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# Management of Household-Generated Construction and Demolition Waste: Circularity Principles and the Attitude of Latvian Residents

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**Abstract:** This study aims to investigate to what extent the construction and demolition waste generated by households is managed by the principles of circularity and to identify the main influencing factors in the behavior of households regarding the circularity-based management of construction waste in Latvia. The current research presents principles of circularity of household-generated waste based on a systematic literature review, and the data obtained from a survey were analyzed using both descriptive and inferential statistics. This study clarifies the circular economy rationale for construction and demolition waste (CDW) management in Latvia and proposes further development to promote the achievement of sustainable development goals and increased energy efficiency. The results reveal that the observance of circular economy principles in construction and demolition waste management among Latvian households does not correspond to good circular economy practices due to attitudes toward environmental issues, expenses, and logistics; thus, compliance with these principles and legislation as well as closer cooperation between municipalities and households can promote significant economic benefits.

**Keywords:** construction and demolition waste; waste management; households; circularity; energy; awareness; expenses



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## 1. Introduction

Recent studies emphasize the development of circularity and its importance in sustainability, which has a positive effect on increasing the efficiency of building materials and energy use and reducing the impact of emissions [1,2]. Reasonable construction and demolition waste management and the use of environmentally friendly materials as well as the introduction of circularity principles, with special emphasis on digital solutions, have a clear positive effect on the reduction in primary resource consumption [3–6].

Construction and demolition waste constitutes a large part of the total mass of waste, has a relatively low environmental impact, and is inert but characterized by a high volume and weight. The construction sector is responsible for over 35% of the EU's total waste generation; consequently, the large environmental impact of CDW is an important logistical and land-use issue [7]. Thus, CDW management is a priority for most environmental programs worldwide, especially in Europe [8].

In recent years, the EU has activated certain measurements, guidelines, and directives to move toward greater support for a sustainable and circular economy; in 2020, the EU Commission developed a circular economy action plan aimed to promote more sustainable product design, reduce the amount of waste, and support opportunities for consumers to use repaired goods, including in the construction sector [9]. In 2021, the EU Parliament developed a resolution calling for additional measures to achieve a carbon-neutral, environmentally sustainable circular economy by 2050 by introducing conditions for the use of materials by 2030 [10].

The EU Commission presented the 2050 roadmap for reducing whole life-cycle carbon emissions in buildings [11,12]. As part of revising the recovery targets for construction and demolition waste, the EU Commission paid special attention to insulation materials [7]. The EU's strategy for a sustainable built environment in "A European Green Deal" aims to ensure coherence between energy and resource efficiency, promoting circular business models and empowering consumers to go green. At the same time, it was noted that a single market for construction products has not been achieved and that implementation has been suboptimal, as market surveillance activities vary greatly from one Member State to another [7,13].

Construction waste generation, transportation and recycling, implementation of reverse logistics in construction waste processing, and process monitoring system policy measures have been widely studied in different countries and regions [14–16]. Stakeholders play a major role in the management of CDW in the household sector and the waste management policies applied to this sector, where the actions of municipalities are of particular importance [17,18].

Despite the fact that CDW management, including sorting, is mandatory in all EU countries, where each country determines its own priorities in the construction waste management and circulation process, construction waste generated by residents is not always adequately and efficiently collected, managed, and reused [19–21]. The increase in the cost of raw materials and their serious impact on the environment, which requires an appropriate CDM plan and circularity to ensure sustainable development, can we managed by reusing wood materials thus contributing to the conservation of forest recourses [22,23].

Consumption models and preferences in Eastern Europe in general and in Latvia in particular differ significantly from Western European countries [24,25]. The possible return of raw materials into circulation and the most efficient use of materials in construction or their reuse in other spheres is one of the most important tasks at the government and municipal level.

The construction industry in Latvia, as in most EU countries, plays an important role in the growth of the national economy in terms of material consumption [26]. Therefore, the construction industry, by increasing the demand for circular products produced from local recycled materials, could support the pace at which Latvia achieves the goals of sustainable development [27]. Latvia could become a leader in the circularity of environmentally friendly construction materials given the country's historical relations with forestry, wood-based construction, and the unused potential of the modern use of wood in the future. Latvia has a small economy, so it is relatively easy to coordinate CDW management programs to ensure sustainability and develop a model that could be used in other Eastern European countries, where households contribute a significant proportion of CDW; however, the attitudes of households and the factors affecting their contributions to CDW have not been studied until now.

Latvian policymakers hesitate to issue sharp regulations on the construction sector and react with rather soft actions. Nevertheless, the Latvian Ministry of Economy and several state administrative institutions, nongovernmental organizations and state capital companies have agreed on joint cooperation to promote the production and use of wood-based building materials and construction products with high added value in construction, promoting sustainable and energy-efficient development [28].

The aim of this paper is to determine to what extent the construction and demolition waste generated by households is managed in accordance with the principles of circularity and the main influencing factors in the behavior of households regarding the circularity-based management of construction waste in Latvia.

This study pays special attention to household problems during various construction or renovation projects and solutions for waste removal related to possible recycling options and optimization of household expenses since legal waste removal is quite expensive. Conducting this research from a population perspective is considered a limitation of the work.

The paper is organized as follows: in the second section, an analysis of the literature on the composition of building construction and demolition waste, management of CDW, and the possibility of reuse is presented, and the situation in Latvia compared with Northern European countries is highlighted. The third section explains the methodology used in this study, and the fourth section reveals the results of the research study and establishes a scientific discussion. Furthermore, the final section of this study summarizes the conclusions and future research directions.

## 2. Management of Construction and Demolition Waste

### *2.1. Bibliometrics and Literature Analysis*

The sustainable management of construction materials and their waste has the potential to substantially support opportunities to significantly reduce overall greenhouse gas (GHG) emissions in the EU.

The circular economy is a model of production and consumption, which includes the reuse, repair, renewal, and recycling of materials as much as possible, thus extending the life cycle of these materials, unlike the linear economy model based on the principles of take-make-consume-throw. In practice, the circular economy involves minimizing waste, as materials are kept in the economy through reuse and recycling, creating added value [29].

