https://doi.org/10.7494/geom.2026.20.4.151

A Comparative Analysis of Legal Frameworks for Circularity in the Built Environment: A Large Language Model-Assisted Study of Nine Jurisdictions Supporting the Sustainable Development Goals

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Abstract: The high consumption of raw materials and the generation of construction and demolition waste (CDW) represent significant sustainability challenges. The circular economy (CE) offers a promising pathway but requires effective

legislation. Although considerable attention has been devoted to the technical and economic aspects of CE, comparative analyses of national regulatory frameworks remain scarce. This study addresses this gap by conducting a comparative analysis of the regulatory environments of nine countries: Cyprus, Estonia, Greece, Latvia, Poland, Romania, Slovenia, Switzerland, and Türkiye. With a retrieval-augmented generation (RAG) architecture based on a large language model (LLM), national and regional legal texts were analysed and fact-checked by experts. The results reveal substantial differences in regulatory maturity, enforcement mechanisms, and data platforms, resulting in the identification of three country clusters. The findings indicate that effective CDW management depends on legislative harmonisation, institutional capacity, data openness, and economic incentives. In addition, the study suggests that LLMs can serve as powerful instruments for comparative legal analysis in multilingual sustainability research.

Keywords: construction and demolition waste, circular economy, comparative analysis, large language model, legal text, SDG 12

Received: March 6, 2026; accepted: May 7, 2026

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1. Introduction

Global pressure to reduce the environmental impact of the construction sector is mounting amid growing urbanisation and the depletion of natural resources [1]. This sector is responsible for a significant proportion of global raw material consumption and waste production. Construction and demolition waste (CDW) has a significant environmental impact, largely influenced by disposal methods [2]. In addition to conventional patterns of material consumption and management, climate change and the increasing frequency of extreme weather events lead to more construction disasters [3], resulting in additional, unplanned construction waste. In response to these challenges, the concept of the circular economy (CE) is gaining importance as a key paradigm for sustainable development [4].

The shift towards CE is increasingly driven by the convergence of digital innovation and resource-efficiency strategies. Recent scholarship underscores that the efficacy of the material bank concept is inextricably linked to the integration of Digital Twin technology, Building Information Modelling (BIM), and standardised material passports, which facilitate the traceability and quality assurance of secondary resources throughout a building's life cycle [5, 6]. These digital systems serve as the primary mechanism for translating high-level circularity goals into operational data, allowing for the quantification of environmental impact and the mitigation of risks associated with recovered materials [7]. However, the deployment of these digital infrastructures remains uneven, often hampered by institutional rigidities, a lack of assessment tools, and limited data interoperability [8]. While the technical potential for digital resource management is substantial, the legal instruments necessary to enforce these data-driven practices are often missing or fragmented, leaving a void in which technological capability outpaces governance capacity [9].

The contemporary implementation of the Sustainable Development Goals (SDGs), particularly Goal 12, concerning responsible consumption and production, necessitates a radical departure from the linear economic model in favour of a CE in cities [10, 11, p. 12]. In the context of CDW, this transformation relies on perceiving buildings as material banks, in which appropriate Design for Disassembly enables the preservation of the highest utility value of raw materials at the end of a structure's life cycle, thereby minimising the demand for primary materials [12]. The reuse and recycling of construction waste in new structures constitute a fundamental pillar of the decarbonisation of industrial processes and the reduction of the construction sector's carbon footprint [13, 14]. However, for this process to be effective at a macroeconomic scale, it is essential to standardise certification systems for recovered materials and implement digital product passports [15–17], ensuring the safety and durability of new engineering structures. All these elements arise directly from prevailing legal requirements. Although numerous studies focus on the technical, environmental, and economic aspects of circularity in construction materials [18–20], there is a lack of comprehensive comparative analysis of legal frameworks in different jurisdictions.

Existing publications often limit themselves to analysing individual countries or regions, failing to offer a global perspective on the diversity and effectiveness of the legal solutions adopted [21, 22]. This gap in the literature is particularly significant because the effectiveness of CE implementation is largely dependent on the legislative framework, which can be both a stimulus and a barrier to innovation.

The aim of this article is to conduct a comparative analysis of the legal frameworks regulating the closed-loop circulation of waste materials in the construction sector across nine countries selected for their diverse legislative approaches and levels of economic development. An additional objective is to identify common challenges and innovative solutions that could serve as models for future regulations. The analysis conducted in this paper is supported by a large language model (LLM) embedded within artificial intelligence (AI) tools. From a technical point of view, this study demonstrates the potential of employing an LLM for comparative text analysis of content written not only in different languages but also in different alphabets.

2. Materials and Methods

The study is based on an analysis of national and supranational policy, legal, and strategic documents adopted at the national and, where applicable, regional and local levels from nine countries: Cyprus, Estonia, Greece, Latvia, Poland, Romania, Slovenia, Switzerland, and Türkiye (see Appendix). The selected countries show diversity in several dimensions, including EU/non-EU status, large–medium–small population size, and continental/interconnected vs. island/isolated settings. The selection of these nine countries forms a robust analytical framework owing to their diversity in economic development, encompassing both EU member states and non-EU members, as well as different stages of development, including highly developed countries with dominant service economies such as Switzerland and Estonia, and more industrial nations or natural-resource dependent countries such as Poland and Türkiye.

The legal documents were selected by the authors, who are experts in the field. To ensure a comprehensive collection, the documents were retrieved from official governmental and supranational databases (e.g., EUR-Lex for EU directives, national Official Gazettes, or specific Ministry of Environment portals). The search process involved a review of these repositories for documents using keywords such as environmental protection, climate change policy, waste management, and sustainability. It is important to note that the analysis is based only on publicly available environmental laws and, therefore, provides a limited overview of the situation, as in countries such as Estonia and Latvia several environmental rules are set out in supplementary governmental documents and secondary regulations.

The document corpus included national, regional, and local legislation, strategies, and policy documents directly related to CDW management. Documents were selected based on their official legal status, their relationship to institutional governance, and whether they were in force at the time of analysis. Only officially published documents with legal or political force were included. The analytical framework for this study used a retrieval-augmented generation (RAG) system deployed in a scalable cloud environment. This system integrates semantic vector search using Google Cloud Vertex AI Search. A dedicated knowledge base, created from the analysed documents, was used in combination with a state-of-the-art LLM (Gemini 2.5 Pro). This architecture ensured that all generated analyses and data were closely grounded in the provided source materials. To ensure the quality and validation of the results, Google NotebookLM was used as an independent tool to verify the consistency of the generated conclusions with the source texts.

This architecture, in turn, enabled unified semantic searches across multiple languages by leveraging multilingual, multidimensional vector embeddings. This approach facilitated precise legal interpretation. The search and analysis process used the Gemini LLM (Gemini 2.5 Pro), a state-of-the-art LLM known for its large context window and advanced inference capabilities. This configuration ensured that all data and analyses were closely grounded in the provided source materials.

The research was conducted using a two-stage, mixed-method approach that combined AI-powered text analysis with expert human validation. In the first stage, the entire body of documents was processed using AI-based text analysis tools to generate comprehensive, descriptive summaries of the legal and institutional frameworks for each country. The main objective of this stage was to extract and organise information into a standardised comparative framework. This enabled a consistent assessment of all systems. This preliminary result served as an organised but unverified basis for further analysis.

In the second stage, each country-specific summary underwent rigorous verification carried out by members of the research team. This human validation stage aimed to confirm the factual accuracy of the AI-generated summaries and correct any misinterpretations of the national context. Only after expert verification were the data considered validated. From this point forward, the legal documents and regulations of each country will be referred to collectively as ‘Country Name’.

3. Results

3.1. LLM-Based Text Analysis

The comparative evaluation of CDW governance across eight European and associated countries, based on detailed textual analyses of national legislation, policy documents, and implementation frameworks, reveals notable variation

in regulatory maturity, enforcement, and data systems. Scores (on a 0–1 scale) were averaged across six equally weighted dimensions: EU alignment, specific CDW targets, enforcement centralisation, 'polluter pays' principle, secondary market strength, and data availability based on the national, regional, and local documents. Average national scores range from 0.42 (Latvia) to 0.92 (Greece), indicating substantial variation in policy implementation and CE readiness. The clustering reflects the relative maturity and coherence of each country's CE and CDW governance systems. Based on these analyses, three groups were identified. Group 1 (Leaders and Integrated Systems) includes countries with comprehensive legal frameworks, established enforcement mechanisms, and functioning monitoring and market instruments, representing mature and integrated CE systems. Group 2 (Mixed Implementation Profiles) encompasses countries that have largely transposed EU directives and set strategic objectives but exhibit partial implementation, fragmented governance, or limited data reliability. Group 3 (Structural Challenges) comprises countries where CDW management remains underdeveloped, characterised by weak enforcement, low market uptake of secondary materials, and insufficient institutional capacity. This three-tier grouping enables differentiation between formal policy alignment and practical circularity outcomes, highlighting how systemic integration and data transparency distinguish leading systems from those still in transition.

