

Adopting a Circular Economy Model for Sustainable Construction and Demolition Waste Management

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ABSTRACT:

Urban regeneration projects are complex processes that aim to achieve physical, environmental, social, and economic sustainability. However, current practices predominantly focus on physical renewal, neglecting the significant environmental impacts of construction, demolition, and household waste. This failure to integrate waste management processes results in low recycling rates, resource wastage, and increased pollution. A substantial portion of waste from urban transformation is inadequately recycled and sent to landfills, leading to economic losses and environmental damage. This issue is exacerbated by finite landfill capacity, resource depletion, and carbon emissions. The prevailing linear supply chain model (“buy, make, throw”) hinders sustainable outcomes. This research examines the implementation of a circular economy model to manage urban transformation waste effectively. It aims to analyse current waste management practices to identify gaps, establish a framework for integrating circular principles, and explore innovative methods and technologies to enhance waste recovery. The economic benefits, environmental impacts, and social acceptability of these applications are also assessed. The study concludes that a shift to a circular model is not only feasible but essential, offering a strategic framework to minimize waste, maximize resource efficiency, and create a more sustainable and economically viable urban regeneration process.

Keywords: *Circular Economy, Construction And Demolition Waste, Resource Efficiency, Sustainable Waste Management, Urban Regeneration.*

INTRODUCTION

Urban transformation is an important process to address the multidimensional challenges of modern cities, driven by continuous population growth. By transforming urban areas to create sustainable and liveable environments, urban transformation efforts aim to address social, environmental, and economic issues. Although urban transformation offers significant benefits it also brings challenges, particularly in terms of the waste generated. Construction and demolition waste (CDW), is a by-product of urban renewal, and it can lead to serious environmental degradation as well as economic losses if improperly managed. The challenges mentioned above require sustainable and innovative solutions to ensure that urban transformation is in parallel with environmental protection and economic viability [1].

Circular Economy (CE) is a promising approach to CDW management. This paper presents the Circular Economy Model (CEM) as a sustainable solution for waste management in urban transformation projects. It includes definitions, case examples, and implementation. This model integrates social, economic, and environmental approaches to decrease waste during the urban transformation process and also promotes recycling of materials. By optimizing material flows, the CEM reduces waste generation, is consistent with sustainability principles, and promotes a circular approach to resource management.

Circular economy principles advocate maintaining the value of materials for as long as possible through reuse, recycling, and remanufacturing. This approach reduces dependence on natural resources, lowers energy consumption, and minimizes environmental impact.

The main purpose of this research is to examine how to implement Circular Economy model to manage the waste generated during urban transformation process effectively. In this scope, following goals are determined: Analyze current management practices of urban transformation waste and identify gaps and areas for improvement, to establish a framework for integrating circular economy models into urban transformation processes, to examine the feasibility of innovative methods and technologies to increase the recovery potential of waste, to assess the economic benefits, environmental impacts and social acceptability of circular economy applications.

LITERATURE REVIEW

1) *Circular Economy*: In recent years, the concept of the circular economy (CE) has been gaining much attention from scholars and practitioners. In their comprehensive study, Kirchherr, et., al. [3] systematically analysed 114 definitions of CE and unveiled an acute level of conceptual fragmentation. The bulk of definitions revolve around the classic 3R "reduce, reuse, and recycle" notion yet do not truly emphasize that a systemic shift is inherent in CE. The definitions further put heavy emphasis on economic prosperity and environmental quality while rarely focusing on the social dimension of sustainability or on meeting the needs of future generations. The study goes on to note that many of the definitions do not mention enabling factors such as business models or consumer engagement. In conclusion, Kirchherr, et., al. [3] contend that this lack of conceptual coherence in CE could render it doubtful and obstruct its actual implementation. Geisendorf and Pietrulla [4] take the discussion further, expounding CE and adjoining concepts such as cradle-to-cradle approach, blue economy, closed-loop supply chains, and industrial ecology. The literature-based classification attempts to clarify the overlapping yet distinct characteristics of each model and plead for a refinement of the CE concept. Since the CE is not defined uniformly in various academic and practitioner circles, it becomes difficult to arrive at a common understanding, range policy instruments, or establish business approaches. Hence, a unified holistic conceptualization of CE, stressing sustainability in all its forms, ought to be put in place. As a result of these minds, CE is regarded in an integrated fashion: as a systemic frame for decoupling growth from resource depletion by redesigning production and consumption systems for the present generation, as well as the future generations [4].