Although more recent studies have revealed the 60R circularity principles, in accordance with the 9R circularity principles (refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, and recover), building materials can be used and reused at their highest value while minimizing waste and environmental destruction [30,31]. A significant difference between reuse and recycling is the new use of waste in its original form or the conversion of waste into new products with some physiochemical processing; importantly, logistics play an essential role in the operation of the system and the impact of standardization practices on CDW [32]. Recycling requires more energy than reuse and may involve the use of new materials [18].

The main advantages of the circular economy in the construction sector are indicated as follows:

Environmental. The reuse and recycling of waste reduces the use of natural resources, reduces landscape and habitat disturbance, and limits the loss of biological diversity as well as reducing total annual $CO_2$ emissions [33].

Reduction in dependence on raw materials. The supply of essential raw materials is limited; thus, some EU countries are dependent on imported supplies. Recycling of raw materials reduces supply risks.

Reduction in GHG emissions. Decarbonizing the construction sector is one of the most cost-effective ways to mitigate GHG emissions. Energy-efficient buildings make it possible to achieve zero emissions. Addressing construction-related carbon emissions is an important part of reducing the carbon footprint of buildings and construction [19].

Construction and demolition waste is the largest proportion of waste that needs to be treated and used efficiently and sustainably. A comprehensive search of CDW studies in the Scopus database revealed a remarkable 5245 published scientific articles. Academic interest in CDW can be traced back to 1966, marking its first mention in scientific circles. However, it was not until the 1990s that this research topic really gained traction in the academic community. Of particular interest is the increase in publications over time, culminating in an impressive corpus of 740 articles on this topic published in 2022 (Figure 1).

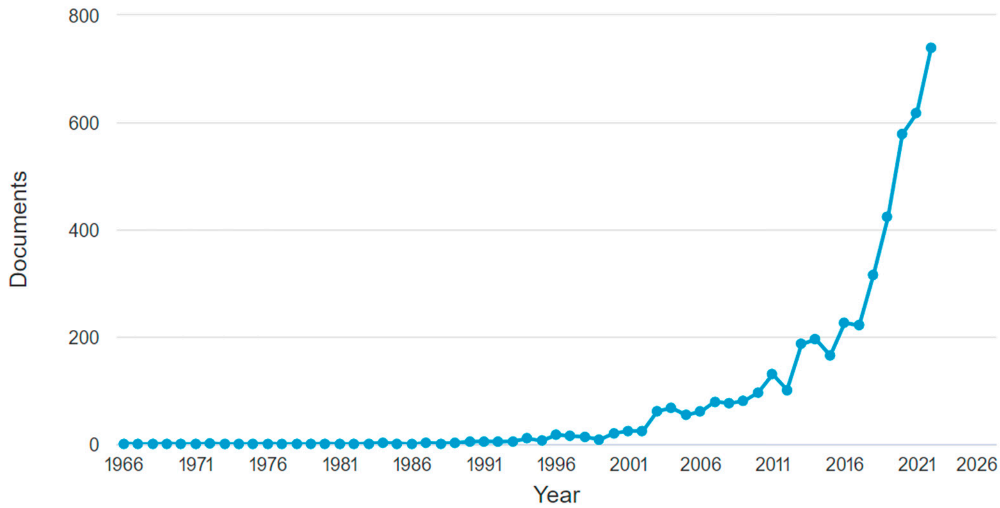


**Figure 1.** Number of articles on CDW published in Scopus 1966–2022.

The authors then performed an analysis of CDW documents retrieved from Scopus and WOS. Figure 2 shows the trending themes in the selected articles. The most common keywords were as follows: ‘circular economy’, ‘sustainability’, ‘life cycle assessment’, ‘management’, ‘concrete’, ‘energy’, ‘debris’, ‘recycled concrete’, ‘material flow’, etc. Within the VOSviewer tool (version 1.6.16), settings were adjusted such that keywords were categorized into distinct clusters based on their co-occurrence associations. Subsequently, the clusters represented on the network maps across different periods were juxtaposed and analyzed in relation to one another, as described by Du et al. [34]. Additionally, the authors employed network analysis using the VOSviewer tool to decipher the academic inputs in the examined field, as suggested by Tandon et al. [35]. For this, the authors chose a criterion of a minimum of five occurrences across a sample of 500 selected articles.

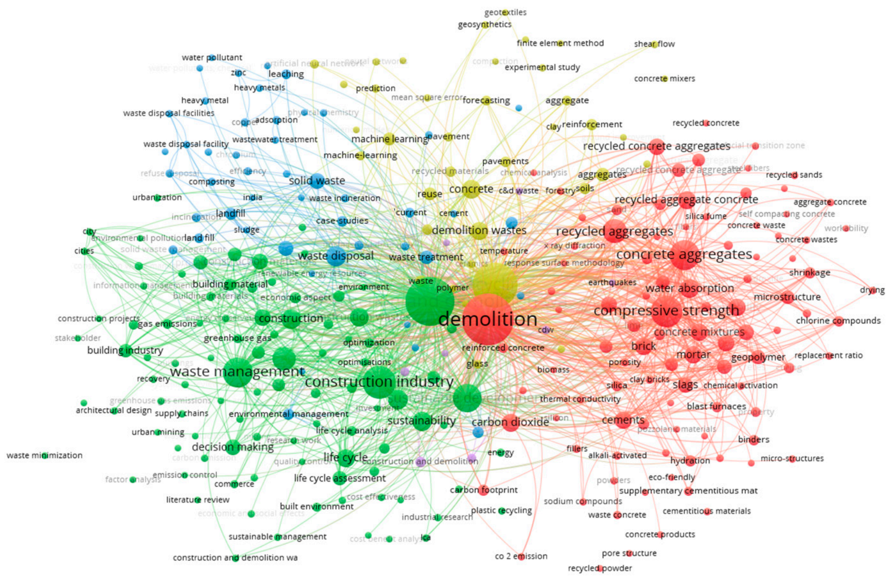


**Figure 2.** Keyword co-occurrence in the analyzed papers. Source: developed by the authors via VOSviewer version 1.6.16.

