CIRCULAR ECONOMY IN BOSNIA AND HERZEGOVINA: FIRST STEPS IN DEVELOPING WASTE-TO-RESOURCE VALUE CHAINS

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ABSTRACT

This paper explores the development of the circular economy in Bosnia and Herzegovina by analysing the first concrete steps away from a linear, landfill-dependent model and towards more resource-efficient waste and material management. It builds on a comprehensive study of waste management systems, secondary raw materials and investment opportunities. Starting from low recycling rates and the predominance of landfilling, while gradual alignment with European Union policies and regulations is underway, the paper analyses the institutional, infrastructural and market preconditions for the development of circular value chains. Particular emphasis is placed on glass, plastics, waste tyres and construction and demolition waste streams, where specific investment models (e.g. facilities for glass cullet processing, tyre granulation, and mobile C&D waste crushing) and indicative ranges of required capital investments and operating costs are identified. By examining the role of extended producer responsibility schemes, local public utility companies and the private sector, the paper identifies "low-hanging fruit" of the circular economy that can be implemented relatively quickly through a combination of regulatory measures, targeted public support and private investments. Finally, the proposed approach underlines the importance of phased development, from pilot projects and modular facilities to the scaling-up of regional capacities, as a realistic pathway to reducing dependence on landfilling, increasing material circularity and retaining more added value within the domestic economy.

Keywords: Circular economy, waste management, secondary raw materials, extended producer responsibility; waste-to-resource value chains.

INTRODUCTION

The transition from a linear to a circular economy has become an important component of contemporary environmental and industrial policy. Its central premise is to reduce the use of primary resources, prevent avoidable waste generation, and retain the value of products and materials through reuse, recycling, and other forms of recovery [1], [2]. In the European Union, this approach is embedded in the Waste Framework Directive 2008/98/EC, which established the waste hierarchy and set a target for at least 50% by weight of selected household waste materials to be prepared for re-use or recycled by 2020 [3], [4]. The 2020 Circular Economy Action Plan further extended this policy direction by linking waste prevention and material efficiency with product design, industrial competitiveness, and the objectives of the European Green Deal [5], [6].

These issues are particularly relevant in countries where landfilling remains the dominant management option and markets for secondary raw materials are still weak [7], [8], [9]. Bosnia and Herzegovina (BiH) illustrates this situation. The country is progressing towards alignment with European Union requirements while at the same time dealing with infrastructure deficits, fragmented governance, and limited material recovery [7], [10]. European Environment Agency data indicate that municipal waste generation reached 345 kg per capita in 2022, while collection services covered about 74% of the population, with a marked difference between urban and rural areas [11]. According to the Agency for Statistics of Bosnia and Herzegovina (BHAS), approximately 1.1 million tonnes of municipal waste were generated in 2024 (329 kg per capita), of which 976,996 tonnes were collected through public services. Of the collected waste delivered to controlled landfills, 99.90% was permanently disposed of [12]. At the same time, local evidence indicates that improvements in municipal waste management can produce measurable environmental benefits, including reductions in greenhouse-gas emissions, as demonstrated in the case of Prnjavor [13]. Eurostat data suggest an average municipal waste recycling rate of about 9% for BiH over the 2008–2023 period [14].

The accession process provides an additional policy context for these challenges. The European Commission's 2024 Report on Bosnia and Herzegovina assessed the country as being between an early stage and some level of preparation in Chapter 27, Environment and Climate Change, and recorded only limited progress [15]. Weaknesses in institutional coordination are accompanied by pressures on resource use. In 2022, the BiH economy consumed 38.7 million tonnes of natural resources, 6.8% more than in 2015, while domestic extraction of non-metallic minerals increased by 34.2% [16]. A circular material use rate could not yet be calculated because comprehensive waste-treatment data had not previously been available to Eurostat [16]. The OECD's 2025 Economic Convergence Scoreboard places the average waste intensity of the Western Balkans at 20.2 g/USD of GDP, compared with 12.7 g/USD in the European Union. BiH records the lowest value among the six Western Balkan economies, at 17.8 g/USD [17]. This comparatively favourable indicator does not, however, offset the country's weak performance in recycling and material recovery.