2) *Construction and Demolition Waste (CDW)*: Construction and demolition waste is defined as the damaged and surplus materials generated during construction, renovation, and demolition processes altogether [5]. Most of the time construction and demolition are referred to as CDW for easier mentioning. Although all wastes are gathered under the name of CDW, there is an internal classification of wastes according to their source of origin. There are 4 main categories as; waste generated from total or partial demolition, construction, general civil works, and road maintenance activities [6]. CDW is a critical issue considering the amount produced. Almost 2.01 billion tonnes of waste were generated worldwide in 2016 and it is expected to increase to 3.40 billion tonnes by 2050 [2]. Therefore, even a small reduction in the CDW would have a big impact. Circular economy (CE) aims to utilize resources while waste generation is kept to a minimum. Main approach is to extend utilization, re-usage, recycling, and energy consumption which is against to conventional "take-make-dispose" model [7]. In the article, it is also indicated that CE is contributing urban transformation by resource efficiency, energy conservation, zero-waste target. Unlike linear economies, urban waste is reintegrated into the economy. In urban planning and construction processes, circular economy practices focus on the recycling of building materials, modular building designs, and energy-efficient buildings.

3) *European Union Circular Economy Action Plan*: In 2020, the European Union has published Circular Economy Action Plan. The main goal is to develop a sustainable economy model in resource-intensive based sectors. This plan incentivizes to apply circular economy principles, especially in sectors which produces most of the waste and has high resource usage like construction and demolition sectors. Construction sector attracts most of the attention since it is responsible for producing 35% of total waste and consuming nearly 50% of resources of the European Union [8]. Thus, reducing environmental effects of construction sector becomes the prior goal of the Circular Economy Action Plan. In context of managing the urban transformation waste, this plan gives critical solutions and strategies.

One of the most important steps of the Action Plan for the construction sector is the "Sustainable Building Initiative", which aims to reduce environmental impacts throughout the building life cycle. This initiative prioritizes using energy efficient, durable, reused and recycled materials. Modularization and repairability will create buildings that will last longer and be more adaptable.

Most of the recycled building materials are expected more widely used in this sense for new building materials. In addition to that, European Commission proposed a system of Digital Product Passport for enhanced traceability of materials [8]. This means that traceable recycled products, their composition, recycling potential, and life cycle will be included into account (2020). Furthermore, EU Commission is prioritizing the projects that adopt circular economy principles in public procurement. With this approach budget allocated to circular economy projects are increasing and accelerates the spread of sustainable implementations.

Construction and demolition waste generated during the urban transformation process has a significant impact on action plan. European Union set a standard indicating that recycling 70% of this waste is a must [9]. Through the demolition process, effective separation can be implemented for recyclable materials such as concrete, glass, metal and wood by use of selective demolition practices. As a consequence, efficiency in waste management and construction waste recycling rates are increasing.

To sum up, the EU's Circular Economy Action Plan provides an effective guide for the management of construction and demolition waste in urban transformation projects by reducing waste, conserving resources and reaching the goal of European Green Deal: "climate-neutral by 2050 – an economy with net-zero greenhouse gas emissions" [10].

4) *Green Supply Chain Management for Construction Waste in Türkiye:* In Türkiye, the construction industry generates a lot of waste due to both construction and demolition. This situation creates an important challenge for sustainable development. Applying Green Supply Chain Management (GSCM) practices promotes the principles of reducing, reusing, recycling, and remanufacturing, offering a way to minimize environmental impacts parallel to European Union directives [11].

Türkiye's commitment to GSCM principles' integration continues however, it faces some challenges such as inconsistent regulatory practices, insufficient infrastructure for recycling, and a low level of awareness among stakeholders. With the increasing global focus on the circular economy, Türkiye has widened its recycling targets to more closely align with the EU Waste Framework Directive (2008/98/EC), which requires a 70% recovery rate for CDW by 2025 [12]. Despite these efforts, Türkiye's recovery rates remain below this target, particularly due to infrastructure and logistical deficiencies [13].

The supply chain model for CDW management has developed to incorporate public-private partnerships (PPPs) that streamline recycling and recovery operations. ISTAC, a subsidiary of the Istanbul Metropolitan Municipality, now collaborates with private companies to run enhanced recycling facilities. While the Vehicle Tracking System (VTS) continues to operate, further controls are being applied through automated weighing systems and GPS integration [11].

In 2024, the Ministry of Environment [13], Urbanization, and Climate Change revised the Regulation on Control of Excavated Soil, Construction and Demolition Wastes, imposing harsher punishments for non-compliance and introducing tax incentives for companies that use recovered materials in construction [13].