As Figure 2 shows, overall, there were 293 items grouped in five clusters. The most often occurring keywords were waste management, construction industry, recycled aggregates, carbon footprint, waste disposal, compressive strength, life cycle assessment, decision making, reuse, and recycling.

CDW incorporates a number of valuable materials, most of which can be used as construction materials. An initial step in understanding how to manage CDW is to characterize it in terms of its composition at the chemical level; the composition of CDW is extremely heterogeneous and varies greatly depending on the type of construction, traditions (e.g., timber vs. reinforced concrete), and local resources. The heterogeneity of construction materials does not allow for the development of universal construction material consumption models or waste management indicators [36]. The researchers believe logistical issues are important, and ideally this waste is treated near demolition sites to ensure a constant supply of raw materials for use in construction without high costs [37].

Construction and demolition waste is usually divided into three groups—waste after the demolition or removal of buildings, waste after road and street repair projects, and hazardous construction materials (Figure 3).

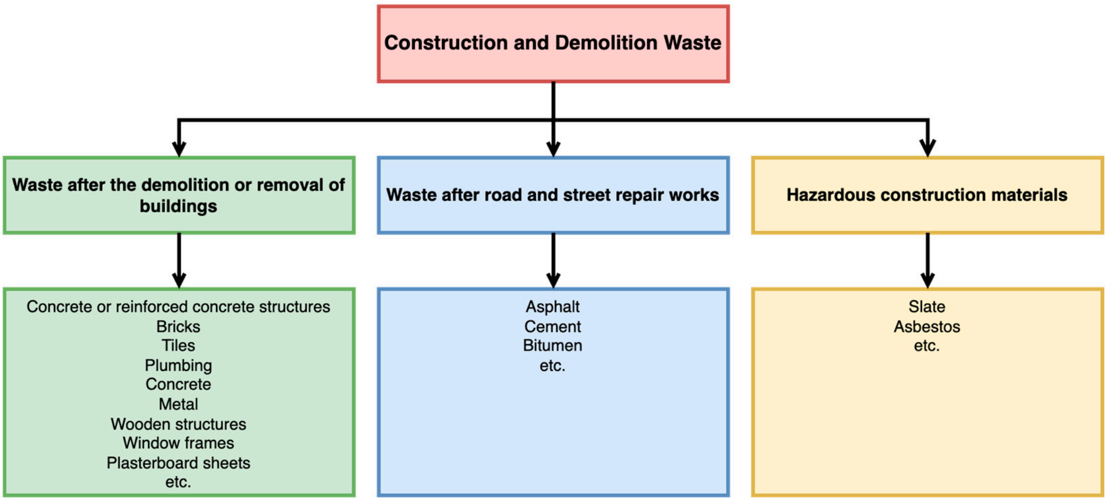


**Figure 3.** Classification of construction and demolition waste per activities Source: compiled by the authors using Deloitte [38].

As Figure 3 shows, the types of CDW in most cases involve the following common materials: concrete, glass, cement, bricks, wood, plastic, etc. Many of the mentioned materials contain chemicals and can be flammable, so they should not end up in a landfill, where they would be buried, or in nature, where they would not only not decompose but also pollute the soil and groundwater. Construction and demolition waste comprises a wide list of waste subtypes that have huge potential for reuse in the circular economy. The construction industry is responsible for a significant impact on the environment through the use of energy or other resources as well as the generation of waste. The circular economy can significantly change the sustainability of the construction industry.

While some researchers are investigating the economic and environmental benefits of implementing reverse logistics in the solid waste processing of construction companies, others are proposing a process monitoring system for policy measures covering the entire process of waste generation, transportation, and recycling [14,15].

Construction and demolition waste management is considered an area with high circulation possibilities and low impact on the reduction in primary resource consumption [39]. Using principles of circularity, it is possible to reduce the consumption of primary resources, extend the use of resources by bringing them back into the economic cycle, and reduce the initial amount of waste. Such preservation of the material value of waste can be achieved by funding research and workforce training, implementing stakeholder education and awareness campaigns, and through knowledge generation.

Construction and demolition waste is mostly generated by the construction industry, while household waste management is also important but is the least researched topic. The household sector, or individuals carrying out small-scale construction, repair, or demolition work, can be considered the sector with the greatest potential for inclusion in the circular economy, in which municipalities play a major role [40]. Municipalities do not have specific collection routes, which promote the sorting of waste at the point of origin and thus prevent landfill disposal of recyclable waste [17].

Studies have analyzed the introduction of smart waste management systems and its obstacles [41,42]. Smart basic technologies have great potential for improving waste management and construction waste management operations, but there are many obstacles, such as lack of knowledge about smart waste management, lack of environmental education and public environmental protection culture, lack of innovation capacity, difficulties in technology applications (IoT), lack of regulations, and financing problems [20,43,44].

The built environment in the EU requires huge amounts of resources; thus, higher material efficiency could save 80% of the EU's GHG emissions, which occur in the extraction of materials, the production of building products, and the construction and renovation of buildings [7]. The conducted comparative studies show a clear trend of decreasing waste generation in the EU, which indicates the implementation of the "green deal", and improvements in the construction sector and CDW management [45].

The use of three materials, namely, concrete, steel, and aluminum, account for 23% of the total global emissions. New strategies are needed to support the increased use of sustainable materials such as wood and wood-based materials in the construction industry, which is the main consumer of the abovementioned high-impact materials.

Since the crisis of 2008–2009, the share of prefabricated (wooden) houses among all single-family houses in the EU market has been relatively stable at around 15% [46]. Growing awareness of the impact of climate change is expected to increase the demand for wooden housing. Responsible use of wood in construction is based on circular principles and is sustainable. Wood has inherent advantages, as it is a natural material that can be used in building construction with minimal impact on the climate and with lower energy consumption and reduction in $CO_2$ emissions.