Greece had the highest total score, at 0.92, indicating a completely transposed and operational legal framework that ensures EU conformity (Fig. 1). Enforcement is centralised through the Ministry of Environment and EOAN, and data quality ranks among the highest observed. For example, Law 4819/2021 transposes the 2018 Waste Directives and establishes a robust traceability system that requires the use of GPS location coordinates and verified weights. Only minor deficiencies were identified in the maturity of secondary markets, particularly for non-mineral fractions. Slovenia's composite score of 0.73 indicates its alignment with EU requirements and the existence of legally binding CDW recovery targets. The country effectively enforces monitoring through inspectorates and environmental agencies and currently meets the EU's 70% CDW recovery target.

Slovenia is followed by Switzerland, a non-EU country with a composite performance score of 0.60, which demonstrates a desire to explicitly align with EU waste principles. Switzerland's framework strongly incorporates the 'polluter pays' principle, and mineral waste recovery performance in Switzerland is above 80% (Fig. 1). However, waste management enforcement is decentralised across Switzerland's 26 cantons, resulting in geographical variation in implementation. The Federal Office for the Environment is responsible for aggregating data across cantons to provide a national overview, while it acknowledges that inherent variability imposes limitations.

Cyprus (0.73) demonstrates high alignment with EU directives and legally binding CDW recovery targets (≥70%) (Fig. 2). Cyprus applies strong 'polluter pays'

instruments, though enforcement fragmentation and weak data systems constrain performance. It benefits from substantial financial penalties and extended producer responsibility (EPR) mechanisms. Cyprus, however, faces barriers to market demand for secondary materials and gaps in data completeness.

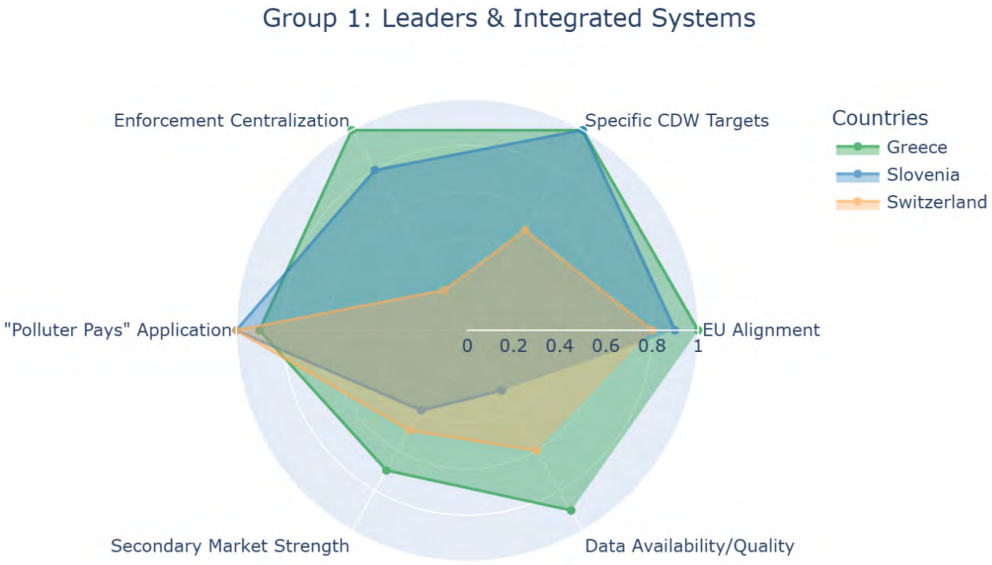

Fig. 1. Scores of Greece, Slovenia, and Switzerland across six equally weighted dimensions

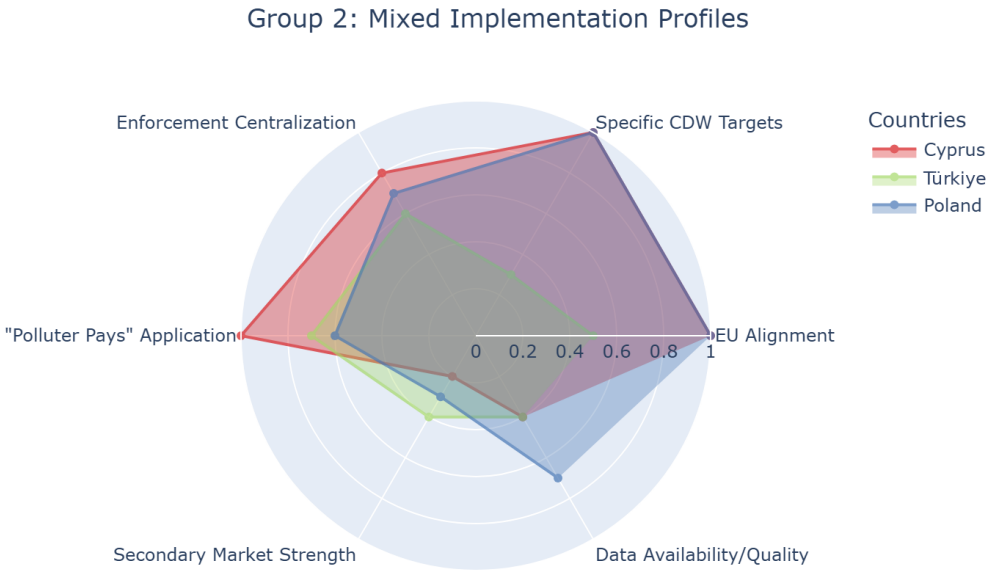

Fig. 2. Scores of Cyprus, Türkiye and Poland across six equally weighted dimensions

Türkiye (0.48) demonstrates convergence towards EU standards via the Zero Waste programme and End-of-Waste (EoW) initiatives. Its regulatory framework combines centralised policy formulation with municipal enforcement and conditional incentives; however, the absence of explicit CDW targets, combined with limited monitoring mechanisms, continues to inhibit CDW recovery performance.

Türkiye's framework, which is based on both regulatory and developmental approaches, is founded on the Regulation on the Control of Excavation Soil, Construction and Demolition Waste. It relies on the development of the Zero Waste strategy (60% recycling targets by 2035) and projects aimed at developing EoW criteria, both of which demonstrate significant convergence with EU standards for developing regulatory criteria, although comprehensive circularity criteria and high-quality recovery pathways have yet to be established. It also provides tax reductions and energy discounts for sites certified as zero waste.

Poland (0.72) applies full transposition of the WFD (Waste Framework Directive) and consistent monitoring through the national registry, the BDO (Central Database on Products, Packaging and Waste Management). The 70% CDW recovery target has also been achieved, while enforcement is managed through national inspectorates. However, illegal dumping and incomplete data reporting remain challenges. Economic instruments are in place, but strengthening enforcement remains essential. The secondary materials market is developing but remains focused primarily on mineral fractions.

Estonia (0.53) and Romania (0.45) operate within transitional systems. Estonia's CE framework is closely aligned with EU principles. However, enforcement is decentralised, and the markets for CDW materials remain immature.

Romania has a functioning central oversight apparatus, which includes continuous monitoring by ANPM (National Environmental Protection Agency), but CDW recovery and reuse are predominantly implemented for mineral/inert fractions (concrete, bricks, tiles, and soils), mainly via crushing and their use as aggregates for backfilling or road construction, while recovery of non-mineral fractions (metals, wood, gypsum, glass, plastics, and insulation materials) is limited, fragmented, and often diverted to informal collection or disposal rather than high-value recycling.

Both countries face limitations in data reliability that constrain the comprehensive assessment of CDW outcomes. Territorial responsibilities for stakeholders generally conform to the waste producer–holder principle, although its implementation is more operationally variable. In Romania, permit holders are responsible for preparing waste management plans for permit approvals. Latvia (0.42) ranks the lowest, despite its formal alignment with the EU. National CDW targets lack enforcement capacity, and limited incentives to apply the 'polluter pays' principle, along with low landfill costs and limited market incentives, signify a lack of progress. The data systems remain inconsistent and are currently under external review, reflecting Latvia's overall lowest performance in the dataset. Economic instruments and

control instruments differ substantially. Latvia and Estonia employ differential fee schemes and have also implemented a landfill tax to incentivise waste separation and recycling.

