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# Construction and Demolition Waste and Recycling Opportunities: A Case Study of Novi Sad, Serbia

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**Abstract:** Construction and demolition waste (CDW) poses a significant environmental and economic challenge in urban areas, especially in rapidly developing cities. This study examines the types, quantities, and management practices of CDW in Novi Sad, Serbia, emphasizing recycling potential and sustainability. Drawing on data from local environmental authorities and recent waste generation reports (City of Novi Sad, 2024; SEPA, 2024), we identify key waste types and evaluate current recycling practices and infrastructure. The analysis reveals that soil and stones constitute the largest share of CDW in Novi Sad, with concrete, bricks, and metals also playing major roles. Although legal frameworks require selective collection and recycling, actual recycling rates are low. The paper proposes strategies to enhance recycling efficiency, such as investing in material recovery facilities, enforcing regulations more rigorously, and fostering public-private partnerships. These findings aim to guide local policy and advance circular economy goals and environmental protection.

**Keywords:** Construction waste, Demolition waste, Recycling, Novi Sad, Circular economy, Serbia, Waste management

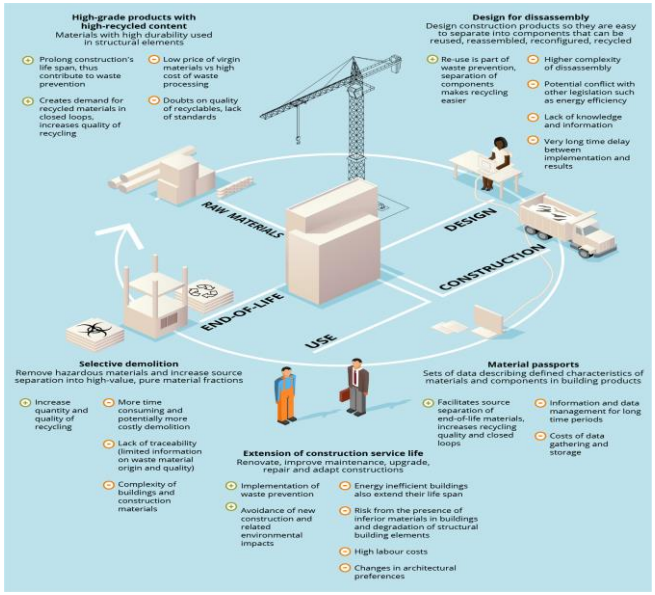
## 1. Introduction

Construction and demolition waste (CDW) is one of the heaviest and most voluminous waste streams generated in the European Union and globally (Fig. 1). It comprises a wide range of materials including concrete, bricks, wood, glass, metals, plastic, and excavated soil and stones. The mismanagement of this type of waste can result in significant environmental degradation, inefficient resource use, and increased pressure on landfills.

It is a rapidly growing waste stream worldwide, closely linked to urban development, population growth, and infrastructure expansion. According to the European Commission, CDW accounts for approximately 25%–30% of all waste generated in the European Union, making it the single largest waste stream by volume (European Commission, 2020). This trend is not limited to Europe; countries around the world are facing similar challenges in managing the environmental impact of construction activities (Fig. 2).

In high-income countries, significant attention has been given to reducing, reusing, and recycling CDW. For example, in the Netherlands, approximately 98% of CDW is recycled or reused, primarily as secondary raw materials in road base layers or new construction. This success is attributed to strong regulatory frameworks, market incentives for recycled materials, and the integration of circular economy principles into national waste strategies (Coelho and de Brito, 2011).

**Figure 1.** EU challenges and opportunities diagram – illustrates CDW flows,




issues, and strategic solutions in Europe.

Germany also demonstrates a robust system, where over 90% of mineral-based CDW is recycled. The country benefits from well-developed infrastructure for sorting and processing, as well as legal mandates for selective demolition and material recovery. In contrast, the United States still struggles with inconsistent CDW management practices across states. While some states like California have implemented stringent recycling targets and green building codes, others continue to rely heavily on landfilling due to low tipping fees and limited policy enforcement.