### *2.2. CDW Management in the Baltic Sea Region and Latvia*

In Western and Northern European countries, CDW management has developed successfully, and regulatory acts either provide for relaxed inspection requirements (used construction materials in excellent condition do not require special preparation and do not initially acquire the status of waste) or municipal institutions grant exceptions, in the event that the lower quality of the product does not cause significant risks (e.g., interior doors as opposed to exterior doors) [47–49]. The goal of the implemented project "Facilitating the circulation of reclaimed building elements in Northwestern Europe", which was launched in 2020, is to increase the amount of reclaimed building elements by +50% by 2032 [50]. In 2021 and 2022, several EU countries, including France, Denmark, Netherlands, and Sweden, adopted national legislation in the fields of climate, sustainability, circulation, and waste management that mainly affects the construction sector and represents a paradigm shift in the use of environmentally friendly building materials.

On the other hand, similar relief does not currently exist in Latvia. Accordingly, if construction waste ends up in the hands of waste managers, it can no longer be reused, and it is counted as recycling and no longer reusable. However, it is potentially possible to reuse the materials while they are still in the hands of the owners. Legislation could establish changes along with the creation and regulation of the status of construction waste as well as the clarification of recovered construction materials. The authors emphasize that the development of waste treatment and secondary material markets is essential, and the technologies and potential for high-performance waste management systems already exist in Europe and are available to those regions, municipalities, and waste managers who want to operate more efficiently and be more sustainable [36,51,52].

In Latvia in 2019, 70% of the collected construction waste was a mixture of construction debris and inert materials, while 20% consisted of only inert materials. Total construction and demolition waste is currently around 380,000 tons per year; therefore, the Waste

Management Plan 2021–2028 has been developed, but there are several obstacles to its implementation, especially related to the household sector [53].

In Latvia, no separate statistics on the collection of construction and demolition waste generated in industry and households are collected. The authors assumed that the household sector might be more likely to lack information about the appropriate and more cost-effective management of this type of waste with minimal environmental damage. In order to evaluate the best potential solutions that can be applied to Latvia, good practices from the countries of North-West Europe have been analyzed.

The management of CDW in the developed countries of the Baltic Sea region and in Latvia according to types of materials is described in Table 1.

**Table 1.** CDW management in Denmark, Finland, and Sweden by types of materials in 2019 and in Latvia in 2021.

| | Denmark | | | | Finland | | | | Sweden | | | | Latvia | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reuse | Recycling | Recovery | Energy | Reuse | Recycling | Recovery | Energy | Reuse | Recycling | Recovery | Energy | Reuse | Recycling | Recovery | Energy |
| Concrete | RD | C | C | | | | C | | | C | C | | | C | C | |
| Bricks | RD | | C | | | | C | | | | C | | | C | C | |
| Gypsum | | C | C | | | C | | | | C | | | | C | C | |
| Scrap metal | | C | | | | C | | | RD | C | | | | C | | |
| Insulation | | C | | | | C | | | RD | C | | | | C | | |
| PVC | | C | | | | | | | | C | | | | C | | |
| Other plastics | | C | | | | | | | | C | | | | C | | |
| Glass | | C | | | | C | | | C | C | | | | C | | |
| Wood | | C | | | | RD/C | | | C | C | | | C | C | | |
| Roofing bitumen | | C (tar paper) | | | | C | | | | C | | | | C | | |

Note: RD—research and development (one or more projects exist); C—Commercial (one or more companies are businesses). Source: compiled by the authors using Wahlström et al. [40] and survey data.

Table 1 compares the most important waste flow indicators in Denmark, Finland, Sweden, and Latvia. Resource mapping before demolition, deconstruction, or renovation identified earlier reuse and recycling opportunities and indicated the greater chances that are possible according to the quality of the material. Waste streams should be separated to achieve greater reuse and recycling compared to material or energy recovery or landfilling. Characterizing the dynamics of CDW collection and recycling volumes in Latvia, it can be concluded that the collected amount has decreased, while the recycling amount has increased. The status of CDW recycling in Latvia is adequate, but the reuse indicators could be better.

Figure 4 summarizes data on nonhazardous municipal waste management from 2002 to 2021, household-generated CDW constituted a significant proportion of total municipal waste in Latvia.

As can be seen in Figure 4, the amount of collected municipal waste has increased significantly since 2015, reaching 2,369,248 t in 2021, the amount of processed municipal waste and the amount of exported municipal waste has stabilized, reaching 500,145 t in 2021, and the amount of waste buried in landfills has significantly decreased including in 2016. The amount of generated waste has stabilized in recent years, with the exception of 2021, which can be justified by the pandemic.