Türkiye's revised supply chain model emphasises a closed-loop structure in which recycled materials are either processed and reused in new construction projects or sold to secondary markets. Rather than simply sending waste to landfill, companies can either process the materials on site or sell them to secondary markets. For example, steel and other metals are remanufactured for further industrial use [11], and recycled concrete is commonly used in road construction and other infrastructure projects.

Türkiye decreased the amount of construction and demolition waste (CDW) sent to landfills by 25% between the years 2020 and 2024. This is because of the broad usage of waste-to-energy generation technologies. By turning CDW that cannot be recycled into energy, these facilities were able to reduce their environmental impact significantly. In addition, the reuse of recycled materials has allowed companies to reduce raw material costs by 15-20%, resulting in significant cost savings [14]. Development of markets for recovered materials, like recycled materials such as metals, etc., also contributed to economic growth by providing a regular revenue for companies involved in recycling activities. Also, construction industry reduced its carbon emissions around 12% since 2020 [11]. All these mentioned waste reduction efforts have been important in terms of reducing greenhouse gas emissions.

METHODOLOGY

This research searches the ability of the principles of circular economy in managing construction and demolition waste resultant from transforming cities in Türkiye. Methodologically, this study sets out to give a thorough understanding of how the system currently exists and the challenges facing key actors in dealing with the integration of circular economy streams. A mixed methods study was engaged combining both qualitative and quantitative data sources under primary emphasis on stakeholder engagement through interviews and reviewing technical documentation.

A two-stage strategy was followed for data collection in this research. The first stage involved a thorough review of secondary data sources such as municipal regulations, academic literature, government reports and technical documents associated with CDW. During phase two, primary data collection was done in order to get more in-depth insights on the ground. Interviews with stakeholders in the various sectors involved in the CDW chain were held to probe into stakeholder perceptions on management options for CDW. By combining quantitative information with qualitative insights into the current CDW management system, a complete picture of the situation was formed. As a result, the current measurable inefficiencies (such as material loss or low recycling rates) can be understood in context with structural, regulatory, and behavioural factors that give rise to these inefficiencies.

ANALYSIS AND DISCUSSION

The current construction and demolition waste supply chain of Türkiye mainly adopts a linear, unsustainable approach where the differences are faraway from the principles of the circular economy. In the case of demolition works, selective dismantling of recyclable or reusable pieces is typically not done with too much thought during an urban transformation program. Pre-demolition audits scarcely take place but are fundamentally important in locating recoverable materials like bricks, concrete, steel, or wood. Material recovery becomes less feasible because of the creation of diverse and polluted waste streams.

Once the demolition has been done, the produced wastes are collected and loaded onto trucks without any sorting at the source. The on-site activity segregation reduces further the potential of the secondary materials; recyclable and non-recyclables are mixed up. Concrete or metals are usually contaminated by toxic or unusable wastes.

Most of the time, the transport of CDW is done by independent logistics providers or subcontractors. Collect all these entities, and then bring them down into either temporary storage, to a licensed CDW facility, or a near landfill. Very often, it is cost and distance considerations that go more than sustainability or circularity.

An insignificant fraction of the collected CDW is directed toward licensed recycling facilities that are processing usable fractions on sorting. These few facilities in the country are poorly distributed across the land, and most of their operations are wasting resources, either technologically or economically. Thus, most recyclable materials fail to be recovered and reincorporated into the construction market.

On the other hand, most of the CDW in Türkiye ends up in the so-called landfills. Waste materials that do not seem economically feasible for recycling or are too contaminated end up being discarded without systematic tracking or recovery accounting. As such, this does not only lose valuable resources but also adds up to the environment's disposal burden through land waste. This model lacks the number of feedbacks essential for a circular economy. Most of the valuable materials are either not separated early enough or directed toward secondary markets for logistical or financial reasons. On-site separation is linearly proportional to waste recovery efficiency. However, only 7% of on-site separation has been achieved on demolition waste based on statistics. This low proportion of separation effectively limits the recycling capacity of recoverable materials. Therefore, recycling efficiency for CDW remains a mere 10%. A whopping 84% of waste is sent to landfills, such as land use, pollution, and lost possibility for material recycling. Moreover, 6% of the waste goes unclassified or gets lost through collection and handling. CDW transportation is one of the principal cost drivers of the current linear waste management system. On average, a demolition site is 20 kilometres away from the nearest recycling facility. Waste is typically transported by trucks with an average payload of 15 tons. The trucks are, however, typically underloaded due to logistical inefficiencies and a lack of coordination between the recyclers and waste generators. CDW hauling represents one of the largest costs of the new linear waste management model. Driving from a demolition location to a recycling plant closest to it requires an average distance of 20 kilometres. Waste is usually carried in trucks with an average capacity of 15 tons. The trucks are not optimally used due to logistic