Against this background, work undertaken within the EU-funded project “EU Support for Waste Management in the Circular Economy” provides an applied basis for identifying areas in which circular value chains could develop in the near term [18]. Project activities considered construction waste, packaging waste, tyres, waste electrical and electronic equipment, batteries, oils, and end-of-life vehicles, each of which faces a different combination of regulatory, infrastructural, and market constraints. Based on this work, glass, plastics, waste tyres, and construction and demolition (C&D) waste were identified as particularly suitable for early waste-to-resource initiatives because they combine recoverable material value, established treatment technologies, and business models that can be adapted to local conditions [18], [19].

This selection is consistent with the literature on circular value chains. Treatment technology is only one determinant of material recovery; the organisation of collection, reverse logistics, producer responsibility, quality control and demand for recovered outputs weigh just as heavily [7], [8], [20]. Research on extended producer responsibility (EPR) similarly shows that collection and recycling outcomes are strongly influenced by the design of compliance systems, the quality of enforcement, and the distribution of responsibilities among producers, operators, and public authorities [21], [22], [23], [24]. For plastics, glass, tyres and construction products the implication

is that circularity has to be treated as a property of the whole value chain, not of the final waste-management step [8], [19], [25], [26].

The regional and European policy framework also affects the conditions under which these value chains may develop. Through the Sofia Declaration on the Green Agenda for the Western Balkans, endorsed on 10 November 2020, the Western Balkan economies committed to a transition from a linear to a circular economy as one of five pillars of regional green development [27]. Several EU instruments reinforce this direction. The EU Taxonomy includes the transition to a circular economy among its six environmental objectives [28], while the Ecodesign for Sustainable Products Regulation, in force since 18 July 2024, extends requirements related to durability, reparability, and resource efficiency across a broad range of products placed on the EU market [29]. The Carbon Border Adjustment Mechanism (CBAM), which entered its definitive financial phase in January 2026 for sectors including cement, iron and steel, aluminium, fertilisers, electricity, and hydrogen, adds a further competitiveness dimension for carbon-intensive exporters [30], [31]. Circular-economy policy in BiH is thus tied to industrial competitiveness as much as to domestic waste management and EU approximation and access to European markets.

The aim of this paper is to interpret evidence generated through the project in relation to the wider scientific literature and the evolving European policy framework. The analysis focuses on four questions: which structural factors currently constrain circular value chains in BiH; why glass, plastics, waste tyres, and C&D waste offer comparatively realistic entry points; what form of phased development is appropriate under conditions of fragmented governance and uneven market maturity; and how recent EU policy instruments alter the incentives for circular investment and resource recovery in BiH [6], [18].

METHODOLOGY

The paper is based on work undertaken within the EU-funded project “EU Support for Waste Management in the Circular Economy” in Bosnia and Herzegovina [18], during which the authors contributed to activities related to the assessment of waste management systems and circular-economy opportunities. The empirical basis includes evidence generated during project implementation: field visits, consultations with competent institutions, public utility companies, EPR schemes and private operators, together with data collection, technology screening and financial assessment carried out within the project. The present paper uses this material as a case-based evidence base and combines it with selected official statistics and published literature.

A qualitative document-analysis and comparative-synthesis approach was used. Evidence generated through the project was organised around four analytical dimensions: institutional and regulatory conditions, characteristics of priority waste streams, technological and market options for material recovery, and factors affecting investment feasibility [18]. Quantitative values derived from project work were used to indicate the relative scale of individual waste streams and investment opportunities rather than to establish project-level feasibility.

Work in the project passed through six stages, and the same sequence organises the evidence used here [18]. The first stage was a review of policy and regulation, covering the Waste Framework Directive as amended by Directive (EU) 2018/851, the remaining acts of the EU waste package, the Green Agenda for the Western Balkans, and the corresponding gaps in BiH legislation [33], [34]. Stakeholders were then mapped across public authorities, private operators, extended producer responsibility (EPR) schemes, non-governmental organisations, industry and academia. Waste stream analysis followed, dealing with generated quantities, collection arrangements and existing treatment capacity. The financial assessment produced capital and operating cost estimates together with funding gaps and possible financing routes. In the fifth stage the streams were ranked by market potential, technical feasibility, expected impact and institutional readiness. The last stage converted the ranked streams into indicative business models, the policy measures each of them would require, and options for scaling them in phases [18], [35]. Figure 1 shows the sequence.