Emerging economies face even greater challenges. In rapidly urbanizing countries such as India and China, the volume of CDW has surged dramatically over the past decade. In China, it is estimated that the annual generation of CDW exceeds 3 billion tons, yet only a small percentage—less than 10%—is effectively recycled (Zhao et al., 2020). The lack of infrastructure, public awareness, and economic incentives contributes to low recycling rates and widespread illegal dumping.

India presents a similar case. With rapid urban sprawl and infrastructure development, CDW generation is expected to rise sharply. Despite the launch of the Construction and Demolition Waste Management Rules in 2016, implementation remains weak, especially at the municipal level. Studies indicate that over 50% of CDW in Indian cities remains uncollected or is dumped in open areas, leading to air and water pollution, encroachment on natural habitats, and public health risks.

In Latin America and Africa, data on CDW generation and treatment is often scarce. However, anecdotal evidence and case studies suggest that informal recycling practices are common, often carried out by unregulated workers who recover valuable materials such as metals and wood. While these activities provide income opportunities, they also expose workers to hazardous conditions and contribute to environmental degradation due to lack of safety measures and pollution control.

On a global scale, the push toward sustainable construction practices and circular economy models has sparked interest in improving CDW management. Innovations such as modular construction, prefabrication, and design-for-disassembly are being explored to reduce waste generation at the source. Furthermore, international initiatives like the UN's Sustainable Development Goal 11 (Sustainable Cities and Communities) emphasize the importance of resource-efficient construction and responsible waste management (Shao et al., 2022).

Despite these efforts, major obstacles remain, including the high cost of recycling infrastructure, inconsistent legislation, lack of standardized classification systems for waste, and limited market demand for recycled construction materials. Addressing these barriers requires coordinated action among policymakers, industry stakeholders, and the public (Yu et al., 2025).

In conclusion, while some countries have made significant progress in managing CDW sustainably, many others lag behind due to financial, institutional, and technical constraints. Lessons from global best practices can inform the development of more effective policies and systems in countries like Serbia, where urban centers such as Novi Sad are experiencing growth and increased pressure on waste management infrastructure.

Recycling construction and demolition waste (CDW) has emerged as a central strategy in the transition toward a circular economy in the construction sector. Successful recycling not only conserves natural resources and reduces landfill usage but also decreases greenhouse gas emissions and energy consumption associated with the production of virgin construction materials. However, recycling practices vary widely across regions due to differences in regulatory frameworks, economic incentives, infrastructure availability, and technological development (European Environment Agency, 2020).


**Figure 2.** Global CDW management market infographic

European countries are among the global leaders in CDW recycling. The European Union's Waste Framework Directive (2008/98/EC) mandates a minimum 70% recovery rate (by weight) for non-hazardous CDW. Several countries have exceeded this target through coordinated efforts involving regulation, incentives, and infrastructure investment (European Commission, 2016).

In many developing countries, formal recycling systems are underdeveloped, but informal practices play a significant role. In Brazil, for example, a large portion of CDW is recycled by small-scale enterprises that process debris into handmade bricks, pavers, and fill material. Municipalities such as Belo Horizonte have piloted public CDW collection and recycling centers, with some success in diverting materials from illegal dumping sites (Tseng, 2021).

South Africa has launched initiatives such as the Waste Economy Master Plan to increase CDW recovery through extended producer responsibility and green job creation. Pilot projects in Cape Town have demonstrated the viability of crushing concrete and masonry into secondary materials for use in low-cost housing developments.

Several technological innovations are advancing the global capacity to recycle CDW more efficiently. Mobile crushers and screening units now allow on-site processing of concrete and masonry waste, reducing transportation emissions and costs (Ragossnig, 2020). Artificial intelligence (AI) and robotics are increasingly being used for automated sorting and deconstruction, improving accuracy and material purity (Fig. 3). (Saka et al., 2024)