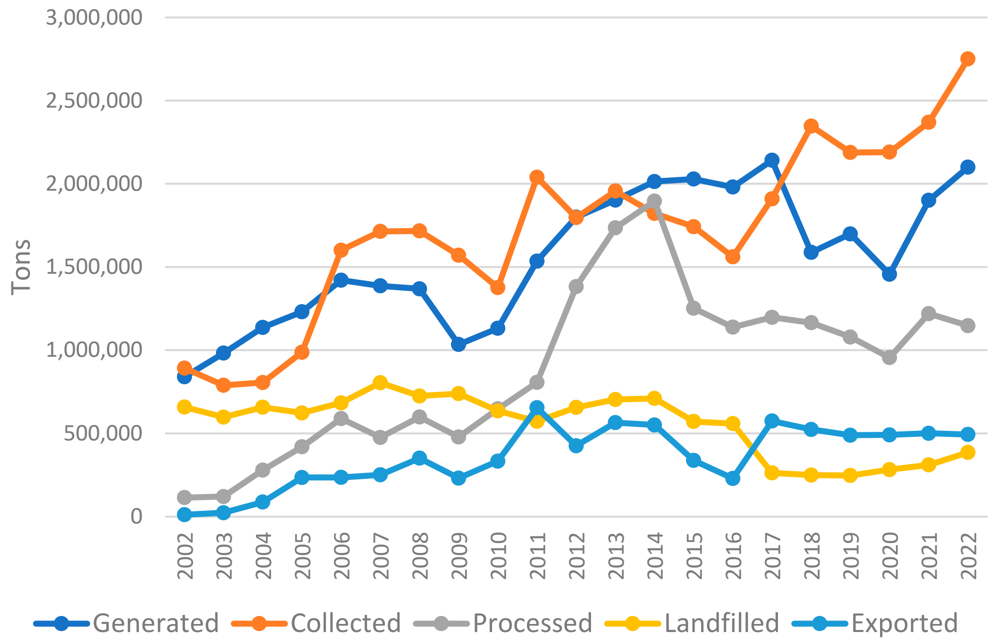


**Figure 4.** Data on nonhazardous municipal waste management in Latvia from 2002 to 2021, tons. Source: compiled by the authors according to Cabinet of Ministers [54] and Geo Consultants [55].

Despite the improvements, in general, the amount of construction materials that enter secondary circulation in Latvia is relatively small [56,57]. According to survey data of the Ministry of Environmental Protection, the largest mass of construction materials that enter secondary circulation are finishing materials (32%), timber (28%), and bricks and stones (22%), and windows and doors are also a significant part (10%). On the other hand, according to the number of units, the volumes of bricks, stones (28%), finishing materials (27%), and timber (23%) are similar [27].

Latvian legislation defines construction and demolition waste as waste that occurs as a result of construction or demolition [58]. In Latvia, building materials and construction products obtained during construction works, including renovation and dismantling works, are always initially classified as waste. This is different, for example, from the secondhand textile sector, where the concept of reuse also applies to products that have not yet become waste; for construction waste to be reused in construction and road works, it must have a suitable end-of-waste status and must meet the standards of products used in construction, and there must be documentation certifying compliance.

This study reveals that the existing system is more suitable for the preparation of large amounts of inorganic mass for reuse and recycling. On the other hand, in such product groups, where it is necessary to prove the quality and compliance of several different aggregates with the existing product standards as well as to provide appropriate documentation, for example, for doors, windows, roof cover plates, hygiene and sanitary equipment, radiators, floor coverings, etc.; the existing approach does not facilitate the return of products to the market, as they require high costs of material inspection and reuse.

Construction waste must be handed over to a manager who has received appropriate permits for waste collection, transportation, and recovery. Each shipment of construction waste from legal entities must be registered in the transportation accounting system. In addition, in order to be able to use recycled waste on the construction site, it must be provided in advance for construction projects. Another important point is that backfilling is not waste reclamation itself, although materials that have been reclaimed can be used to fill spaces.

In Latvia, several environmentally friendly and legal options exist; for instance, construction and demolition waste—both sorted and unsorted—can be taken by residents to a waste sorting site to be sorted and recycled, showing that this waste can be reused;

containers can be ordered by contacting a licensed waste manager, who will then collect the containers and recycle the materials, showing that this waste can be reused [59].

In order to make construction debris management even more convenient and simple for customers, the waste manager "CleanR Grupa" has introduced an innovation in the customer self-service portal and mobile app "Manai Videi", providing the opportunity to digitally apply for and pay for the service more conveniently and quickly.

Construction and demolition waste of different types and sizes can also be removed by residents by handing it over to one of the legal construction waste collection points. However, it should be noted that not all waste collection sites or landfills accept construction debris from individuals.

In the self-service portal and mobile app "Manai Videi", households can apply for the removal of small, medium, and large amounts of construction debris, paying only for the amount of waste they have created. Households can take small amounts of construction debris, such as sinks or tiles, to one of the "CleanR Grupa" waste management points themselves, receiving information on the nearest location on the "My Environment" website.

Also, household-generated construction debris can be delivered to the "CleanR Verso" waste sorting and recycling center "Nomales". Unfortunately, it is the only construction debris center in Latvia that ensures and fulfills all environmental requirements. In all, 80% of the construction debris handed over to "Nomales" is processed d—it is sorted and processed into rubble, soil, and other materials that can be further used [27]. The fee for the transfer of waste to "Nomalės" depends on the type and amount of waste. Each unit of waste is weighed, and the customer is charged according to the weight of the waste. If the amount of construction debris is sufficiently small, households can use "BIG BAG" for more convenient transportation, or use sugar, potato, or another durable bag. When moving to a new building or renovating an existing one, households can contact the construction waste manager themselves to prevent overpaying for the service and fines and to reduce environmental pollution.

## 3. Research Methodology

This study is based on the use of theoretical and empirical methods of research. The authors analyzed scientific and practical literature, and the main subject of research (energy, circularity, and CDW) was split into several smaller parts (characterization of the process of CDW circularity in the construction system, key directions, analysis of CDW management in Latvia, etc.). The study also applied systematic, structural, and functional methods of research. The authors characterized the general problems of CDW management development in Europe and formed conclusions via concretization and abstraction, and the problem of implementation of CDW management mechanisms in Latvia and characterization of its prospects at commercial and household levels were investigated.

Among the empirical methods of research was a survey of residents with the aim of clarifying the attitude of residents toward the management of construction waste and identifying conditions that hinder circulation in the waste segment and identifying possibilities to change the behavior of residents; the results were analyzed using descriptive statistics, the chi-square test, and hypothesis testing.

In order to understand the potential of implementing a circular approach in the management of construction and demolition waste generated in households and the readiness of Latvian society to be greener in waste solutions, the authors analyzed the primary data provided in the survey of 2005 respondents (permanent residents of Latvia between 18 and 75 years old) regarding construction and demolition waste habits; this survey was created by the authors as part of the Life Waste to Resources project in November–December 2022.

The purpose of this survey (65 questions in total) was to obtain information about the inhabitants' knowledge of and attitude toward the removal of construction and demolition waste as well as to identify the main shortcomings in the management of this waste in Latvia. In the survey of the respondents, the evaluation of the dependent variables was conducted using a Likert scale from 1 to 5 (1—definitely yes; 2—rather yes; 3—hard to say; 4—rather no; and 5—definitely no).