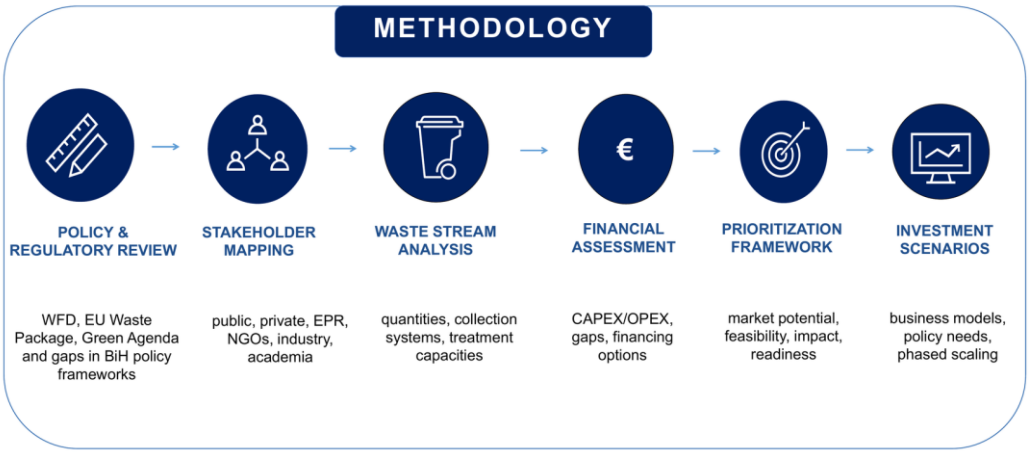


Figure 1. Six-stage analytical workflow applied in the project

The literature review was used to place the BiH findings in a broader analytical context and to support the interpretation of the project results. It covered scientific literature on circular value chains, extended producer responsibility, reverse logistics, waste valorisation and the management of selected waste streams. The analysis also drew on relevant policy documents and official statistical sources, including the BiH Circular Economy White Paper [6], the Sofia Declaration on the Green Agenda for the Western Balkans [27], European Commission enlargement reporting [15], Eurostat and European Environment Agency data on waste and material use [11], [14], [16], the OECD Economic Convergence Scoreboard for the Western Balkans [17], and official BHAS statistics [12].

The analysis comprised four related steps. Evidence generated through project activities was first reviewed with respect to institutional arrangements, data quality, EPR performance, available treatment technologies, and investor constraints [18]. The four priority streams: glass, plastics, waste tyres, and C&D waste were then compared with findings from the scientific literature relevant to material recovery and circular value chains. In a third step, selected quantitative results were checked against national and regional indicators reported by BHAS, Eurostat, the EEA, and the OECD [11], [12], [14], [16], [17]. Finally, the combined evidence was used to formulate a phased development model for BiH, with attention to practical entry points, modular investment, market formation, and alignment with the relevant EU policy framework [4], [5], [27], [28], [29].

The analysis is subject to two main limitations. First, the underlying project work identified substantial data gaps, particularly for packaging, EPR-controlled collection, and the transparency of system costs; some quantitative estimates therefore had to be reconstructed from incomplete reporting [18]. Second, official circular-economy indicators for BiH remain incomplete. The most recent EEA reporting notes that a circular material use rate could not yet be calculated because comprehensive waste-treatment data had only recently become available for Eurostat reporting [16]. For this reason, quantitative and financial values are treated as indicative and are used primarily to compare the relative scale of opportunities and constraints, not as substitutes for detailed project-level feasibility assessments.

RESULTS

Institutional and Market Context for Circular Value Chains in BiH

Evidence generated through the project indicates that the principal constraints on circular-economy development in BiH arise from implementation and coordination rather than from a complete absence of policy or legislation [18]. Responsibilities are distributed across the state, the Federation of Bosnia and Herzegovina (FBiH), Republika Srpska (RS), Brčko District, cantons, and municipalities, creating uneven conditions for planning, enforcement, and service delivery

[10], [18]. The European Commission's 2024 assessment of Chapter 27 is consistent with this picture, recording limited progress and continuing gaps in the national environmental and climate framework [15]. Similar findings are reported in the circular-value-chain literature, where institutional coordination across collection, financing, processing, and end markets is identified as a prerequisite for effective material recovery [7], [23], [36].