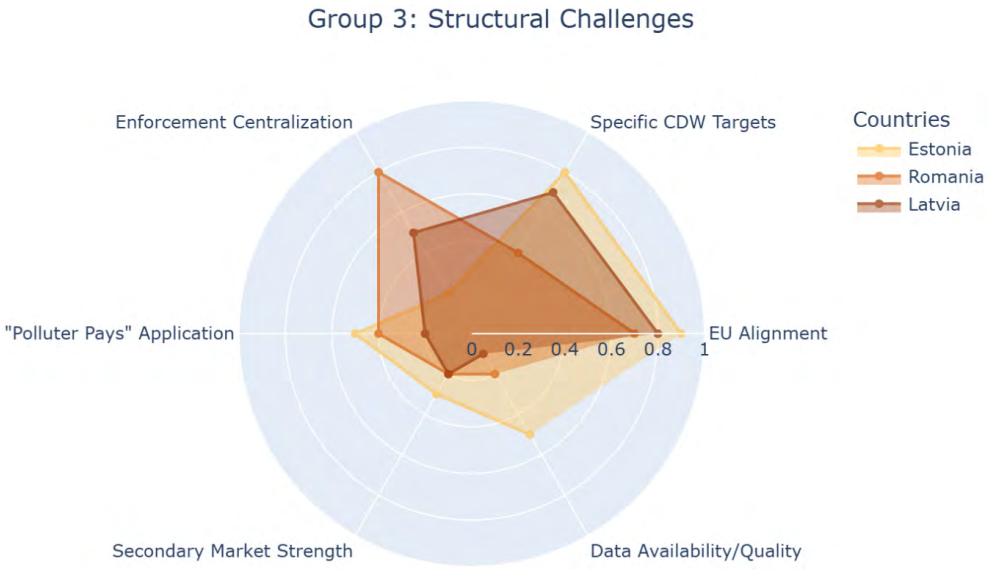

Fig. 3. Scores of Estonia, Romania and Latvia across six equally weighted dimensions

Romania has implemented a landfill tax and 'pay-as-you-throw' pilots, although it is far from fully implemented nationwide. Based on the analyses, enforcement capacity is moderate in Estonia and Romania, but weakest in Latvia.

In summary, the results highlight an uneven landscape of CDW governance. Slovenia and Romania embed circularity through green public procurement and national strategies; Estonia promotes digitalisation and innovation ecosystems; Latvia focuses on non-binding on-site sorting guidelines; and Türkiye and Switzerland develop technical standards for EoW criteria and material quality. The findings suggest that effective CDW management depends not only on the legal transposition of EU directives but also on administrative capacity, data integrity, and the presence of economic incentives supporting circular outcomes.

3.2. LLM-Based Cross-Sectional Analysis

A cross-sectional analysis reveals three distinct trends. First, achieving policy alignment does not necessarily mean that a country will implement the policy. All but one of the countries sampled had either transposed or otherwise harmonised with the relevant EU directives; however, enforcement, regulatory frameworks, and

market activation remain unsettled and inconsistent in practice. Second, although 'digitalisation' is a new institutional imperative, countries are beginning to deploy digital tools (e.g., Greece's GPS traceability, Estonia's e-construction, and Slovenia's CinderOSS) that improve data transparency and tracking of the life cycle of materials. Lastly, the weakest dimensions across all sampled countries were the development of secondary markets for materials generated as CDW and the establishment of standardised EoW criteria with legally recognised and regulated attribution. Both of these dimensions are critical to ensuring material recirculation beyond the recovery of mineral fractions and other resource-intensive construction products.

To evaluate the policy landscape, we employed a qualitative maturity matrix (Table 1). Each country was assessed based on the comprehensiveness of its legal framework, the effectiveness of its enforcement, and the degree of integration with broader CE strategies. The findings were categorised into three levels: Comprehensive (green), where policy is clearly articulated, legally binding, and actively monitored with specific circularity metrics; Partial (orange), where frameworks exist but are either fragmented, lack specific CDW-focus, or suffer from implementation gaps; and Absent (red), where specific CDW legislation is non-existent, and policy is restricted to general waste management guidelines. In short, European and associated states recognise converging policy directions towards circularity in construction; however, performance remains uneven (Table 1). The high-performing circular systems (Group 1) achieve legal clarity absent in lower-performing systems and have legally mandated paths and processes for data-tracing systems to promote economic incentives and predictable returns for diverted materials. The mid-tier countries also reflect execution gaps, and in the lower tier (Group 3) the cases reveal the importance of institutional capacity for enforcing data-traced systems, reliable information systems, and demand-side instruments to close the loop in buildings and infrastructural construction materials. Future policy considerations should focus on how to establish clear EoW criteria, how to harmonise these standards across the EU and associated states, and how to integrate cross-border digital information systems and fiscal instruments to promote circular construction practices.

Based on the results of the LLM analysis, experts from each country reviewed the content and confirmed the accuracy of the findings. Each paragraph under Section 3.3 subsequently reports the validation outcomes specific to each country. To ensure the integrity of the data and mitigate risks associated with AI-generated content, the summaries underwent a systematic, two-step expert validation protocol:

1) Experts from each country reviewed each summary. They utilised a standardised verification checklist evaluating (a) the factual accuracy of legal citations, (b) alignment with national legislative frameworks, and (c) the detection of potential AI hallucinations or context-dependent errors.
2) Where discrepancies were identified among expert validation assessments, the disputed information was re-verified against official governmental databases, and a consensus decision was documented.

Table 1. Summary table for policy directions toward circularity in construction

Country	Overall CE/CDW Strategy	Key CDW Legislation	End-of-Waste (EoW) Criteria	Reuse Guidelines in Buildings	Circularity Indicators	Digital Tools	Best Practices / Initiatives	Drivers	Barriers
Switzerland	Strong federal & constitutional support. Cantonal flexibility. Waste Ordinance within evolving resource management Policy	Long-standing, comprehensive legal framework with multiple ordinances	Possible with proper documentation. No national standardisation	Cantonal-level guidelines. Decentralised but conceptually strong	Not public but embedded in federal sustainability principles	No digital tools explicitly mentioned	RUSS & Cirkla. Advanced sector coordination	Strong top-down sustainability support via federal governance	Legal fragmentation due to cantonal autonomy
Greece	Comprehensive national plans aligned with EU goals	Strong law and dedicated ministerial decisions	No information found on CDW-specific EoW criteria	'Smart design' and selective demolition promoted in national plans	No CDW-specific indicators mentioned	Mandatory GPS in CDW transport vehicles	Selective demolition. EMAS promotion. 'Smart design'. GPP in public buildings	Strong legal framework. Permit-based obligations	Overcoming inertia. Ensuring full implementation of the ambitious law
Slovenia	National Waste Management Programme. CDW is a priority	Decree on waste from construction work (2008) and other regulations. Aligned with WFD	Criteria for aggregates (under development). Otherwise, case by case	Promoted via mandatory selective collection and quality targets. Some recommendations exist	Waste stats collected (circular material use rate, %). National adaptation of Sustainable Building Indicators from Level(s) (in progress)	CinderOSS one-stop shop platform (CINDERELA project)	Selective demolition. ReBirth project, GPP	Legal mandates. Permit Obligations (NGGO)	Conflicting legal provisions. Inconsistent statistics
Cyprus	Comprehensive CE/CDW strategies aligned with the EU	EU-aligned, updated CDW-specific legislation (2023)	No formal EoW criteria. This limits reuse	No national guidelines. Pilot projects exist (e.g., DEFEAT)	General CE indicators reported to the EU. Participation in CEN TC350	Digital monitoring via KODA. National platform planned	Collective systems (OAK, KODA). Awareness raising	Strong legal drivers. Permit-based obligations	Implementation weaknesses. Contractor apathy. No landfill tax

Country	Overall CE/CDW Strategy	Key CDW Legislation	End-of-Waste (EoW) Criteria	Reuse Guidelines in Buildings	Circularity Indicators	Digital Tools	Best Practices / Initiatives	Drivers	Barriers
Poland	National Waste Management Plan (KPGO) is the main strategic document	Obligated to reach 70% recycling target (Directive 2008/98/WE)	No information on CDW-specific criteria	Promoted in KPGO, but no detailed reuse guidelines	KPGO includes indicators. CDW circularity specificity remains unclear	No digital tools explicitly mentioned	KPGO promotes incentives and education campaigns	EU directives and KPGO framework	Dependence on primary raw materials. Market barriers. Illegal practices
Estonia	'Estonia 2035' strategy. National plans exist, but implementation challenges persist	CDW under general Waste Act (2004). No dedicated law. Local authority responsibility	No information on CDW-specific criteria	Research on CE in construction. E-construction platform for life- cycle data. No specific reuse guidelines	Some monitoring procedures (biowaste). No CDW-specific indicators	E-construction platform facilitates building-life-cycle data. Goal to digitise the full waste management system	Selective demolition. GPP. Waste Reduction Weeks. Circular business model support	EU directives and national strategy	Below-average recycling rates. Illegal dumping. Low investor interest. Low awareness
Türkiye	UDESEP & sectoral guidelines. CE strategy prioritises the construction sector	Current regulations insufficient. Landfilling rules dominate. No CDW-specific law	No CDW-specific EoW yet. EU-funded pilot ongoing	Embedded in codes. Selective demolition emphasised	No construction-specific indicators	TLCID & TMM digital tools. Sector-specific and cloud-based	SKD Türkiye. EPR. Adaptive reuse examples	Sector strength. Skilled workforce. Improving framework	Data gaps. Immature market. Lack of prioritisation
Latvia	National plan exists, but CDW is not prioritised. Waste Management Law transposes WFD. No specific C&D law	No CDW-specific law. Regulated under the general waste law	Guidelines promote EoW status	Guidelines for sorting CDW promote reuse	Data availability/reliability is an issue. No CDW-specific indicators	No digital tools explicitly mentioned	Guidelines for sorting CDW at construction sites	Mostly EU-driven. Weak national support	Lack of framework. Low landfill costs. Weak incentives. Illegal dumping
Romania	National plans exist, but implementation failures dominate. EU directives transposed. Some deadlines missed	National legislation transposes EU directives. Not fully complete	EU-level criteria apply. No national CDW-specific criteria	National CE Strategy and Action Plan promotes reuse/ repair	Monitoring focuses on collection & recycling. Few advanced CE indicators	Waste Information System (SIM). No dedicated CDW traceability tools	CE Strategy & Action Plan GPP. Private initiatives	National Recovery & Resilience Plan. EU targets	Very low recycling rates. Weak infrastructure. Delayed EU compliance

Colour legend: green – comprehensive, orange – partial, red – absent.