As Table 2 shows, the distribution of respondents is representative of the entire population of Latvia. According to the results of the survey, 67% of all respondents had carried out repairs or construction projects on their household during the last five years, which resulted in construction debris; 47% of respondents had carried out repairs and/or construction work on an apartment, compared to 36% on a private house and 6% on a summer house or garden house (private houses and summer houses in Latvia are mostly built from wood and wood-based materials).

**Table 2.** Distribution of respondents by age, sex, region, level of education, place and type of residence, and level of income.

| | Variable | Frequency | Percent |
|---|---|---|---|
| Sex | Male | 939 | 46.83 |
| | Female | 1066 | 53.17 |
| Age group | 18–24 years | 132 | 6.58 |
| | 25–34 years | 324 | 16.16 |
| | 35–44 years | 425 | 21.20 |
| | 45–54 years | 416 | 20.75 |
| | 55–63 years | 366 | 18.25 |
| | 64–75 years | 342 | 17.06 |
| Level of education | Primary Education | 37 | 1.85 |
| | Secondary, Vocational Secondary | 707 | 35.26 |
| | Higher Education | 1261 | 62.89 |
| Place of residence | Riga | 698 | 34.81 |
| | Riga region | 400 | 19.95 |
| | Vidzeme | 184 | 9.18 |
| | Kurzeme | 245 | 12.22 |
| | Zemgale | 219 | 10.92 |
| | Latgale | 259 | 12.92 |
| Type of residence | Apartment in a multi-apartment building | 1317 | 65.69 |
| | Private house | 651 | 32.47 |
| | Row house | 37 | 1.85 |
| Level of income per household member | 0–500 euro | 281 | 14.02 |
| | 501–1000 euro | 237 | 11.82 |
| | 1001–1500 euro | 279 | 13.92 |
| | 1501–2000 euro | 283 | 14.12 |
| | >2000 euro | 284 | 14.17 |
| | Difficult to say | 641 | 31.97 |

As shown in Figure 5, cardboard and paper were the most frequent type of waste obtained during renovation or construction projects (61%), while wood materials were also a common type of waste (46%).

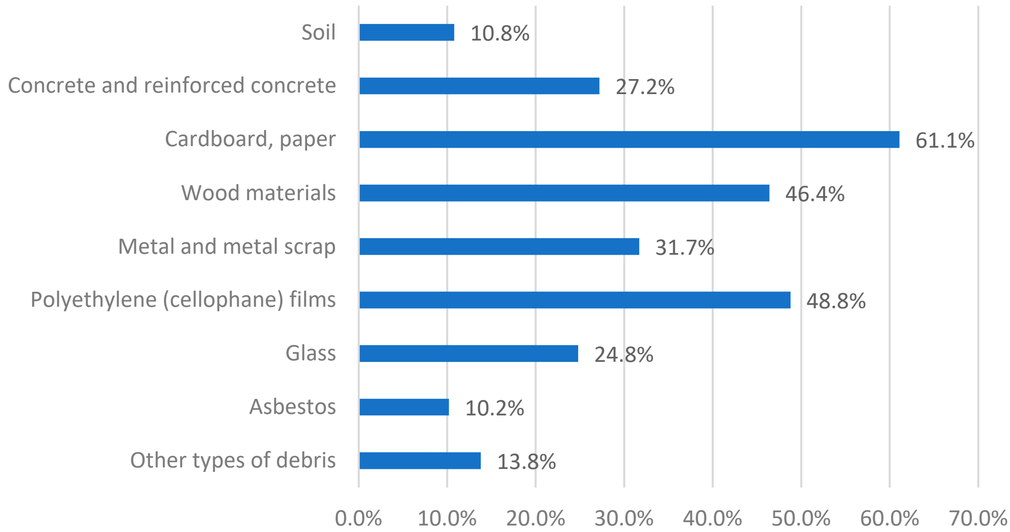


**Figure 5.** Distribution of types of construction or renovation debris generated by households while carrying out construction and renovation projects (multiple answers).

The current study was designed to analyze household problems during various construction or renovation projects and identify solutions for waste removal with possible recycling and optimization of household expenses since legal waste removal is quite expensive; for this purpose, the authors proposed the following hypotheses:

- H1: Female respondents are more willing to properly dispose of construction debris regardless of cost, and they prioritize the environmental impact.
- H2: Younger respondents are more willing to properly dispose of construction debris regardless of cost, and they prioritize the environmental impact.
- H3: Residents with higher education are more willing to properly dispose of construction debris regardless of cost, and they prioritize the environmental impact.
- H4: Residents from the Riga region are more willing to properly dispose of construction debris compared with those from rural regions regardless of cost, and they prioritize the environmental impact.
- H5: Respondents with higher incomes (>2000 euro) are more willing to properly dispose of construction debris regardless of cost, and they prioritize the environmental impact.

## 4. Results and Discussion

In order to determine the understanding of Latvian households about the possibilities of destruction or recycling of construction debris and their attitude toward legal possibilities of disposal or recycling of construction debris, the authors analyzed the descriptive statistics presented in Table 3.

The data in Table 3 suggest that 56.89% of respondents consider themselves to be sufficiently informed about the options for recycling/disposing of construction waste (the mean—2.792); 17% of the respondents agreed with the construction board about the projects that required it, while 3% stated that not all projects that require approval are coordinated; and 7% of the respondents stated that they are not aware of whether the projects carried out require the approval of the building board. Subsequently, in most cases, the decisions on CDW were left to individuals and were not recorded or dated, leaving no visible traces of the waste flow, what could be termed "shadow construction waste".