Five governance weaknesses emerged from the project work. No circular-economy strategy has been adopted at state level, and there is no mechanism through which environmental, industrial, fiscal and municipal decisions on material flows are coordinated, so such decisions continue to be taken in separate institutional tracks. The regulatory framework is itself divided between the entities and Brčko District, which prevents uniform obligations for producers and operators. Planning at local level is thin: waste management plans have been adopted in only about 30% of municipalities, which leaves much of the country without the institutional basis for separate collection or for municipal contributions to recovery targets. Enforcement, monitoring and reporting are weak throughout. Weak monitoring and reporting also reduce the reliability of the indicators used to support investment decisions [18], [35].

Table 1 presents the main quantitative indicators used to describe the current waste-management and material-use context in BiH, based on BHAS, Eurostat, EEA, and OECD sources [11], [12], [16], [17], [35].

Table 1. Selected waste and material-flow indicators for Bosnia and Herzegovina

Indicator	Value
Municipal waste generated (2024)	≈1.1 Mt (329 kg/cap.)
Waste collected, public service (2024)	976,996 t
Share landfilled, of collected (2024)	99.90%
Population covered, collection (2022)	≈74% (80–90% urban; 40–45% rural)
Waste generated per capita (2022)	345 kg/cap.
Avg. recycling rate (2008–2023)	≈9%
Natural resources consumed (2022)	38.7 Mt (+6.8% vs. 2015)
Non-metallic mineral extraction (2022)	+34.2%
Circular material use rate	Not yet calculable
Waste intensity, WB6 average	20.2 g/USD GDP
Waste intensity, BiH (lowest in WB6)	17.8 g/USD GDP
WEEE collected, formal channels (2023)	≈16%
Packaging captured under EPR (2023)	≈7%
Packaging placed on the market (2023)	256,402 t
Annual OPEX funding gap	EUR 25–35 million

EPR is a particularly important element of this institutional setting. Project analysis indicates that formal packaging systems capture only a limited share of the actual waste stream and that the absence of a consolidated state-level register contributes to under-declaration and free-riding [18]. A World Bank review reached a similar conclusion, noting that although EPR is recognised in both entities, the FBiH and RS systems for packaging and waste electrical and electronic equipment operate independently, with no cross-entity legal effect, while secondary legislation for waste

electrical and electronic equipment was still incomplete in RS [37]. International experience indicates that EPR performs more effectively where fees reflect system costs, reporting is transparent, and compliance obligations are enforceable [21], [24], [36]. Where these conditions are weak, formal producer-responsibility arrangements may generate neither the quantity nor the quality of material needed to support investment in recycling capacity [23], [24].

Capture rates for individual streams show how large this shortfall is. For 2023 the project estimated that formal channels collected roughly 16% of waste electrical and electronic equipment, while EPR arrangements captured only about 7% of the packaging placed on the market, which in that year amounted to 256402 tonnes [18], [35]. The financing picture is comparable. Measured against the recurrent cost of a system able to meet EU-aligned targets, revenues from tariffs, EPR fees and public budgets fall short by an estimated EUR 25–35 million a year [18], [35]. This estimated gap relates to operating expenditure rather than capital investment. A gap of that kind is not closed by donor-financed infrastructure, and whatever recovery capacity is built will have to be run within it.

A related constraint identified through the project is uncertainty over feedstock quantity, quality, and long-term offtake, all of which affect the bankability of circular investments [18]. Waste generation alone does not guarantee a viable recovery system. Investors also require predictable collection, consistent sorting, reliable logistics, and identifiable buyers for recovered materials [7], [8], [20]. Under current BiH conditions, early-stage investments are therefore more plausible where waste streams are sufficiently concentrated, treatment technology is established, and an anchor buyer or clearly defined end market is available [18].

Glass Value Chain

Glass is among the more straightforward near-term opportunities identified through the project analysis. Container glass is technically well understood, and recycled cullet has established industrial uses [18]. Project work identified potential interventions in collection, pre-treatment, cullet preparation, and cooperation with industrial partners within and outside BiH. An important advantage is that the value chain can be developed through regional collection and processing hubs without requiring a domestic integrated remelting facility at the outset [18].

Published research points to the same practical requirements. Recycled glass can be returned to remelting processes or used in selected construction applications, provided contamination is controlled and the required particle characteristics are achieved [19]. Collecting more glass is thus only half of the task. The other half is delivering cullet at a quality that downstream users will accept. For BiH, this places particular importance on source separation, colour sorting, contamination control, and efficient transport arrangements [7], [18], [20].