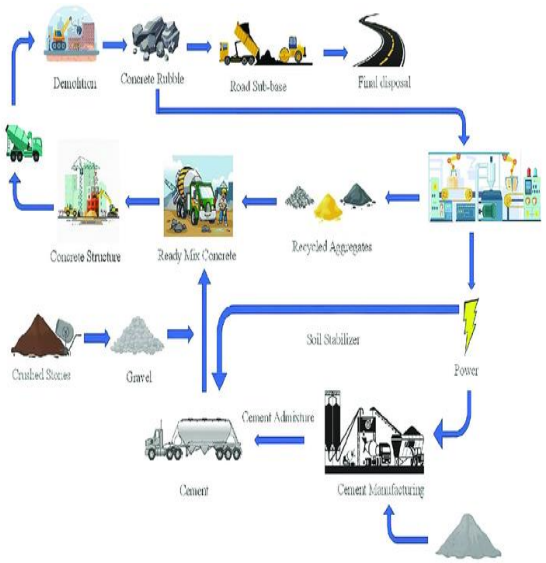



**Figure 3.** Production and recycling process schematic – detailed flow of CDW materials to recycled aggregates.

Materials science research has also expanded the potential applications of recycled CDW. For example, fine recycled aggregates are now being integrated into prefabricated concrete panels and non-structural building elements. Carbon capture techniques are being explored in the curing process of recycled concrete blocks to improve environmental performance (Papamichael et al, 2023).

Despite the progress in many parts of the world, CDW recycling still faces significant challenges, including the lack of standardized quality specifications, low demand for recycled products, contamination of materials, and weak enforcement of waste regulations. Financial incentives, public procurement standards, and urban planning policies that prioritize reuse and recycling are critical to overcoming these barriers (Bajwa et al., 2025).

Governments, construction companies, and civil society must work collaboratively to scale up successful models and integrate circular thinking into the life cycle of buildings. As global demand for raw materials continues to rise, the role of CDW recycling will become even more central to achieving sustainability goal (Cook and Velis, 2022).

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In Serbia, and particularly in the city of Novi Sad, urban expansion and infrastructure development have led to increasing amounts of CDW. Although Serbian legislation aligns with EU directives to some extent, the implementation and efficiency of recycling practices vary significantly across municipalities. Novi Sad, as the second-largest city in Serbia, provides a representative case for examining the challenges and opportunities in CDW recycling (SEPA 2024; Statistical Office of Republic of Serbia, 2024).

An important recent development in the Serbian regulatory framework is the new Regulation on the Management of Construction Waste (Regulation, 2024). This Regulation introduces the obligation to prepare and approve a Construction Waste Management Plan for construction, demolition, and removal works. Importantly, the Plan must be prepared already at the building permit project stage, which strengthens the responsibility of the investor/owner and enables earlier and more systematic control of CDW generation, sorting, storage, and final treatment. This measure provides a concrete opportunity for improving construction waste management in cities such as Novi Sad in the near future.

This paper aims to analyze the quantities and types of CDW generated in Novi Sad, assess current waste management practices, and propose sustainable solutions to enhance recycling rates. Using data collected from local environmental reports and statistical analyses, this research contributes to the understanding of urban waste dynamics in the Western Balkans and offers practical policy recommendations.

## 2. Materials and Methods

This study employs a descriptive and analytical methodology based on the review and processing of official data on construction and demolition waste generated in the territory of Novi Sad. The municipal dataset used in this study is based on several key city-level documents and reports, including: Local Waste Management Plan For the City of Novi Sad for the Period 2023-2032. ("Official Gazette of the City of Novi Sad", No. 21/2023) 2023–2032 (City of Novi Sad), the Annual Report on Generated and Processed Waste for the City of Novi Sad, reports from licensed construction and demolition waste operators active in the Novi Sad administrative area, and relevant chapters of the

Environmental Protection Programme of the City of Novi Sad. These documents provide detailed information on CDW quantities, composition, and current management practices at the local level. Primary data were sourced from the official reports on generated waste quantities, which presents detailed information on the types and volumes of CDW collected and categorized by composition.

The analysis includes the classification of waste types according to standard categories such as concrete, bricks, ceramics, wood, glass, plastic, metals, cables, insulation materials, gypsum-based materials, and soil and stones. Quantitative data were analyzed to determine the relative proportions of each waste type and to evaluate trends in waste generation.