Most often, respondents got rid of repair and construction waste by throwing it into the common household waste container (34%) or burning it (29%). Respondents also tended to dispose of construction and demolition waste by taking the waste to the landfill with a special container for construction waste (19%), to the landfill themselves (16%), or to an enterprise or physical person that they found on the Internet or through a recommendation

(16%). In all, 14% of the respondents disposed of their repair and construction waste by using it to strengthen the road, and 10% used it to fill low (wet) places. Respondents also disposed of their repair and construction waste by taking it to the landfill with special construction waste bags (6%), selling it (4%), burying it (3%), and disposing of it in a forest, quarry, ditch, or similar place (1%); 17% of respondents stated that they were still storing the waste (or part of it). It can be assumed that respondents associated wood and wood-based waste management with "incineration/burning" (29%) and partially indicated "return with/free of charge" (16%) and "material storing" (17%).

**Table 3.** Descriptive statistics for respondents' awareness of construction debris recycling/disposal options and attitudes toward legal disposal of construction debris, depending on the cost and regardless of the harmfulness to the environment.

| Question | Mode | Median | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Do you consider yourself sufficiently informed about the options for recycling/disposing of construction debris? | 2 | 2 | 2.792 | 1.266 | 1 | 5 |
| A. You will choose to dispose of construction waste through legal disposal methods, regardless of financial expenses. | 2 | 2 | 2.51 | 1.23 | 1 | 5 |
| B. Are you willing to choose a cheaper service even if it results in environmental impact? | 4 | 4 | 3.54 | 1.30 | 1 | 5 |

In total, 63% of respondents had sorted their repair and construction waste for disposal in order to reduce costs; however, almost one-third of respondents had not done so in general; 10% knew that costs can be reduced this way, and 20% did not. It can be observed that repair and construction waste was more often sorted by respondents who carried out repairs on a private house and summer house/garden house as well as respondents living outside of Riga. Given the higher probability that wood and wood-based construction waste were sorted, this suggests a potential to participate in the circulation of wood products. The majority of respondents (59%) were aware that repair and construction waste was divided into hazardous waste and reusable or recyclable production materials. It can be observed that as the level of urbanization decreased, the proportion of respondents who knew that repair and construction waste was divided into hazardous waste and reusable or recyclable production materials increased.

In all, 41% of the respondents believed that, in general, there was a high possibility that the materials remaining after repair or construction would be offered to others on a special internet portal (fairly high—26%, very high—15%). However, one-third of respondents indicated that the opportunity to offer others repair/building material surplus was generally low or nonexistent (fairly low—13%, very low—11%).

As Table 3 shows, in general, respondents exhibited a positive attitude toward the proper disposal of construction debris, even if it incurred additional costs; 61.35% of users expressed a favorable disposition, indicating their full agreement or rather agreement with this stance. The same holds true for the question to choose a cheaper service even if it results in environmental impact. In this case, 60.55% of the respondents had a negative attitude toward this statement, indicating their readiness to prioritize proper disposal of construction debris. Overall, it can be concluded that users are willing to support the proper management of construction waste and are open to bearing the associated costs, fostering a more environmentally friendly approach to these issues.

Subsequently, the chi-square test was then used to assess the significance of any observed differences in the distribution of responses by sex, age, education level, place of residence, and income level, thereby testing the hypotheses set out in Section 3.

As the indicators in Table 4 show, no *p*-values exceeded 0.05, which means that differences in respondents' distribution by sex, age, region, education level, place of residence, and income level were statistically significant.

**Table 4.** Chi-square statistics and *p*-values according to the distribution of respondents by age, sex, education level, place of residence, and income level.

| Question | Factor | $X^2$ Test Results | | |
|---|---|---|---|---|
| | | Value | df | *p* |
| A | Sex | 29.23 | 4 | <0.001 |
| B | Sex | 17.35 | 4 | 0.002 |
| A | Age group | 43.01 | 20 | 0.002 |
| B | Age group | 36.26 | 20 | 0.014 |
| A | Education level | 26.02 | 8 | 0.001 |
| B | Education level | 21.09 | 8 | 0.007 |
| A | Place of residence | 46.15 | 20 | <0.001 |
| B | Place of residence | 46.61 | 20 | <0.001 |
| A | Income category | 60.83 | 20 | <0.001 |
| B | Income category | 52.58 | 20 | <0.001 |

Statistically significant differences were observed between males and females in their responses to questions. Females were more willing to properly dispose of construction debris regardless of cost, and they considered the environmental impact, while males were more inclined to opt for cheaper services despite potential environmental consequences, thus confirming H1.

Significant differences were found among various age groups, as indicated by researchers Benediktsdóttir and Gíslason [60]. Younger age groups (25–44 years) were more willing to choose proper disposal regardless of cost, while the elderly age group (45–63 years) was less likely to choose it. The younger age group (18–24 years) was less willing to prioritize the environmental impact over cost compared with elderly groups; thus, H2 is particularly confirmed.

Level of education significantly influenced responses. Respondents with higher education levels were more willing to properly dispose of debris regardless of cost, while individuals with a primary education were less inclined to prioritize the environmental impact over cost, thus confirming H3.

Residence location also affected the responses. Residents from Riga and the Riga region were more likely to opt for proper disposal regardless of cost but were less willing to prioritize the environmental impact over cost; therefore, H4 was partially proven only in the cost impact section.

Significant differences were observed among respondents in different income categories. Respondents with higher incomes (>2000 euro) were more willing to properly dispose of construction debris regardless of cost, and they prioritized the environmental impact. In contrast, those with lower incomes (0–500 euro) were less likely to choose proper disposal and were more inclined to opt for cheaper services despite potential environmental consequences, thus confirming H5.

In addition, some findings indicated a general awareness and willingness to participate and engage in the circular construction model:

(1) More than half of respondents (58%) would mostly use recycled construction debris in construction (rather yes—43%, definitely yes—15%), compared to 19% of respondents who would not (rather not—15%, definitely not—4%). It can be observed that men and younger respondents would use recycled construction debris more often in construction.