For a facility producing furnace-ready cullet, the project financial assessment put capital expenditure at EUR 1.5–3 million, a moderate figure when set against the other three streams [18], [35]. Technology complexity is similarly moderate. An export market for cullet is already in place, drawing on demand from container-glass producers in neighbouring countries. It is this combination of a working outlet, mature technology and a manageable capital requirement that makes glass an accessible entry point and not a long-term ambition.

Plastics Value Chain

Plastics offer a larger but more heterogeneous opportunity. Packaging waste is substantial in volume, yet only a limited share is captured through formal household collection and EPR-related channels [18]. Project data indicate that 256,402 tonnes of packaging across the main material categories were placed on the market in 2023, while modelled collection under EPR arrangements amounted to only 18,646 tonnes [18]. The difference points less to a shortage of recyclable material than to the inability of the present system to channel that material into transparent and traceable recovery pathways.

The literature on plastic recycling and EPR helps explain this gap. Effective systems depend on the interaction of fee design, collection architecture, reverse logistics, sorting, and design for recyclability [8], [21], [26], [36]. In markets that are still developing, investment is often more viable when it begins with a limited number of polymer fractions, such as PET and HDPE, for

which specifications, processing technologies, and end markets are comparatively well established [7], [26]. This suggests that a selective approach may be more appropriate for BiH than attempting to process all plastic fractions within a single early-stage system.

The project analysis narrowed this stream to PET and HDPE [18], [35]. Collection for both already runs through EPR arrangements, the sorting and reprocessing technology is proven and can be added in modules, and EU demand for recycled content is strong and still growing, reinforced by the mandatory recycled-content requirements now applying to beverage packaging [32]. Bottle-to-bottle recycling of PET is thus a medium-term prospect for BiH, on condition that separate collection delivers sufficient volume at an acceptable quality.

Waste Tyres Value Chain

Waste tyres are another stream with relatively favourable conditions for early intervention. Project work included baseline estimates, scenario analysis, and financial summaries for tyre collection and treatment, indicating that the stream is sufficiently defined to support targeted investment [18]. Among the options considered, granulation represents a technically established model with identifiable applications for the recovered rubber and other fractions.

Tyres have several practical advantages over mixed municipal waste. The stream is comparatively homogeneous, collection points can be organised through take-back systems, and established outlets include granulated-rubber products, sports surfaces, and tyre-derived fuel [19]. These advantages do not remove the need for effective governance. Reliable take-back obligations, traceable flows, and organised reverse logistics remain essential if treatment facilities are to receive stable quantities of material [8], [36]. In the BiH context, tyres pair mature technology with a collection problem that is manageable, which places them among the more implementation-ready streams examined in the project [18], [20].

Granulation was confirmed in the project work as a technically settled route for this stream, with reasonably stable outlets in sports surfaces, insulation materials and flooring [18], [19], [35]. Financing is a further advantage. Tyre management can be paid for from EPR fees, which removes part of the dependence on municipal budgets and gives operators a steadier revenue base than tariff-financed services provide.

Construction and Demolition (C&D) Waste Value Chain

C&D waste is significant both in quantity and in its potential for local material recovery [18]. Project data indicate that, in the Federation of BiH, 349,780 tonnes from eight special waste categories were collected in 2023, of which construction waste accounted for 229,237 tonnes, the largest share among the categories examined [18]. The project analysis also considered collection and treatment costs, potential material revenues, and processing scenarios for this stream. Its scale makes C&D waste particularly relevant for circular-economy policy, although its management differs from that of packaging or consumer-product waste. Earlier World Bank analysis also pointed to limited centralised waste-treatment infrastructure in FBiH, where only four regional sanitary landfills were operational and served 24 municipalities [38].

The international literature identifies C&D waste as one of the largest material flows with potential for recovery of concrete, bricks, metals, wood, plastics, and glass [25], [26]. The built environment can also provide an important outlet for secondary materials originating from other waste streams [19]. Unlike some recycling chains that depend on distant specialised markets, recovered aggregates can often be used close to the point of generation, reducing transport requirements. Their use nevertheless depends on technical specifications, quality assurance, and procurement rules that recognise recycled materials as acceptable inputs [25], [26].