Supplementary data on legal frameworks, infrastructure availability, and recycling practices in Serbia and the city of Novi Sad were obtained from local municipal sources, academic literature, and international guidelines on construction waste management.

## 3. Results

The main source of data used in this study includes data collected from construction sites and waste management operators in Novi Sad for a recent one-year period. These data form the empirical basis for evaluating current waste management practices and estimating the potential for material recovery and recycling in Novi Sad's construction sector (City of Novi Sad, 2024).

The data analysis reveals that soil and stones constitute by far the largest portion of CDW in Novi Sad, accounting for over 90% of the total volume. This category, often associated with excavation and earthworks, poses specific challenges for reuse and recycling due to contamination and variability in composition.

Following soil and stones, bricks and concrete are the most significant contributors to the CDW stream. These materials have well-established recycling methods and are often used as secondary aggregates in road construction or as base materials in new building projects. However, their actual recovery rates remain modest due to lack of separation at source, insufficient infrastructure, and limited market demand for recycled materials.

Metals, particularly iron and steel, represent a valuable waste stream with high recycling potential and existing markets. Despite their relatively low volume compared to inert materials, they offer economic incentives for recovery.

Other waste types such as ceramics, wood, glass, plastics, and insulation materials appear in much smaller quantities. Their recycling potential is currently underutilized, mostly due to technological and economic constraints. These materials require specialized treatment facilities that are not yet sufficiently developed in Novi Sad or the broader region.

The quantitative analysis of CDW composition in Novi Sad is presented in Figure 4. A horizontal bar chart was used to effectively visualize the significant disparity in the proportions of different waste types, particularly to highlight the very small but potentially valuable fractions.

The analysis reveals the extreme dominance of soil and stones, which constitute the vast majority of the waste stream at 93.22%. The second and third most prevalent materials are bricks (2.80%) and concrete (2.53%), which are clearly visible and comparable on the chart. All other materials each account for less than 1.0% of the total CDW. Among these, gypsum-based materials (1.00%) and metals, specifically iron and steel (0.25%), are the most significant. The remaining fractions (wood, cables, insulation, ceramics, glass, and plastic)

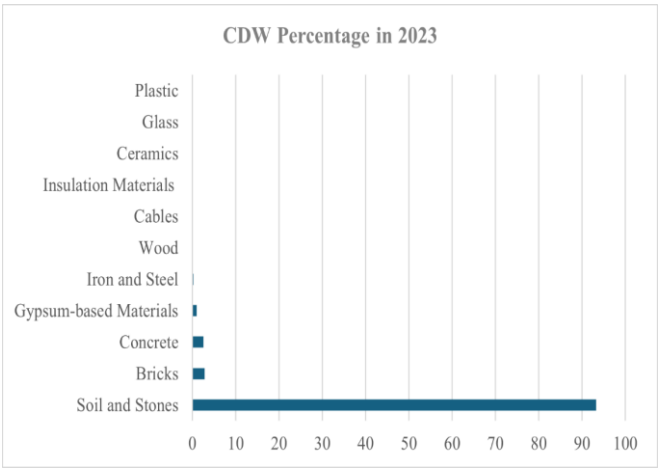


**Figure 4.** Horizontajl bar chart showing the composition of CDW in Novi Sad by material type.

collectively represent less than 0.20% and are all easily identifiable on the horizontal bar chart, which allows for a clear comparison of their minimal but non-zero values.

This composition is typical for urban construction sites and underscores the critical need for targeted management strategies for the mineral fraction (soil, stones, bricks, concrete) and the development of specialized recycling channels for the smaller, yet valuable, fractions like metals.

This composition illustrates the dominance of inert and mineral-based waste, which is typical for urban construction sites. It also underscores the need for systematic sorting and targeted investments in recycling infrastructure.

In the current context, CDW management in Novi Sad is primarily reliant on disposal, with limited instances of material recovery. Factors contributing to this situation include inadequate enforcement of construction waste regulations, lack of incentives for recycling, and the absence of well-equipped facilities. Public awareness regarding the benefits of recycling and circular construction practices also remains low.