inefficiencies as well as inadequate coordination between recyclers and waste producers. The transportation per ton is also provided as 1000 Turkish Lira covering fuel, wages, and the maintenance of the vehicle. With the majority of the waste heavy (specifically concrete) and low-value in nature, it discourages the contractors from making recycling their mode of disposal, especially to a landfill. The cost to recycle 1 ton of demolition waste is currently estimated at 90 TL. This includes 72 TL for energy and 18 TL for labour. But when mixed waste is collected all together in a non-separated form, there is an extra 500 TL per ton for sorting and processing. This additional cost has the effect of making recycling unprofitable for private contractors. Recycled products have a marginal market value. The selling price of such products is around 75 TL per ton, and this does not cover the cost of recycling and transportation. The price of new concrete is 2200 TL per square meter. The quantity of concrete in a 100 m² building area is typically 18 tons, considering that the thickness will be 0.1 meters.

It must also be noted that, due to requirements for performance and quality, there can be no more than the utilization of up to 35% recycled CDW in fresh cement mixes. This limitation again limits the prospect for scalability in recycling activities under current regulatory situations.

PROPOSED CIRCULAR ECONOMY MODEL

This part introduces a proposed Circular Economy (CE) model for the management of Construction and Demolition Waste (CDW) in Türkiye's ongoing urban transformation processes. Unlike the traditional linear system where disposal is emphasized, this model promotes reuse, recycling, and longer retention of materials in the economic loop. The rationale for applying such a model is grounded in the need to reduce landfill dependency, improve material efficiency, and foster environmental sustainability in rapidly developing urban cities. The model relies on several basic objectives.

One of its key aims is to minimize waste generation through the redesign of demolition and construction operations. This entails encouraging selective demolition methods and planning approaches that eschew the unnecessary demolition of reusable materials. In tandem with this, the model aims to maximize recovery of resources through expanded source separation activities and promoting facility development with high-end material processing capability. At its core, an extension of material life cycles is crucial—the material extracted or generated will extend its life, where once processed, it still serves a new purpose via repurposing, remanufacturing, or recycling into the construction supply base.

TABLE I
COMPARISON TABLE BETWEEN LINEAR AND CIRCULAR MODEL

| Metrics | Linear Model | Circular Model |
|----------------------|----------------------------------|-------------------------------|
| Waste Management | Landfill focused | Recovery and reuse focused |
| Cost Structure | High transport and disposal cost | Reduced raw material costs |
| Material Use | Single-use | Multiple use, recycled inputs |
| Environmental Impact | High Emissions and land use | Reduced carbon footprint |

One of the most crucial issues addressed by this model is the overly heavy reliance on landfills. The model proposed includes a dramatic reduction in landfill use by encouraging decentralized recovery operations and achieving national targets for zero waste. Beyond the ecological imperatives, the circular model is also economically motivated. By encouraging the reuse of materials and minimizing the use of virgin resources, the change offers opportunities for long-term savings in construction costs. The transition also aids national climate goals, for example, emission reductions and energy efficiency targets.

The operational procedure of the CE model set begins with a pre-demolition audit, where buildings are surveyed to identify recoverable materials and plan with efficient dismantling. This audit process enables teams to provide estimates of volumes of material and set up separation plans in advance. On-site separation is the second process and is vital in maintaining purity and value in recyclable material. Source sorting enables better sorting and reduces contamination, thus greater marketability at subsequent recycling operations.

Logistics and transportation are salient following separation. Instead of trucking unsorted, low-value mixed waste long distances, the CE model is focused on route efficiency and load optimization. Shipping only sorted, high-

quality material to the domestic recycling facility avoids emissions and expense. Recycling specialty plants sort material, utilizing technology such as crushing, magnetic sorting, and screening to prepare the material for re-use. Subsequent material return can then be recycled back into the construction supply chain as road base material, concrete aggregate, or other structure.