For BiH, mobile crushing and modular processing are particularly relevant because construction activity is geographically dispersed and centralised treatment capacity is limited [18]. Technology alone, however, will not create a functioning market. Clearer requirements for on-site sorting, separate handling of mineral fractions, quality control, and the use of recycled aggregates in public works are needed if the resource value of C&D waste is to be captured more consistently

[18]. For this stream, standards and procurement practice matter as much as the processing equipment [26].

Of the four streams, C&D waste needs the least capital according to the project financial assessment. Mobile crushing and screening capacity can be bought in stages and moved between sites, so investment need not be concentrated in one fixed plant [18], [35]. Demand for recycled aggregates is local and immediate, and it follows infrastructure works, which makes this the stream most likely to respond to demand created through public procurement.

Comparative Assessment of Priority Value Chains

Table 2 brings together the comparative characteristics of the four chains as they emerged from the project prioritisation framework and financial assessment. The four waste streams differ substantially in capital intensity, technology maturity, downstream market conditions, and the extent to which EPR fees can support operating costs. These differences provide a practical rationale for sequencing interventions rather than applying a uniform investment approach across all four streams. That variation is the practical case for sequencing interventions instead of running one uniform investment programme [18], [35].

Table 2. Comparative characteristics of the four priority value chains

Characteristic	Glass (cullet)	PET / HDPE	Waste tyres	C&D waste
Indicative CAPEX	EUR 1.5–3 million	Moderate; modular	Moderate	Lowest of the four
Technology maturity	Established	Proven, scalable	Proven granulation	Mature; mobile units
Principal market outlet	Export cullet	Bottle-to-bottle; EU recycled content	Sports surfaces, insulation, flooring	Recycled aggregates
EPR financing relevance	Packaging EPR	Packaging EPR	Strong; fee-based	Limited
Main constraint	Cullet quality	Low capture (≈7%)	Take-back enforcement	Sorting and procurement rules

Regional Benchmark: BiH within the Western Balkans

A regional comparison helps place the BiH indicators in context. According to the OECD Convergence Scoreboard, waste intensity across the Western Balkans is about 1.5 times the EU average, while BiH records the lowest value among the six economies, at 17.8 g/USD of GDP [17]. This relatively favourable result contrasts with the country's low recorded municipal recycling rate of about 9% and with the previous absence of sufficiently complete waste-treatment data to calculate a circular material use rate [14], [16]. The contrast suggests that the main circularity deficit lies not simply in the amount of waste generated relative to economic output, but in the weak conversion of waste into documented secondary raw materials. Limited collection infrastructure, incomplete data systems, and underdeveloped end markets remain common constraints across the region and form part of the rationale for the Green Agenda for the Western Balkans [27].

Phased Development Model

Across the four priority streams, a common implication emerges: the initial development of circular value chains in BiH is more likely to succeed through phased and modular investment than through large, fully integrated facilities introduced at an early stage [18]. This approach is consistent with findings generated through the project and with literature emphasising the importance of reliable supply, institutional capacity, and market coordination before major processing capacity is installed [7], [20], [23]. Where data remain uncertain and responsibilities are fragmented, smaller projects can test feedstock availability, operational performance, product quality, and market demand before investment is scaled up.

A practical sequence would begin with clearer reporting requirements, pilot separate-collection schemes, and small or medium processing facilities in the priority streams [18]. Once

material flows and product quality are better established, regional partnerships and contract-based supply and offtake arrangements could support larger private investment [8], [18], [36]. More advanced forms of industrial symbiosis and greater domestic use of secondary raw materials would then become realistic as collection systems, compliance mechanisms, and end markets mature [18], [20], [26].

The proposed transition involves a shift from a predominantly linear material flow towards a system in which separate collection feeds sorting and recycling, and recovered secondary raw materials are returned to productive use. Achieving this transition is not primarily a technological challenge. It depends on policy design, targeted investment, innovation, alignment with EU requirements, and the gradual building of chains that link collection points to industrial buyers who can be identified in advance [5], [34]. Figure 2 summarises the shift.