To improve CDW recycling in Novi Sad, strategic interventions are needed. These may include the introduction of mandatory waste separation on construction sites, subsidies for recyclers, development of local markets for secondary materials, and stronger cooperation between municipalities and private companies. Moreover, incorporating circular economy principles into urban planning and public procurement processes can provide long-term benefits for both the environment and the local economy.

# 4. Conclusion

The findings of this study, visually emphasized by the horizontal bar chart analysis, unequivocally demonstrate the overwhelming dominance of soil and stones (93.22%) in the CDW stream of Novi Sad. This composition presents both a significant challenge and a clear opportunity. While the recycling potential for inert mineral fractions (bricks, concrete) and valuable metals exists, the current infrastructure, regulatory enforcement, and economic incentives remain insufficient to support a transition to sustainable waste management practices.

Improving the CDW recycling system in Novi Sad requires a multi-faceted and modern approach, drawing on successful global practices:

Infrastructure Investment: The establishment of a modern, regional CDW recycling center equipped with mechanical screening and crushing technology is paramount. This facility should specifically handle the large volume of soil and stones, focusing on screening for contamination and processing for reuse in earthworks and construction backfill, following the examples set by Western European countries.

Regulatory Strengthening and Enforcement: Moving beyond existing mandates, stricter enforcement of waste separation at source on construction sites is needed. This should be complemented by the introduction of digital waste tracking tickets to monitor CDW flows from generation to final disposal or recycling, ensuring transparency and accountability.

Economic and Market Incentives: To stimulate demand, public procurement policies must be updated to mandate the use of recycled CDW materials (e.g., recycled concrete aggregate, processed soil) in municipal infrastructure projects. Additionally, the introduction of a reduced VAT rate for products containing recycled content could boost market competitiveness, mirroring successful incentives in the EU.

Targeted Material Recovery: While managing the mineral fraction is crucial, strategies must also create pathways for high-value, low-volume streams. This includes promoting on-site separation of metals (which have a ready market) and exploring innovative solutions for gypsum recycling, thus embracing the principle of material-specific valorization.

Data-Driven Policy and Awareness: Enhancing the quality and transparency of CDW data is fundamental for informed policy-making. Concurrently, professional training programs for construction managers and architects on circular economy principles and deconstruction techniques are essential to reduce waste generation at the source.

By adopting these measures, which combine infrastructure modernization, regulatory diligence, economic incentives, and targeted material recovery, Novi Sad can transform its CDW management from a linear disposal model to a circular, resource-efficient system. This transition is not only critical for achieving local and national environmental objectives but also for aligning with broader European Green Deal goals and building a more resilient and sustainable construction sector.

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# References

Bajwa, A. U. R., Siriwardana, C., & Naeem, M. A. (2025). Material selection in the construction industry: a systematic literature review on MCDM. arXiv. https://arxiv.org/abs/2409.13112

City of Novi Sad. (2024). Local waste management plan for the city of novi sad for the period 2023-2032. Of the year ("Official Gazette of the City of Novi Sad", no. 21/2023) https://www.eupropisi.com/dokumenti/NS_021_2023_001.pdf

Coelho, A., & de Brito, J. (2011). Distribution of materials in construction and demolition waste in Portugal. *Waste Management*, 31(6), 1464–1474. https://doi.org/10.1016/j.wasman.2011.03.010

Cook, E., & Velis, C. (2022). A material flow systems approach to occupational and public health hazards from CDW in LIMICs. *Frontiers in Sustainability*, 3, 924926. https://doi.org/10.3389/frsus.2022.924926

European Commission. (2016). EU Construction and Demolition Waste Protocol and Guidelines. Brussels. https://single-market-economy.ec.europa.eu/news/eu-construction-and-demolition-waste-protocol-2018-09-18_en

European Commission. (2020). A new Circular Economy Action Plan. For a cleaner and more competitive Europe. Brussels. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0098

