay: A case study in Shenzhen. *J. Clean. Prod.* **2018**, *172*, 14–26. [CrossRef]