The success of the system is not only dependent on infrastructure, but also on policy and citizen involvement. Local ordinances need to promote source separation and use of recyclables, and standardization efforts need to allow secondary materials to be equivalent in safety and performance to primary materials. Furthermore, stakeholders' active engagement—ranging from collectors and contractors to recyclers and customers—needs to be ensured. Public awareness campaigns and worker training will also play a crucial role in changing embedded behaviours and nudging circular behaviours.

While the benefits of the model are substantial, its implementation will be hampered by multiple challenges. Initial costs related to equipment, technology for separation, and staff training can be discouraging. In addition, the current market for recycled materials is poorly developed with ambiguous demand variation on the basis of perceived concerns over quality and availability. In order to surmount these setbacks, the model suggests government intervention in the form of financial support, preference of recycled content in public purchasing, and internet platforms such as material tracking systems to enhance transparency and accountability.

In short, the proposed Circular Economy model for CDW management aims to reframe waste as a resource. It is interested in optimizing material cycles, reducing environmental footprints, and establishing a sustainable and efficient construction sector. On its own, this model has the potential to transform Türkiye's approach to urban sustainability and resource management dramatically if backed by enabling policy landscapes and a cooperative stakeholder setting.

The proposed closed-loop urban transformation waste management system greatly enhances operational efficiency, economic feasibility, and environmental sustainability through the application of innovative technologies. These innovations ensure that resources are deliberately conserved and that procedures are appropriately streamlined throughout the system, in line with circular economy principles. This section discusses the specific contributions of the four strategic axes to assessing the impact of the key technologies, beginning with their contribution to efficiency. These axes are accelerated carbonation, digital tracking, 3D printing, and XRT smart sorting.

The construction and material processing workflow usually encompass an increase in efficiencies when anything state-of-the-art is utilized. The XRT (X-ray Transmission) smart sorting technology offers the highest throughput with a 10–15 tons per hour operation at full capacity, simultaneously pushing the frontiers of reducing manual labor by 30–50% [15]. It cuts down construction time by about 60%, decreases manual working hours, and diminishes traditional formworks owing to 3D printing. Digital product passports provide 100% real-time traceability and make logistics efficient through just-in-time delivery and automated documentation; while, on the other hand, accelerated carbonation makes it possible to process materials even faster by about twice.

TABLE III
EFFICIENCY IMPROVEMENTS PER TECHNOLOGY

| Technology | Efficiency Gain |
|-------------------------|------------------------------|
| XRT Sorting | 30-50% labour cost reduction |
| Accelerated Carbonation | 2x material throughput |
| 3D Printing | 60% shorter construction |
| Digital Passports | 100% real-time traceability |

Together, these developments generate a well-integrated ecosystem that improves traceability and usability of recovered materials while boosting circularity, cutting costs, and enhancing throughput. Thus, this integrated technological backing lays a foundation on which to build a scalable and replicable model in the valorisation of waste and sustainable construction.

Complementary technologies such as catalytic pyrolysis further enhance carbon mitigation by halting methane emissions from landfill-bound polyurethane wastes while substituting polymer production from fossil sources.

According to the construction industry stakeholders, digital product passports will further support carbon accounting by enabling material-level footprint tracking, which is vital to the verification of performance for green construction and regulatory compliance.

By the application of separation and reuse technologies, this scheme can elevate material recovery to a high level and keep matter wastes from being landfilled. High-purity fractions of concrete such as aggregates, sand, and hydrated cement paste (HCP) are recovered and reused for the production of low-carbon cement and concrete. Wood wastes are processed into Cement-Bonded Particle Boards (CBPB) that contribute to mechanical strength. Plastics and various polymeric materials are processed and reused in secondary applications such as window panels and thermal insulation. Of these valorisation technologies, the field trials under the H4C initiative have demonstrated that the valorisation rate of materials has increased from a baseline of about 65% to above 90%. This confirmed the ability of the model to maximize resource efficiency and circularity of construction and demolition waste streams [15].

The system reduces carbon emissions by almost 30% through production- and waste-handling-based carbonation techniques. Such a reduction will foster the sustainability of the environment and will also prove that companies could generate further revenues through carbon credits due to their shrinking carbon footprints. Traceability mechanisms enable both waste-treatment and waste-recovery processes to be tracked in full transparency, thereby optimizing carbon emissions data. At the same time, sorted waste from the origin level would be sent for recycling through local channels with minimal transportation element, thereby sharply reducing fossil fuel consumption and carbon emissions. These system-level upgrades, therefore, become very profitable, posing benefits to both environmental and economic fronts.