3.3. Human Expert Validation

Cyprus

The LLM analysis for Cyprus appears to adequately cover the situation in the Republic of Cyprus, with no apparent discrepancies. It correctly highlights its adherence to EU directives in national regulations regarding CDW, but limitations associated with the country's scale hinder both enforcement and initiatives for secondary markets. No formal EoW criteria for CDW have been established at the national level, which limits reuse and the development of secondary materials markets, despite the legal possibility of case-by-case EoW decisions under Waste Law 185(I)/2011. However, efforts towards digital transformation offer hope for improvement in monitoring (and thus enforcement), while research initiatives like DEFEAT can open the discussion on EoW criteria and waste valorisation. It should be noted that the data provided considers only CDW regulations in the areas controlled by the Republic of Cyprus in the south of the island.

Estonia

For Estonia, the analysis is based on openly accessible framework-level environmental legislation. As several CDW-related requirements are implemented through secondary legislation, ministerial regulations, administrative guidance at the municipal level, and project-based policy instruments not systematically consolidated in public legal databases, the analysis may not fully reflect national implementation practices. The specific objectives and detailed measures related to CDW are set out in the 'National Waste Plan 2023–2028' (Riigi jäätmekava 2023–2028; Kliimaministeerium) and its implementation programme. This limitation should be considered when interpreting cross-country comparisons and regulatory maturity assessments.

The validation suggests that elements of the Estonian waste management system are evolving in ways that go beyond what a static assessment of the regulatory framework alone might indicate. In particular, the ongoing development and phased implementation of the Waste Transportation Accounting System (PISTRIK) reflect a strategic effort to strengthen waste accounting, traceability, and data transparency across waste streams, including CDW. By improving the availability and reliability of data on waste generation and treatment, digitalisation tools can support evidence-based policymaking, enhance monitoring of CE targets, and enable more effective implementation of higher-value reuse and recycling pathways in line with Estonia's CE ambitions.

Greece

The LLM analysis for Greece sufficiently reflects the legal framework. The model captures the integration of EU Directives 2018/851 and 2018/852 into primary legislation and relevant ministerial decisions. Although the National Waste Management Plan sets a specific recovery target for the CDW (70%) and promotes measures such as the separate collection of specific materials, i.e., wood, mineral fractions

(e.g. concrete, bricks, tiles, ceramics, stone), metals, glass, plastics, and gypsum, and selective demolition to facilitate reuse and high-quality recycling, only the general EoW provisions set out in the EU directives have been adopted, and no specific EoW criteria have yet been established to further stimulate the secondary raw materials market.

Overall, Greek policy aims to enhance circularity in the design and construction of buildings and infrastructure. This involves the integration of 'smart building design' principles into both new and renovated buildings to prolong their lifespan and improve their adaptability. In addition, legislation mandates the installation of GPS tracking systems on all vehicles transporting CDW, with competent authorities having access for control purposes; and CDW treatment and recovery facilities are required to have certified weighing machinery and software that ensures data traceability. However, effective monitoring of CDW generation and management, nationwide availability of CDW management facilities, and clear, effective incentives to support the use of recycled/reused materials remain challenges that have yet to be effectively addressed.

Latvia

The LLM's characterisation of the Latvian regulatory environment is accurate and conceptually well-grounded. It correctly identifies that CDW management operates within the broader waste management system and largely reflects the transposition of EU directives into national legislation (for details, see Chapter 1, 'General Provisions', of the Waste Management Law (Atkritumu apsaimniekošanas likums)). At the same time, it recognises that regulation alone does not ensure CE implementation, which also depends on institutional capacity, monitoring, data quality, and economic conditions.

Validation indicates that several elements of the national system are evolving more dynamically than a static regulatory view suggests. Waste accounting and monitoring are gradually being strengthened, notably through the development of the Waste Transportation Accounting System (WTS), which aims to improve traceability and transparency across waste streams, including CDW (for details, see the Construction Information System (Būvniecības informācijas sistēma)). Data exchange between the Construction Information System and waste accounting platforms is also being enhanced, enabling more structured information on construction-related waste (for details, see Chapter 1, 'General Provisions', of the Waste Management Law (Atkritumu apsaimniekošanas likums)). These developments signal a shift towards data-driven sector governance. Policy documents promote resource efficiency and recycling (for details, see Guidelines for the Circular Management of Construction Waste on Construction Sites (Vadlīnijas apritīgai būvniecības atkritumu apsaimniekošanai būvlaukumā) (2024)), yet their practical impact is shaped by market conditions. Latvia's construction sector is small, natural material availability is high, and CDW volumes are relatively low, which means that demand for

secondary materials grows slowly. This reflects structural factors rather than regulatory shortcomings. Regulation allows certain mineral materials to be reused on-site without waste classification, whereas transport off-site typically triggers waste status (for details, see Guidelines for the Circular Management of Construction Waste on Construction Sites (Vadlīnijas apritīgai būvniecības atkritumu apsaimniekošanai būvlaukumā) (2024), and Chapter 1, 'General Provisions', of the Waste Management Law (Atkritumu apsaimniekošanas likums)). This supports traceability but may slow broader market development.

Overall, Latvia is undergoing a gradual transition towards circular construction, supported by aligned legislation and improving governance systems. LLM-based analyses can reliably support such assessments when complemented with expert contextual interpretation.

Poland

The analysis conducted by the LLM within the Polish context was performed correctly. We have not identified any discrepancies between the legal realities currently in force in Poland and their description in the LLM-based comparison above. The differences between practices across parts of Poland do not result from legal conditions but rather from individual administrative decisions, specifically the Voivodeship Marshal's decision on whether a material ceases to be classified as waste and is recognised as a by-product. There is no specific classification catalogue that requires a single classification method. Furthermore, there is no binding case law in Poland; therefore, each decision is made on an individual basis. It is therefore possible for the same administrative body to set different conditions for different entities. It should therefore be concluded that the LLM analysis of conditions, when limited to the legal texts themselves, is correct.

Romania

The analysis conducted by the LLM regarding Romania is broadly accurate in relation to the current legal and institutional framework governing CDW. No major discrepancies were identified in the description of the transposition of EU directives or in the existence of national CE strategies. However, several clarifications are necessary to ensure full alignment with the legal and institutional realities currently in force.

Romania has transposed Directive 2008/98/EC as amended by Directive (EU) 2018/851 through Emergency Ordinance No. 92/2021, approved by Law No. 17/2023, which establishes binding obligations for selective demolition, on-site sorting of CDW, and the preparation of waste management plans by the permit holder. The economic instrument referred to as a 'landfill tax' should be specified as the 'contribuția pentru economia circulară (CEC),' namely 'the contribution for circular economy,' applicable to landfilled waste, including CDW. While 'pay-as-you-throw' schemes have been promoted, their implementation remains uneven at the municipal level and cannot yet be considered nationally consolidated.

Romania operates national reporting systems, such as SIM and the SIATD traceability platform, for certain waste streams; however, no dedicated digital traceability system exists for CDW. The observation that recovery practices predominantly focus on mineral fractions reflects current market realities, although emerging reuse initiatives are beginning to develop. Overall, the characterisation of Romania as a transitional system with moderate enforcement capacity and implementation gaps is accurate, provided that the above clarifications are incorporated.

Slovenia

The analysis conducted by the LLM shows relatively good consistency with real conditions in the field of CDW circularity in Slovenia. Targets related to the CDW recovery rate (at least 70%) are being met primarily through backfilling; however, the situation is similar in other EU Member States. Inconsistencies in the statistical data and their generally low quality remain key weaknesses, as correctly identified by the LLM, which relied on documents up to 11 years old. The secondary materials market is still immature, although it has been developing positively for several years. EU alignment and the 'polluter pays' principle are indeed important drivers of CE in Slovenia's CDW sector, as confirmed by the LLM.

Switzerland

The analysis for Switzerland accurately reflects the structural characteristics of the national framework governing CE, construction, and CDW. Switzerland operates under a stable federal legal foundation, primarily based on the Environmental Protection Act (EPA/USG) and the Ordinance on the Avoidance and Disposal of Waste (VVEA). These instruments comprehensively regulate waste prevention, recovery, and disposal. The 'polluter pays' principle is firmly embedded in federal legislation, and recovery rates for mineral construction waste are comparatively high.