(2) An overwhelming majority of respondents (89%) generally believed that giving a "second life" to construction debris is essential and reduces the use of natural resources (rather yes—41%, definitely yes—48%). Only 5% of respondents were of the opposite opinion (rather not—4%, definitely not—1%).
(3) In general, 45% of respondents would pay a higher price for the removal of household repair or construction waste, knowing that it will in no case be thrown into nature and will be recycled for the production of new raw materials or building materials (rather yes—35%, definitely yes—10%). In all, 38% of respondents in general would not be ready to make such a payment (rather not—24%, definitely not—14%).

Regarding the evaluation of the effectiveness of municipal measures by the respondents, the following analysis was performed (Table 5).

**Table 5.** Descriptive statistics on the opinion of the respondents regarding the measures taken by municipalities to reduce disposal of renovation and construction debris in nature.

| Question | Mode | Median | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|---|
| Municipalities would more actively inform households about waste management procedure | 2 | 2 | 2.10 | 1.07 | 1 | 5 |
| More active informing of households about waste management procedure by waste managers | 2 | 2 | 2.09 | 1.05 | 1 | 5 |
| Reinforcement of waste control by local authorities (municipal police, building authorities) | 2 | 2 | 2.35 | 1.23 | 1 | 5 |
| Strengthening of the control of waste by state institutions (State Environmental Service, State Police) | 2 | 2 | 2.42 | 1.26 | 1 | 5 |
| Running social campaigns to reduce waste (e.g., forest cleanups, lectures to various community, etc.) | 2 | 2 | 2.35 | 1.20 | 1 | 5 |

As shown in Table 5, for this set of measures, it could be emphasized in the summary that, in general, both municipalities and waste management companies perceived active informing of households as relatively effective in reducing renovation and construction debris disposal in nature.

An overwhelming majority of the respondents (91%) stated that the state support program in Latvia is necessary in general to help the population dispose of hazardous repair and construction waste at lower costs (rather necessary—36%, very necessary—55%). It can be observed that such a program was most supported by respondents who believed the release of construction waste into nature in Latvia as a whole is a significant problem. Proactivity and both legal and financial support are expected from the state and municipalities, which could support or suppress the potential of construction waste circulation in general.

Research indicates that high processing technologies that require high investment and quality labor are options only in developed countries and that lower income countries should promote waste reduction and recycling and reduce waste disposal in landfills, using cheap labor resources for decentralized processing, low cost, and less technical processing methods such as landfilling [61]. The current study emphasized the need for lower-income economies to focus on the advantages of the circular economy in municipal solid waste (MSW) including CDW management, by promoting education of the citizens. The authors also propose integrated solid waste management (ISWM) as the best solution to achieve the least environmental impact and improve resource recovery from MSW to achieve GHG reductions and reduce landfilling through incineration and utilization organic waste treatment facilities, e.g., anaerobic digestion and composting [62]. A study comparing landfilling alone with a combination of landfilling with anaerobic digestion and composting revealed that the latter approach resulted in a reduction of up to 56% of net GHE [63]. The LCA approach can be used to compare alternative MSW management approaches and analyze existing management policies from the perspective of sustainability [64].

The current research is in line with studies conducted in the Baltic States, which found that CDW management in Latvia differs from that in Western and Northern European countries in several aspects, including that wood as a national renewable resource is one of the core components in increasing sustainability [26]. Building materials and construction products obtained during renovation and dismantling work are initially always classified as waste, so usable construction waste can be given end-of-waste status, thus preparing it for reuse or recycling, and this can be accomplished by companies with appropriate waste management permits; additionally, a quality control procedure must be developed for the application of the final status of construction waste.

According to the authors, the amount of construction material that ends up in secondary circulation in Latvia is relatively small, and this finding is related to several factors, starting from legislative deficiencies and inefficient administration and ending with the attitude of the population; this conclusion has been indicated in other studies [57].

As the experience assessed within current research shows, effective results in the beneficial use of household construction and demolition waste can be achieved by creating and developing public platforms and exchange points, so that residents can transfer for further use construction waste that can be used, including construction materials left over from repair, construction, and demolition projects, taking into account difficulties in technology applications (IoT), cost, and financial issues [43,44].

## 5. Conclusions

Currently, in order for the economy to be sustainable, it is necessary to move to the principles of circularity; this issue has been widely studied in the literature, and presently, 9R and even 60R circularity principles have been proposed. The application of these principles is essential in managing CDW, reusing building materials at their highest value, and reducing the amount of waste and the environmental destruction.

In order to prepare usable construction waste for reuse or recycling, it is necessary to grant an appropriate waste management permit to companies with developed quality control procedures; this approach can be offered to Latvian regulatory institutions. This model considers that the main prerequisite for effective and efficient management of construction and demolition waste is providing accurate, clear, and comprehensive information about the nature of construction and demolition waste and its management, with less harm to the environment and reduced costs.

CDW is an important waste flow, which can be turned into a resource by implementing the principle of waste circulation; to do this as efficiently as possible, it is necessary to significantly improve the appropriate management of construction waste generated in households and the awareness of citizens about the actions to be taken.

In order to motivate households to sort construction and demolition waste at the point of origin and to hand it over for reuse and/or recycling, households must be informed and create appropriate infrastructure for waste collection in municipalities. The collection system should be understandable, simple, and clear, and at the same time, the fee for waste collection and management should be understandable to the citizens.

Factors such as sex, age, education level, and place of residence play a significant role in the attitudes of citizens toward proper disposal of construction debris and considering the impact on the environment, and differences between them were observed. The survey carried out by the authors provides useful information for the development of future solutions to achieve changes in citizens' attitudes and behaviors in the management of CDW generated in households, including sorting and selection of CDW management companies.

Citizens should be as energy efficient as possible by designing new buildings and equipping them with clean energy solutions such as heat pumps, reducing the amount of energy consumed, reusing and refurbishing materials in existing buildings, using recycled materials where possible and future-proofing new buildings.

The studies carried out represent a significant contribution to the review of the household CDW management system and to the development of proposals for further policy-making in the field of waste management. Further research would require, inter alia, an in-depth analysis of the factors influencing the management of construction waste directly in the waste managers segment in order to prepare proposals for redirecting CDW from landfilling in favor of circularity solutions.

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