European Environment Agency. (2020). Construction and demolition waste: challenges and opportunities in a circular economy. https://www.eea.europa.eu/en/analysis/publications/construction-and-demolition-waste-challenges

Papamichael, I., Voukkali, I., Loizia, P., & Zorpas, A. A. (2023). Construction and demolition waste framework of circular economy: A mini review. *Waste Management & Research*. https://doi.org/10.1177/0734242X231190804

Ragossnig, A. M. (2020). Construction and demolition waste — Major challenges ahead!. *Waste Management Research*, 38(6), 1–10. https://doi.org/10.1177/0734242X20910309

Regulation (2024). Regulation on the management of construction waste during execution of works (Official Gazette of the Republic of Serbia, No. 81/2024).

Saka, A., Taiwo, R., & Oluleye, B. (2024). Integrated BIM and Machine Learning system for circularity prediction of construction demolition waste. arXiv. https://arxiv.org/abs/2407.14847

SEPA (2024). Report on waste management 2011-2023 (in Serbian). Serbian Environmental Protection Agency, Ministry of Environmental Protection, Republic of Serbia. https://sepa.gov.rs/wp-content/uploads/2024/12/Otpad2011-2023.pdf

Shao, Z., Li, M., & Yu, D. (2022). Bibliometric analysis of construction and demolition waste recycling: review and prospects. *Proceedings of the Institution of Civil Engineers - Engineering Sustainability*.

https://doi.org/10.1680/jensu.21.00089

Statistical Office of Republic of Serbia (2024) Waste generation and treatment, Table: Waste treatment by treatment category, waste category (EWC-STAT) and hazardousness, 2023. https://data.stat.gov.rs/Home/Result/2502010201?languageCode=en-US&displayMode=table

Tseng, M.-L., Jeng, S.-Y., Lin, C.-W., & Lim, M. K. (2021). Recycled construction and demolition waste material: a cost–benefit analysis under uncertainty. *Management of Environmental Quality*, 32(3), 665–680. https://doi.org/10.1108/MEQ-08-2020-0175

Yu, L., Ge, Q., Han, K., Ji, W., & Liu, Y. (2025). Designing optimal subsidy schemes and recycling plans for sustainable treatment of construction and demolition waste. arXiv. https://arxiv.org/abs/2504.10955

Zhao, W., Leeftink, R. B., & Rotter, V. S. (2020). Evaluation of the economic feasibility for the recycling of construction and demolition waste in China—The case of Chongqing. Resources, *Conservation and Recycling,* 154, 104563. https://doi.org/10.1016/j.resconrec.2019.104563

# Otpad od građenja i rušenja i mogućnosti njegove reciklaže: Studija slučaja Novog Sada, Srbija

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**Apstrakt:** Otpad od građenja i rušenja predstavlja sve veći ekološki i ekonomski izazov u urbanim područjima, posebno u gradovima koji se brzo razvijaju. Ova studija ispituje vrste, količine i prakse upravljanja otpadom od građenja i rušenja u Novom Sadu, Srbija, sa fokusom na potencijal recikliranja i održivost. Koristeći podatke od lokalne samouprave i iz nedavnih izveštaja o generisanju otpada (Grad Novi Sad, 2024; SEPA, 2024), identifikovane su ključne vrste otpada i procenjene trenutne prakse recikliranja i infrastrukturu. Analiza pokazuje da zemlja i kamen čine najveći deo otpada od građenja i rušenja u Novom Sadu, dok materijali poput betona, cigle i metala takođe igraju značajnu ulogu. Iako pravni okvir zahteva selektivno sakupljanje i recikliranje, stvarne stope reciklaže su niske. Rad predlaže strategije za poboljšanje efikasnosti reciklaže, uključujući ulaganja u objekte za oporavak materijala, strožiju primenu propisa i javno-privatna partnerstva. Ovi nalazi imaju za cilj da informišu lokalnu politiku i doprinesu širim ciljevima cirkularne ekonomije i zaštite životne sredine.

**Ključne reči:** Građevinski otpad, Otpad od rušenja, Reciklaža, Novi Sad, Cirkularna ekonomija, Srbija, Upravljanje otpadom