A defining feature of the Swiss system is its federal enforcement structure. The implementation of federal environmental law is delegated to the 26 cantons. This arrangement enables regional adaptability but also results in differences in enforcement intensity, data granularity, and policy prioritisation. The Federal Office for the Environment (FOEN) aggregates national data; however, the inherent variability of cantonal implementation remains a structural characteristic of the system.

At the same time, Switzerland employs nationwide coordinating instruments that extend beyond formal federal legislation. A prominent example is the Model Energy Regulations of the Cantons (MuKEn 2025), developed jointly by the Conference of Cantonal Energy Directors (EnDK). While not federal law, these model regulations become legally binding once adopted into cantonal energy legislation, thereby ensuring a high degree of harmonisation across the country. Importantly, MuKEn 2025 introduce requirements concerning embodied energy (grey energy) in new buildings. Although not framed explicitly as CE legislation, these provisions indirectly promote core CE principles by internalising resource use at the construction

stage. Demolition and replacement construction are not prohibited; however, the regulatory framework increases the incentive to evaluate refurbishment, adaptive reuse, and material-efficient design solutions. In this sense, MuKEn 2025 function as a structurally significant transformation mechanism within the Swiss building sector.

Switzerland does not apply a formally codified, nationwide EoW system comparable to certain EU secondary legislation. The transition from waste status to product status is determined through compliance with environmental, technical, and product regulations, often assessed on a case-by-case basis. Likewise, reuse guidelines are primarily embedded in cantonal enforcement practice and technical standards (e.g., SIA recommendations) rather than centralised statutory provisions.

Circularity indicators are not defined as standalone CDW-specific metrics within binding federal law but are integrated into broader sustainability and resource-efficiency strategies. Digital tools for material traceability and data integration are developing mainly through sectoral or cantonal initiatives; a centralised national CDW traceability platform does not currently exist.

Overall, Switzerland can be characterised as a system with a strong federal legal foundation, high mineral recovery performance, and a clear top-level commitment to sustainability. The principal structural challenge lies not in legislative gaps but in inter-cantonal coordination and harmonisation of implementation practices. At the same time, instruments such as MuKEn 2025 demonstrate that Switzerland, despite its federal structure, can systematically and broadly embed circularity-relevant requirements within the construction sector.

Türkiye

The analysis conducted by the LLM regarding the Turkish context accurately reflects the current legal and policy framework governing circularity in the built environment. However, it is important to note that while the legal framework provides a general basis for waste recovery and CE principles, the lack of explicit circularity targets for CDW, detailed EoW criteria, and systematic monitoring mechanisms limits the practical implementation of these principles. In Türkiye, policy formulation is largely centralised, while enforcement and implementation depend heavily on municipal capacities and project-based initiatives. This situation leads to variability in practice. As a result, the LLM-based assessment, primarily derived from legislative texts, strategies, and official policy documents, offers an accurate depiction of the formal regulatory landscape. Nonetheless, the differences between the regulatory intent and actual performance in CDW recovery do not stem from misinterpretation of legal provisions. Instead, they arise from gaps in secondary legislation, technical standards, and institutional capacity for implementation. In this context, the LLM analysis provides a valid and reliable representation of Türkiye's situation, but it is limited to the legal framework.

4. Discussion and Conclusions

The results obtained should be considered from two perspectives: First, the stage of development of legal systems in creating conditions for CE across different countries, and second, the possibility of using LLMs to conduct this type of analysis in the future.

4.1. Discussion and Conclusions from LLM-Assisted Analysis

Cross-country comparison of CE and waste management requires meticulous planning and careful evaluation. The heterogeneity of governance frameworks, policy tools, terminology, and legal regimes complicates efforts to achieve comparability in evaluation and analysis. The data used in this research is rich in information on waste management policies, legislative regulations, and institutional arrangements within different country contexts and illustrates the complexity of this exercise. LLMs have the potential to amplify cross-country comparative research by enabling automated, scalable, and context-sensitive analyses of text data gathered from heterogeneous sources [23].

Large language models were used in this study as analytical support tools to organise, condense, and compare complex legal texts, while the interpretation of outcomes and conclusions remained the responsibility of human experts. At the CE policy level, LLMs can be useful instruments for summarising vast amounts of legislative and regulatory documents. The policy and legislative documents under scrutiny in this study are highly heterogeneous, integrating waste prevention, producer responsibility, and secondary material markets, yet fragmented across multiple regulatory frameworks. Mechanically reconciling these heterogeneous sources requires immense expertise and time. LLMs can significantly accelerate this process by assisting in identifying general concepts and underlying policy principles in text corpora, irrespective of differences in terminology or legal frameworks. For example, if used on a corpus of policy documents, an LLM would be capable of automatically recognising thematic groups such as ‘extended producer responsibility’, ‘municipal solid waste management’, ‘recycling targets’, or ‘bio-based material promotion’, thereby facilitating systematic comparison of policy maturity among countries.

One important benefit of LLMs in this context is their ability to operate across domains and languages [24]. Waste legislation and CE structures often exist in national languages and adapt to country contexts and administrative vernacular. Multilingual LLMs, particularly when enhanced with retrieval-augmented generation (RAG), can analyse these documents in their native format while generating structured, comparative summaries in a common language, such as English. This function is not purely translational, but synthetic, as the model is designed to extract specific legal provisions and policy instruments into a uniform comparative

framework. This is particularly relevant for datasets such as the ones used here, which include documents from European, Turkish, and Swiss policy contexts. Cross-lingual analysis helps researchers understand how 'waste management' and 'circular resource management' are interpreted within the EU's Circular Economy Action Plan and outside the EU. Furthermore, LLM-assisted analysis can help identify patterns of policy convergence and divergence among jurisdictions that more traditional coding methodologies may overlook. By detecting semantic analogies and differences in policy language, models can indicate the extent to which CE models across various countries align with principles of resource circularity, the waste hierarchy, and life-cycle thinking.

Another significant function of LLMs in comparative policy analysis is their ability to incorporate multi-domain knowledge. Circular economy and waste management policies intersect with a range of other policy areas, including environmental protection, infrastructure, energy, and social development. LLMs can trace interlinkages among these policy fields by connecting references and cross-sectoral provisions across legislative texts. This inter-domain mapping improves understanding of policy coherence and facilitates the recognition of systemic barriers or synergies between sectors, a task that is both labour-intensive and open to subjective bias when done manually.

It is important to note that this study did not replace expert 'with LLMs. Instead, it used LLMs to systematically and transparently analyse large and diverse legal corpora, which were subsequently verified by experts.

4.2. Discussion and Conclusions from Human Experts

An evaluation of the LLM analysis conducted by human experts demonstrates structural accuracy across the participating countries, particularly in capturing the formal transposition of EU directives into national law. In countries such as Cyprus, Poland, and Latvia, it has been confirmed that the LLM successfully captures the legal framework and accurately identifies compliance with waste regulations and CDW regulatory provisions. This finding demonstrates that the LLM is highly accurate in synthesising codified legal texts with centralised and accessible documentation and high-level national strategies. However, one recurring criticism of the assessments is the difference between the 'static and dynamic' aspects of governance; that is, the difference between what is prescribed in the law and what is actually implemented. Experts from Türkiye and Romania have noted that while the LLM has captured the regulatory intent, it has not captured institutional implementation capacity or implementation at the municipal level. In Estonia and Latvia, experts have noted that the system changes faster than static regulatory texts, particularly with regard to the development of digital traceability tools, which have not yet been reflected in consolidated legal texts.

In conclusion, there is a consensus that LLM-based analysis, when combined with human expert evaluation, is a valid and efficient starting point for cross-country regulatory analysis. Experiences in Slovenia, Greece, and Romania have shown the need for experts to refine technical terminology and update conclusions drawn from outdated source documents. The combination of LLMs' data-processing capabilities with the situational awareness of national experts ensures that the final results are both legally accurate and relevant.

4.3. Limitations

In terms of the methodology of the study, it should be noted that the challenge was not only to analyse nine different national systems and legal documents but also to address multiple languages and alphabets. Aware of the limitations of constantly evolving LLM-based AI systems, the research procedure included human verification of the content to determine the correctness of the AI's interpretation and to check that the content was not the result of system hallucinations, a recognised limitation of such systems [25, 26]. It should be noted that working on a limited set of selected documents in our study led to full confirmation of the correctness of the generated content. The only problems we encountered were organisational and involved assigning the correct document numbers to the content sources. It is worth noting that preliminary research with the same objective using Google NotebookLM, conducted only for three countries and a limited number of documents (up to 50 files), did not encounter such problems. It can therefore be concluded that the number of documents to be analysed at the time of the study was the greatest challenge.

The nature of the documents certainly also facilitated the comparative analysis. Legal documents often use a similar and structured form. Moreover, most of the countries analysed belong to the European Union, and therefore, the implementation of EU directives into national law further makes the legal systems similar to each other. It could be more challenging to analyse documents of a different nature, where the form is more flexible and depends on the authors' approach. Nevertheless, our research indicates that with the right system operator expertise in prompt design, LLMs can effectively support the analysis of legal documents, thereby speeding comparisons across different conditions. The authors remain convinced that these solutions should be used to support task performance and be subject to human verification in each case.