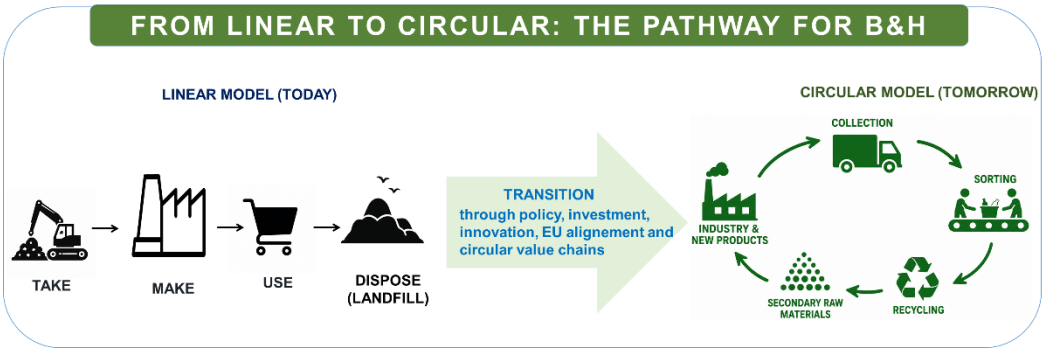


Figure 2. Transition pathway from the linear to the circular model in BiH

DISCUSSION

The results indicate that the principal barriers to circular-economy development in BiH are institutional and market-related rather than technological. Fragmented responsibilities across levels of government, together with entity-based producer-responsibility systems that are not mutually recognised, make it difficult to create uniform conditions for material collection and recovery [18], [36]. The European Commission's assessment of limited progress under Chapter 27 provides a broader policy context for these findings [15]. This interpretation is also consistent with the circular-value-chain and EPR literature, which emphasises coordination across collection, financing, processing, compliance and end markets [7], [23], [36]. Consequently, investment in processing equipment, although necessary, will have limited effect unless accompanied by more consistent rules, comparable data and stronger coordination between FBiH, RS, Brčko District and local authorities.

The quantitative indicators reveal a notable contrast. BiH has the lowest waste intensity per unit of GDP among the Western Balkan economies [17], yet its recorded municipal recycling rate remains close to 9% [14], and a circular material use rate could not previously be calculated because of incomplete treatment data [16]. This suggests a weakness in the middle stages of the value chain: materials are generated and collected, but a large share does not pass through systems that can sort, document, process and return them to productive use. Project analysis points to a similar conclusion from an investment perspective, identifying uncertainty over feedstock volume, quality and offtake as more immediate constraints than the absolute availability of waste [18].

The four priority streams illustrate these constraints in different ways. For glass, the principal issue is the quality and consistency of separately collected cullet rather than the absence of established recycling technology [18], [19]. For plastics, the large difference between estimated packaging placed on the market and the quantity modelled as collected under EPR arrangements indicates substantial leakage from formal recovery channels [18], while international evidence shows that EPR performance depends strongly on collection architecture, compliance and

traceability [21], [24]. Waste tyres are comparatively homogeneous and have mature treatment options, but their viability still depends on enforceable take-back and traceable collection [18], [19]. C&D waste is available in large quantities, yet its use as a secondary resource is constrained by sorting practices, quality standards and procurement rules for recycled aggregates [18], [25], [26]. These differences argue against a single policy instrument for all waste streams and in favour of stream-specific interventions within a common circular-economy framework.

EU policy developments add an economic dimension to these domestic constraints. The Waste Framework Directive and Circular Economy Action Plan continue to shape the direction of waste and resource policy, while the EU Taxonomy and the Ecodesign for Sustainable Products Regulation increasingly affect investment criteria and product requirements [3], [4], [6], [28], [29]. For BiH companies supplying the EU market, the ability to document recycled content, resource efficiency and lower material intensity is likely to become a commercial requirement rather than only an environmental merit. CBAM introduces a different type of pressure by assigning a carbon-related cost to selected imports. Given the exposure of regional cement and electricity exports, greater use of secondary materials and lower-carbon production routes may contribute to maintaining competitiveness, although the scale of this effect will vary by sector and requires further quantitative assessment [30], [31].

The phased model proposed here is best interpreted as a form of investment risk management rather than as a general preference for small projects. Pilot and modular investments can generate information on collection costs, feedstock quality, operating performance and market acceptance, which are among the uncertainties currently limiting bankable circular-economy investments in BiH [18]. If these projects are linked to clearer EPR obligations, transparent reporting and identifiable industrial users, they can provide a basis for later regional scaling [20], [24]. This approach is also compatible with the Sofia Declaration's regional perspective, since some material streams may achieve viable scale more readily through cross-border or regional logistics than within individual domestic markets [27].