As a result, the proposed model creates a circular structure by transforming waste into a strategic resource pool. In particular, digital labelling, blockchain-based digital product passports and IoT-based tracking systems make it possible to track each piece of material throughout its lifecycle. This makes processes both transparent and traceable, building trust between municipalities, contractors and consumers. At the same time, the data required for environmental and regulatory compliance is continuously provided. This transparency strengthens coordination between stakeholders while optimizing resource use and offers the potential to simultaneously achieve economic, social and environmental sustainability in CDW management.

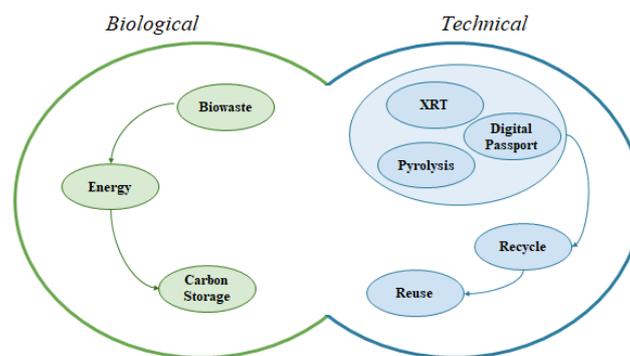


Fig. 1 Butterfly Diagram for the Proposed Circular Economy Model

The proposed model in the biological cycle allows the use of materials that can be incorporated into the natural cycle by actively decomposing biological properties among building elements. Materials such as straw insulation, bamboo panels, mycelium-based products and unfired clay bricks become compostable or usable for soil remediation at the end of their building life. Especially, clean wood and organic insulation waste can be used to make steps or bulwarks, and sent to composting sites to be used as bio-fill for landscaping/bioremediation, thus adding value to the soil.

This is especially critical in integrating agriculture and urban landscapes given the cost-effectiveness and increased carbon sequestering service of using organic CDW-based soil in the rehabilitation of the urban green space.

Material efficiency and carbon reduction are systematically strengthened, which is integrated into each stage of the technological cycle. This reduces the need for new production while preserving embedded carbon. Again, by conducting a digital inventory prior to demolition and matching this inventory to building platforms, usable structural elements (bricks, windows, doors) are available for use in situ or by others. This reduces the demand for refurbished building component. In the remanufacturing step, in cooperation with SMEs, broken or damaged parts such as aluminium, wood, door hinges, etc. are repaired and refurbished and brought to the market with performance close to their original function, thus preserving the ecological benefits as well as the economic potential of the material use. In the recycling phase, the model installs intelligent sorting lines with x-ray transmission (XRT) to separate mixed CDW materials such as concrete, metal, plastic and glass into separate categories with an efficiency of 30-40%. Thanks to this sorting, the second-hand material achieves a quality indistinguishable from the raw material in many uses, so it can be safely used in construction and infrastructure projects.

As a final step, non-recyclable composite and contaminated materials are utilized in energy recovery facilities, making the system technically efficient in a zero-waste approach. In addition, loss rates are minimized within the total volume of material passing through the system

CONCLUSIONS

In this study, an alternative model has been developed based on circular economy (CE) principles for the sustainable management of construction and demolition waste (CDW) generated in urban transformation processes. It has been comprehensively analyzed that the current linear supply chain structure has many fundamental problems such as low recycling rates, waste of resources, high logistics costs and environmental damages.

As a result of the field data analysis and stakeholder interviews conducted within the scope of the research, it was determined that CDW management in Türkiye is mostly carried out with traditional methods, most of the waste is directed to landfills and material separation processes are inadequate. The low rate of on-site sorting (7%) and the limited recycling rate of 10% clearly reveal the inefficiencies in the system.

Accordingly, the proposed Circular Economy Model includes technological components such as XRT-supported smart sorting systems, accelerated carbonization technologies, industrial 3D printing applications, catalytic pyrolysis methods and digital material passports. With this model, not only waste is sorted and recycled more effectively, but also the use of natural resources is reduced and carbon emissions are reduced.

One cost-benefit analysis showed that despite the initial investment, the installed system is advantageous in the long term due to income from recovered materials, reduced transportation, and environmental costs. Also, the study analyzed in detail how the model positively influences technical and biological cycles in the framework of the butterfly diagram.

In the final chapter, it was argued that circular economy application in municipal solid waste management is doable in Türkiye and that the application itself offers an alternative that is concrete, technological, and sustainable to improve the current system. For the model to take hold widely, strengthening regulations and financial incentives, as well as awareness-raising amongst the sector parties, should be considered.

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