However, cross-country policy comparison with LLMs is not without its risks. Variability in legislative drafting styles, the absence of standardised language, and variable availability of digital copies of policies can erode the precision of automated analysis. Furthermore, model biases arising from English-language and Western-centric dominance of training corpora can distort the interpretation of non-Western policies. This highlights the necessity of refining LLMs on nationally

representative corpora, e.g., national environmental policy collections or local waste legislation libraries, so that the model appropriately reflects local governance realities. Hence, human judgment is still needed. Although LLMs can successfully extract, summarise, and classify policy information, their outputs must be verified by domain specialists familiar with local institutional contexts. Human-in-the-loop methodologies, where researchers verify model output and correct semantic or contextual errors, provide the requisite combination of computational velocity and analytical sophistication. Transparency regarding data sources, model configuration, and prompt engineering is also crucial to render research reproducible and credible.

Aside from these limitations, leveraging LLMs with data like that used in the current study is extremely promising for advancing comparative environmental governance research. Automated policy analysis can reveal global trends in CE uptake, track the diffusion of leading policy instruments, and identify novel models of governance. In the future, such analyses could support the development of dynamic policy observatories, where new national legislation and policies are continuously consolidated and compared to monitor global progress toward circularity. The distinction between legislative intent and effective implementation underscores the implementation gap that remains a central challenge in environmental governance [27, 28]. The current analysis reveals that while LLMs excel at mapping the formal, written commitments transposed into national law, they are less proficient at diagnosing the existing barriers to implementation, such as administrative capacity, political will, and budgetary allocation. As noted by the experts in Türkiye and Romania, the existence of a robust legislative framework does not guarantee a functioning CE. Policy implementation is frequently hampered by institutional path dependency, where legacy waste management practices persist despite new, progressive legislation [29, 30]. Furthermore, implementation success is often conditional upon the interplay between national-level mandates and local-level execution.

In conclusion, LLMs are an innovative tool for cross-country comparison of CE and waste management policies. They offer unprecedented scalability, multilingualism, and analytical flexibility, enabling scholars to incorporate diverse policy data across governments and domains. Used correctly, with appropriate fine-tuning, human oversight, and transparency, LLMs can significantly enhance our capacity to track how nations design, implement, and harmonise their CE policies. This convergence of environmental governance scholarship and AI not only speeds comparative policy analysis but also supports a more evidence-informed and internationally consistent transition towards circular and resource-efficient systems.

Funding

This study was conducted as part of the project "CABE: Circular Approaches for the Built Environment" (F-DUT-2023-0138), as part of Driving Urban Transitions (DUT) Partnership, co-funded by the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101069506.

This project was funded by: Research & Innovation Foundation (RIF, Cyprus) EP/DUT/0923/0068, Estonian Research Council (ETAg, Estonia) MOB3PRT15, General Secretariat for Research and Innovation (GSRI, Greece) ΓΤDUT-0562774, Latvian Council of Science (LCS, Latvia) F-DUT-2023-0058, National Centre for Research and Development (NCBR, Poland) DUT/2023/25/CABE/2025, Romanian Executive Agency for Higher Education, Research, Development, and Innovation Funding (CNCS/CCCDIUEFISCDI, Romania) COFUND-DUT-CABE 120/2025, Slovenian Research and Innovation Agency (ARIS, Slovenia) H2-8299, Innosuisse – Swiss Innovation Agency F-DUT-2023-0058, and Scientific and Technological Research Council of Türkiye (TÜBİTAK, Türkiye) 224N046.

CRediT Author Contribution

All authors equally contributed to the following roles: resources, validation, writing – review & editing. I.K., R.A. and J.K.K. contributed additionally to the following roles: conceptualization, data curation, formal analysis, investigation, methodology, software, supervision, visualization, writing – original draft. J.K.K. contributed additionally to the following roles: funding acquisition, project administration.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

All documents used in this study are included in Appendix.

Use of Generative AI and AI-Assisted Technologies

Large Language Models were used in this study as stated in the title of the manuscript. All details regarding the models and analytical approach are described in details in Section 2.

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Appendix

National and supranational policy, legal, and strategic documents used in the comparative analysis of circular economy and construction-and-demolition waste management frameworks

Country / Region	Author / Issuing Body	Year	Original Title (English Translation Framework)	Link / Source Type
European Union	European Commission	1994	Directive 94/62/EC on packaging and packaging waste	Official EU Portal
	European Parliament & Council	1999	Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste	Official EU Portal
	European Commission	2000	Commission decision of 3 May 2000 establishing a list of wastes (2000/532/EC)	Official EU Portal
	European Parliament & Council	2008	Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Waste Framework Directive, WFD)	Official EU Portal
	European Commission	2015	Construction and demolition waste: Latvia factsheet	European Commission Factsheet
	European Commission	2017	Guideline on particular cases of technical assessment of buildings for the fundamental requirement 'Mechanical resistance and stability' (C 254/2017)	Publications Office of the EU
	European Union	2018	EU construction and demolition waste management protocol	Publications Office of the EU
	European Environment Agency	2021	Latvia waste prevention country profile 2021	EEA Profile

Country / Region	Author / Issuing Body	Year	Original Title (English Translation Framework)	Link / Source Type
European Union	European Environment Agency	2022	Slovenia circular economy country profile	EEA Profile
	European Environment Agency	2023	Estonia waste prevention programme	EEA Profile
	European Environment Agency	2023	Latvia waste prevention programme	EEA Profile
	European Commission	2025	Latvia waste prevention factsheet	European Commission Factsheet
	European Environment Agency	2025	Waste prevention country profile: Slovenia	EEA Profile
	European Environment Agency	2025	Waste prevention country profile: Estonia	EEA Profile
	European Commission	2015	Construction and demolition waste: Slovenia factsheet	European Commission Factsheet
	European Commission	2024	End-of-waste and by-product practices in the EU and Türkiye	European Commission Report
	European Commission	2016	Guidance on construction and demolition waste management (Document No. 06abc3de)	Publications Office of the EU
	European Commission	2012	Waste management plan and implementation framework	Technical Document
	European Environment Agency	2021–2025	Waste prevention factsheet	EEA Publication
	Overview / SI Group	2021	Overview of national waste prevention programmes in Europe / Waste prevention factsheet	Cross-EU Synthesis Data

Country / Region	Author / Issuing Body	Year	Original Title (English Translation Framework)	Link / Source Type
Poland	Republic of Poland	2012	Ustawa z dnia 14 grudnia 2012 r. o odpadach (Act of 14 December 2012 on waste)	Journal of Laws (Dziennik Ustaw)
	The Lower Silesian Voivodeship Marshal's Office	2017	Wojewódzki plan gospodarki odpadami na lata 2016–2022 (Regional waste management plan for Lower Silesia)	Regional Official Journal
	Lower Silesian Voivodeship Assembly	2022	Uchwała w sprawie przystąpienia do sporządzenia wojewódzkiego planu gospodarki odpadami (WPGO) (Resolution on commencing the preparation of the Voivodeship Waste Management Plan (WPGO))	Resolution Framework
	Ministry of Climate and Environment	2022	Prognoza oddziaływania na środowisko dla KPGO 2028 (Environmental impact forecast for the update of the National waste management plan 2028 (KPGO 2028))	Ministry Portal
	Government of Poland / Council of Ministers	2023	Krajowy plan gospodarki odpadami 2028) / Uchwała Nr 96 Rady Ministrów (National waste management plan 2028)	Official Gazette of the Republic of Poland
	Council of Ministers	2023	Uchwała nr 96 Rady Ministrów z dnia 12 czerwca 2023 r. w sprawie Krajowego planu gospodarki odpadami 2028 (Resolution No. 96 of the Council of Ministers of 12 June 2023 on the National Waste Management Plan 2028)	Legal Database Entry
Romania	Government of Romania	2002	Government Decision No. 856/2002 on waste records and management	Official Gazette of Romania
	Government of Romania	2005	Government Decision No. 349/2005 on waste landfilling	Official Gazette of Romania

Country / Region	Author / Issuing Body	Year	Original Title (English Translation Framework)	Link / Source Type
Romania	Ministry of Environment and Water Management	2006	Regional waste management plan: Region 7 Centre	Regional Framework
	Regional Development Authority Region 7 Center	2022	Regional plan on waste management: Region 7 Center	Institutional Copy
	Romanian Standards Association	2008	SR EN 12620: Aggregates for concrete	Technical Standard
	Gorj County Council	2008	Local plan on waste management for Gorj County	Local Policy
	Government of Romania	2011	Law No. 211/2011 on the waste regime	Official Gazette of Romania
	National Agency for Fiscal Administration	2015	Fiscal Code of Romania	https://static.anaf.ro/static/10/Anaf/legislatie/Cod_fiscal_norme_2016.htm
	Duminica I.E.	2016	Analiza sistemului fiscal românesc (Analysis of the Romanian Fiscal System)	Academic Thesis
	Government of Romania	2016	Government Emergency Ordinance No. 68/2016 on specific provisions regarding end-of-waste status	Official Gazette of Romania
	Government of Romania	2018	Emergency Ordinance No. 74/2018 amending and supplementing Law No. 211/2011 on the treatment of waste	Official Gazette of Romania
	Ministry of Development, Public Works and Administration	2019	Evaluation of non-structural elements (Annex E of P100-3/2019)	Technical Regulation
	Ministry of Development,Public Works and Administration	2019	P100-3/2019: Seismic assessment of existing buildings	Technical Regulation