Three practical policy priorities follow from the analysis. First, greater compatibility between the EPR and packaging systems in FBiH and RS, supported by more consistent reporting, would improve the transparency and predictability of material flows [18], [37]. Second, public procurement and technical standards can help create demand for recycled aggregates, cullet and granulated rubber where these materials meet defined performance requirements [18], [26]. Third, public and donor finance should support modular and regionally coordinated investments that can be expanded once supply and offtake arrangements have been demonstrated [18], [35]. Future research should monitor the circular material use rate as more complete Eurostat-compatible data become available and quantify, by sector, the extent to which greater use of secondary raw materials could reduce exposure to carbon-related trade costs [16], [30].

Taken together, these findings show that the development of circular value chains in BiH cannot be reduced to investment in individual recycling technologies. Progress depends on a broader set of mutually reinforcing measures: the adoption of circular-economy strategies, effective mechanisms for cross-sector and inter-institutional coordination, stronger EPR systems, access to finance for circular investments, quality standards for recycled materials, continued alignment with EU requirements and systematic waste planning at the local level [18], [35]. The interdependencies between these measures are important. A strategy without an operational coordination mechanism risks remaining declarative; stronger EPR systems will have limited effect if collected materials cannot meet quality requirements or find reliable industrial users; and investment in processing capacity is unlikely to be sustainable where local waste planning, separate collection and predictable material flows remain underdeveloped. Figure 3 summarises these seven areas of intervention and their combined role in creating the institutional, technical and market conditions required for functioning waste-to-resource value chains in BiH.

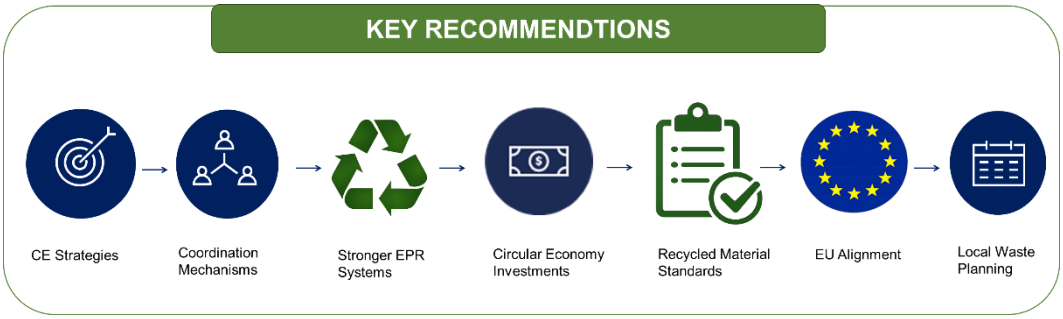


Figure 3. Seven areas of intervention and their interdependencies

CONCLUSION

The analysis identifies glass, plastics, waste tyres and construction and demolition waste as realistic entry points for strengthening circular material flows in Bosnia and Herzegovina. Their potential reflects a combination of recoverable material value, established treatment technologies and identifiable market outlets [18], [19], [26]. At the same time, the findings show that the main barriers to their development are not primarily technological, but arise from fragmented governance, incomplete data, weak collection and EPR systems, uncertain material quality and insufficiently developed markets for secondary raw materials.

Under these conditions, phased and modular development appears more appropriate than immediate investment in large, fully integrated systems. Early projects can establish reliable material-flow data, test collection and processing arrangements, demonstrate product quality and confirm demand before capacity is expanded. Regional logistics, stronger producer-responsibility mechanisms and partnerships with identifiable industrial users can then support subsequent scaling [7], [18], [20].

The transition towards a more circular economy in BiH therefore depends on coordinated improvements in regulation, planning, financing, material standards and market development. Continued alignment with the EU waste and circular-economy framework further strengthens the economic relevance of these reforms by linking resource efficiency and secondary-material use with investment requirements and competitiveness [4], [5], [28], [29], [30], [31]. The four priority waste streams examined in this study can provide practical starting points, but their transformation into functioning waste-to-resource value chains will ultimately depend on the institutional and market conditions that connect waste generation, collection, recovery and productive reuse.

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DECLARATIONS OF INTEREST STATEMENT

The authors affirm that there are no conflicts of interest to declare in relation to the research presented in this paper.

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