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Romania	City Hall of the Municipality of Buzău	2020	Strategia pentru economie circulară Buzău 2020–2030 (Strategy for transition to a circular economy in Buzău City 2020–2030)	https://primariabuzau.ro/wp-content/uploads/2021/02/Strategia-pentru-economie-circulara-Buzau-2020-2030-6mb.pdf
	Chis A. / Timiș County Council	2020	Planul Județean de Gestionare a Deșeurilor în Județul Timiș (2019-2042) (County Waste Management Plan for Timiș County (2019-2042))	County Plan
	Timiș County Council	2020	Local plan on waste management (2020–2025)	County Framework
	Prahova County Council	2020	Local plan on waste management of Prahova County (2020–2025)	County Framework
	Prahova County Council	2014	Local plan on sustainable development of Prahova County	Strategic Framework
	Prahova County Council	2021	Local plan on sustainable development	Generic County Citation
	Prahova County Council	2021	Local plan on waste management (2020–2025)	Complementary Entry
	Romanian Standards Association	2021	SR EN 206+A2: Concrete – Specification, performance, production, and conformity	Technical Standard
	Romanian Technical Committee for Construction	2022	RTC 10-2022: Rapid visual screening methodology	Technical Standard
	Government of Romania	2023	Law No. 17/2023 approving Government Emergency Ordinance No. 92/2021	Official Gazette of Romania
	Buzău County Council	2014	Methodologies for the recovery and recycling of construction and demolition waste in Buzău County	Local Technical Guideline

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Romania	Government of Romania	2021	National Recovery and Resilience Plan (PNRR), Part 2 – Component C3: Waste management	National Strategic Plan
	Government of Romania	2021	National Recovery and Resilience Plan (PNRR), Part 2 – Component C4: Sustainable transport	National Strategic Plan
	Government of Romania	2021	National Recovery and Resilience Plan (PNRR), Part 2 – Component C5: Renovation wave	National Strategic Plan
	Government of Romania	2021	National Recovery and Resilience Plan (PNRR), Part 2 – Component C6: Energy	National Strategic Plan
	United Nations Development Programme	2022	Rapid visual screening methodology	International Project Baseline
Estonia	OECD	2023	The Circular Economy in Tallinn, Estonia	https://doi.org/10.1787/06abc3de-en
	TalTech – Tallinn University of Technology	2023	Local government circular economy roadmaps: Analytical report	Academic Research Report
	Government of Estonia	2024	Hoone olelusringi süsinikujalajälje arvutamise metoodika (Methodology for calculating the life-cycle carbon footprint of buildings)	Government Regulation
	Estonian University of Life Sciences	2024	Tartu linna jäätmekava eelnõu (Draft waste management plan of the City of Tartu)	Local Policy Draft
	Government of Estonia	2023	Ehitussektori teekaart 2040 (Construction roadmap 2040)	Cross-Reference Strategic Plan
	Government of Estonia	2022	Methodology for building carbon footprint assessment	Technical Assessment

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Estonia	Rakvere City Government	2021	Rakvere waste management plan 2021–2027 (draft)	Local Policy Draft
	Tartu County Government	2022	Tartumaa arengustrateegia 2040 (Tartu County Development Strategy 2040)	Regional Strategy
Latvia	Deloitte	2015	Construction and demolition waste management in Latvia: Screening factsheet	Deloitte Sectoral Report
	Latvian Ministry of Environmental Protection	2020	Annex 1 to the National Waste Management Plan for 2021–2028: International, EU-level and Latvian policy planning documents	National Annex
	Latvian Ministry of Environmental Protection	2020	Annex 2 to the National Waste Management Plan for 2021–2028: Target outcomes for specific waste types and waste streams resulting from EU directive requirements	National Annex
	Latvian Ministry of Environmental Protection	2020	Annex 3 to the National Waste Management Plan for 2021–2028: Information on the achievement of target outcomes for specific waste types and waste streams	National Annex
	Latvian Ministry of Environmental Protection	2020	Annex 1 to the National Waste Management Plan for 2021–2028	Duplicate Variant Code
	Latvian Ministry of Environmental Protection	2020	Annex 2 to the National Waste Management Plan for 2021–2028	Duplicate Variant Code
	Latvian Ministry of Environmental Protection	2020	Annex 3 to the National Waste Management Plan for 2021–2028	Duplicate Variant Code
	Republic of Latvia	2020	Amendments to waste management legislation	Legal Update

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Latvia	Lagzdina E.	2021	1.pielikums Atkritumu apsaimniekošanas valsts plānam 2021.-2028. gadam (Annex 1 to the National Waste Management Plan for 2021–2028)	State Plan Annex Work
	Lagzdina E.	2021	2.pielikums Atkritumu apsaimniekošanas valsts plānam 2021.-2028. gadam (Annex 2 to the National Waste Management Plan for 2021–2028)	State Plan Annex Work
	Lagzdina E.	2021	3.pielikums Atkritumu apsaimniekošanas valsts plānam 2021.-2028. gadam (Annex 3 to the National Waste Management Plan for 2021–2028)	State Plan Annex Work
	Republic of Latvia	2021	Amendments to waste-related legal framework	Legal Update
	Government of Latvia	2021	On the National Waste Management Plan for 2021–2028	Government Order
	Ministry of Environmental Protection and Regional Development	2021	National Waste Management Plan for 2021–2028	Cabinet of Ministers Approved
	Ministry of Environmental Protection and Regional Development	2021	Regulations on state and regional waste management plans and the national waste prevention programme (Cabinet Regulation No. 397)	Cabinet Regulation
	Ministry of Environmental Protection and Regional Development	2020	Action plan for the transition to a circular economy 2020–2027 (Cabinet Order No. 489)	Cabinet Order
	Ministry of Environmental Protection and Regional Development	2020	Action plan for the transition to a circular economy 2020–2027	Policy Framework

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Latvia	Ministry of Environmental Protection and Regional Development	2021	Regulations on state and regional waste management plans and the national waste prevention programme	Statutory Rule
	Latvian Construction Association	2023	Būvniecības atkritumu apsaimniekošanas vadlīnijas (Guidelines for construction waste management)	Sectoral Industry Guideline
	Latvian Construction Association	2023	Guidelines for waste sorting at construction sites during demolition and new construction (Annex C2D1)	Operational Guide Entry A
	Latvian Construction Association	2024	Guidelines for construction and demolition waste sorting at construction sites during demolition and new construction	LIFE Waste to Resources Project
	Latvian Construction Association	2024	Guidelines for construction and demolition waste sorting at construction sites	Industrial Blueprint
	Republic of Latvia	2023	Waste law (consolidated version effective 1 January 2024)	Regulatory Cross-Entry
	Republic of Latvia	2010	Law on waste management	General Law Codification
Slovenia	Government of Slovenia / Republic of Slovenia	2017	Slovenian development strategy 2030	Government Strategy Text
	Šooš T. (ed.) / Government Office	2017	Slovenian development strategy 2030: adopted by the Government of the Republic of Slovenia on 7 December 2017	Strategic Book Edition
	Slovenian Institute for Standardization	2008	SR EN 12620: Aggregates for concrete	Coordinated Technical Standard
	Republic of Slovenia	2016/2021	Decree on the implementation of the EU regulation on waste shipment	Environmental Decree

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Slovenia	Republic of Slovenia	2017	Act on building products (ZGPro-1)	Official Journal
	Republic of Slovenia	2021	Building Act (GZ-1)	Official Journal
	Republic of Slovenia	2022	OP Odpadki (Waste management programme)	National Programme
	Slovenian Institute for Standardization	2021	SR EN 206+A2: Concrete – Specification, performance, production and conformity	Coordinated Technical Standard
	Government of Slovenia	2023	Slovenian strategy of smart specialisation (S5), version 1.1	Innovation Strategy
	Slovenian Government Office	2023	Slovenian strategy of smart specialisation	Strategic Policy Blueprint
	Republic of Slovenia	2022/2025	Environmental Protection Act (ZVO-2, consolidated version)	Official Journal
	Government of Slovenia	2018	Roadmap towards the circular economy in Slovenia	National Policy Roadmap
	Government of Slovenia	2008	The decree on the management of waste arising from construction work	Executive Decree
	Government of Slovenia	2008	The decree on the pollution of soil by the introduction of waste	Executive Decree
	Government of Slovenia	2011	The decree on the prevention and reduction of particulate emissions from construction sites	Executive Decree
	Government of Slovenia	2008	The decree on the treatment of waste in mobile installations	Executive Decree
	Government of Slovenia	2014	The decree on waste landfill	Executive Decree
	Government of Slovenia	2022	The decree on waste	Executive Decree

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Greece	Republic of Greece	2010	Joint ministerial decision on the alternative management of construction and demolition waste	Government Gazette
	Republic of Greece, Ministry of Environment and Energy	2018	National strategy for circular economy	National Policy Document
	Republic of Greece	2019	National strategy for sustainable development 2030	Strategic Plan
	Republic of Greece, Ministry of Environment and Energy	2020	National waste management plan	National Masterplan
	Republic of Greece	2021	Law 4819/2021: Integrated framework for waste management and transposition of Directives (EU) 2018/851 and 2018/852	Government Gazette
	Republic of Greece	2021	Joint ministerial decision on landfill management	Executive Framework
	Republic of Greece, Ministry of Environment and Energy	2022	National waste prevention program	National Programme
Cyprus	Government of Cyprus	2002	The Solid and Hazardous Waste Law, 2002 (Law No. 215(I)/2002)	Pancyprian Bar Association
	Cyprus Legal Database	2002	Ο Περί Στερεών και Επικίνδυνων Αποβλήτων Νόμος του 2002 [O Peri Stereon kai Epikindynon Apovliton Nomos tou 2002] – 215(I)/2002 (The Solid and Hazardous Waste Law of 2002 – 215(I)/2002)	Original Script Entry
	Government of Cyprus	2011	Waste Law (Law No. 185(I)/2011)	National Legislation
	Ministry of Agriculture, Rural Development and Environment	2011	Waste laws of 2011–2022 (Law No. 185(I)/2011, as amended)	Amended Statutory Reference
	Ministry of Agriculture, Rural Development and Environment	2016	Waste (recognition and monitoring of waste transport) decree (K.D.P. 31/2016)	Executive Decree
	Ministry of Agriculture, Rural Development and Environment	2023	Waste (management of construction and demolition waste) regulations (K.D.P. 112/2023)	Executive Regulation

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Türkiye	Republic of Türkiye	1983/2006	Çevre Kanunu No. 2872 (Environmental Law)	Official Gazette of the Republic of Türkiye
	Republic of Türkiye	2004	Hafriyat toprağı, inşaat ve yıkıntı atıklarının kontrolü yönetmeliği (Regulation on the control of excavation soil and construction and demolition waste) (Law No. 25406)	Official Gazette of the Republic of Türkiye
	Republic of Türkiye	2010	Atıkların Düzenli Depolanmasına Dair Yönetmelik Hafriyat toprağı, inşaat ve yıkıntı atıklarının kontrolü yönetmeliği (Regulation on the Regular Disposal of Waste) (Law No. 27533)	Official Gazette of the Republic of Türkiye
	Ministry of Environment, Urbanization and Climate Change	2010	Atıkların Düzenli Depolanmasına Dair Yönetmelik (Regulation on landfill of waste)	Official Gazette of the Republic of Türkiye
	Ministry of Environment, Urbanization and Climate Change	2010	Regulation on landfill of waste	Translated Citation Baseline
	İpek U., Gören S., Özkaya B., Çapar B.	2011	İstanbul Büyükşehir Belediyesi Entegre Atık Yönetim Planı (Istanbul Metropolitan Municipality Integrated Waste Management Plan)	https://cevre.ibb.istanbul/wp-content/uploads/2022/03/2011-ENTEGRE-ATIK-YONETIMI-PLANI.pdf
	Ministry of Environment and Urbanization	2011	Entegre atık yönetimi planı (Integrated waste management plan)	Institutional Plan
	Ministry of Environment, Urbanization and Climate Change	2015	Atık yönetimi yönetmeliği (Regulation on waste management)	Official Gazette of the Republic of Türkiye

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Türkiye	Ministry of Environment, Urbanisation and Climate Change	2017	Yıkım işlemleri ile hafriyat toprağı, inşaat ve yıkıntı atıklarının kontrolü yönetmeliği (Regulation on demolition operations and control of excavation soil, construction and demolition waste)	Official Gazette of the Republic of Türkiye
	Ministry of Environment, Urbanisation and Climate Change	2019	Yapı malzemeleri yönetmeliği (Construction Products Regulation)	Official Gazette of the Republic of Türkiye
	Ministry of Environment, Urbanisation and Climate Change	2019	Yapı malzemelerinin tabi olacağı kriterler hakkında yönetmelik (Regulation on criteria for construction materials)	Official Gazette of the Republic of Türkiye
	Ministry of Environment, Urbanization and Climate Change	2021	Binaların yıkılması hakkında yönetmelik (Regulation on demolition of buildings)	Official Gazette of the Republic of Türkiye
	Doğan A.D. (ed.)	2022	Kayseri Kitabı (The Kayseri Book)	https://www.kayseri.bel.tr/uploads/pdf/kayseri_kitabi_2024.pdf
	Presidency of Strategy and Budget	2023	Twelfth development plan (2024–2028)	Strategic Development Plan
	Ministry of Environment, Urbanization and Climate Change	2023	Güncellenmiş birinci ulusal katkı beyanı (Updated first nationally determined contribution)	Climate Action Policy
	Republic of Türkiye	2023	Updated first nationally determined contribution (NDC)	English Variant Citation

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Türkiye	Akınç O.	2024	End-of-Waste and By-Product Practices in the EU and Türkiye and the End of Waste Project	Technical/Academic Thesis
	Ministry of Environment and Urbanization	2023	Türkiye'nin döngüsel ekonomiye geçiş potansiyelinin değerlendirilmesi için teknik destek projesi (Technical support project for assessing Turkey's potential for transition to a circular economy)	https://webdosya.csb.gov.tr/db/dongusel/icerikler/deep_impact_m-ha-l_-d-movsk-_11022025_tr-20250212080631.pdf
	Ministry of Environment, Urbanization and Climate Change	2024	İklim değişikliği azaltım stratejisi eylem planı (Climate change mitigation strategy and action plan)	Strategic Action Plan
	Ministry of Treasury and Finance	2023	Türkiye'de çevresel sürdürülebilirliğe yönelik mali teşvikler: Geri dönüşüm örneği (Financial Incentives for Environmental Sustainability in Türkiye: The Case of Recycling)	Fiscal Evaluation Report
	Republic of Türkiye	2016	Türkiye materials marketplace project	Circular Economy Platform
	Republic of Türkiye	2022	Economic evaluation of waste management practices	Analysis Report
	Republic of Türkiye	2004/2021	Regulation on the control of excavation soil, construction and demolition waste	Legal Document Reference
	Government of Türkiye	2019	Waste marble fragments as road base material	Technical Industrial Report
	Republic of Türkiye	2021	Ministry of Environment, Urbanisation and Climate Change	Corporate Governance Entry

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Switzerland	Swiss Confederation	1983/2025	Bundesgesetzüber den Umweltschutz (Federal Act on the Protection of the Environment, USG)	Fedlex Legal Database
	Swiss Federal Council	2005	Verordnung über den Verkehr mit Abfällen (VeVA) (SR 814.610) (Ordinance on the Movement of Waste (OMW))	Ordinance Codification
	Federal Department of the Environment, Transport, Energy and Communications (DETEC)	2005/2018	Ordinance on lists concerning the movement of waste	Sectional Version
	Swiss Federal Council	2015/2025	Ordinance on the avoidance and the disposal of waste (Waste Ordinance)	Executive Ordinance
	Swiss Federal Council	2015/2025	Ordinance on the avoidance and disposal of waste	Duplicate Entry Variant
	Federal Office for the Environment (FOEN)	2020	Strategies for dealing with existing buildings to strengthen the circular economy	FOEN Strategy Report
	Swiss Cantons of Basel-Stadt and Basel-Landschaft	2023	Kantonale Abfall- und Ressourcenplanung Basel-Landschaft und Basel-Stadt (Cantonal waste and resource management plan Basel-Stadt and Basel-Landschaft)	Cantonal Energy & Environment Office
	Swiss Society of Engineers and Architects	1993	SIA Recommendation 430: Disposal of construction waste in new construction, renovation, and demolition projects	Technical Construction Standard
	Federal Office for the Environment (FOEN)	2006	Kreislaufwirtschaft: Grundlagen und strategische Ausrichtung (Circular Economy: Foundations and Strategic Direction)	FOEN Baseline Policy
	Construction Waste Disposal	2020	Entsorgung von Bauabfällen (Disposal of Construction Waste)	Practical Processing Manual

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Austria / Cross-Border	Federal Ministry for Sustainability and Tourism	2006	Nachhaltige Rohstoffnutzung und Abfallentsorgung: Grundlagen für die Gestaltung der zukünftigen Politik des Bundes (Sustainable Resource Use and Waste Disposal: Foundations for Structuring Future Federal Policy)	Regional Policy Baseline
	Federal Office for the Environment (BAFU) (the Swiss Federal Ministry for the Environment)	2006	Nachhaltige Rohstoffnutzung und Abfallentsorgung (Sustainable Resource Use and Waste Disposal)	Duplicate Bibliography Fragment
International	Baltic Biomass Network Association	2023	BBNA guidelines on biomass and bioresources management	Cross-Border Regional Guidelines