MECHANISMS FOR ADVANCING AN EFFICIENT AND RESOURCE-SAVING ECONOMY

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Abstract. This article provides a scientific analysis of the role of a zero-waste economy in ensuring economic sustainability. It examines the state policy, legal framework, and issues related to the modernization of the waste management system in Uzbekistan in the context of implementing these principles. In addition, ***the volume 18of household waste, the level of recycling, and the development of*** infrastructure are assessed based on statistical data. The study also highlights the effectiveness of expanding recycling practices, developing eco-industrial parks, generating energy from waste, and applying digital technologies. Furthermore, proposals are put forward for the development of a circular economy and the enhancement of environmental culture.

Keywords: waste management, circular economy, economic sustainability, recycling, green economy, environmental sustainability, resource efficiency, eco-industrial parks, efficiency, waste landfills, digital technologies.

Introduction

The core idea of a zero-waste economy lies in ensuring that waste generated throughout the entire lifecycle of a product—from its creation to its consumption—is recycled to the maximum extent possible and reintegrated into economic activity. As a result, the efficiency of natural resource utilization increases, and the negative impact on the environment is significantly reduced. In recent years, the development of this model has become one of the key priorities of state policy in

Uzbekistan, primarily implemented within the framework of the “green economy” concept. Within this framework, the rational use of resources, reduction of waste volumes, recycling, and the introduction of closed-loop production principles are considered priority tasks.

In the process of implementing the principles of a circular economy in practice, the establishment of eco-industrial parks plays an important role in the country. Such parks strengthen cooperation among enterprises and create opportunities to use waste generated in one production process as raw materials for another enterprise. At the same time, increasing energy efficiency and expanding the use of renewable energy sources are being developed as integral components of this system. Particular attention is being paid to the introduction of modern, resource-saving technologies in industrial sectors, the improvement of waste recycling systems, and the development of the necessary infrastructure. Measures are also being undertaken to increase production efficiency and reduce waste in agriculture and textile industries through the broader application of circular approaches.

One of the key documents adopted in this direction is Resolution No. PQ-436, dated December 2, 2022, which is aimed at implementing Uzbekistan’s Strategy for the Transition to a Green Economy for 2022–2026. This document outlines specific mechanisms, priority areas, and comprehensive medium-term measures for the formation of an environmentally sustainable and balanced economy. In particular, significant attention is given to the introduction of circular economy elements, identifying key tasks such as efficient resource utilization, reduction of energy and raw material consumption in production, minimization of waste volumes, and expansion of recycling systems. It also envisages strengthening mechanisms for reintegrating waste into economic circulation through the development of waste sorting and recycling infrastructure, the formation of secondary resource markets, and the широкое introduction of closed-loop systems in production processes. Furthermore, the development of eco-industrial parks is

defined as one of the priority objectives, enabling the establishment of resource exchange systems among enterprises. As a result, waste generated by one enterprise serves as raw material for another, leading to the formation of an integrated system of resource utilization in industry. This, in turn, creates a solid foundation for the large-scale implementation of circular economy principles in practice.

Literature review

The circular economy has emerged as a central paradigm in contemporary economic thought, emphasizing efficient resource utilization, systematic waste recovery, and the stabilization of production and consumption patterns. In the scholarly work of Uzbek economist Z. Sodiqov, this model is examined in depth through the lens of its practical advantages, international experiences, and its adaptability within the national economy. His findings suggest that the circular economy should not be viewed solely as an environmental initiative; rather, it represents a transformative framework for economic development that enhances resource productivity and streamlines production systems. Broadly speaking, the circular economy is recognized as a sustainable model designed to conserve resources, minimize waste generation, and mitigate environmental degradation. Unlike the conventional linear model—characterized by the sequence “take–make–dispose”—the circular approach ensures that resources are continuously cycled, thereby maximizing their reuse and recovery.

At its core, this model seeks to drastically reduce waste within economic processes by reintroducing it as secondary input in subsequent production cycles. Equally important is the emphasis placed on product design, where durability, reparability, and environmentally safe disposal are prioritized from the outset. Such considerations enhance efficiency across the entire product life cycle and reduce the overall ecological footprint. Transitioning to a circular economy, however,

entails more than incremental adjustments; it requires a comprehensive restructuring of economic systems and a fundamental shift in conventional production and consumption paradigms. This transformation is closely linked to the adoption of advanced technologies, the expansion of innovative infrastructure, and the reconfiguration of value chains. Consequently, the successful implementation of this model depends on robust strategic and institutional frameworks capable of embedding its principles consistently throughout all stages of economic activity.

Moreover, both producers and consumers occupy a pivotal position within the circular economy. By favoring durable, repairable, and recyclable goods, they actively support environmental sustainability and contribute to reducing ecological pressures. This behavioral shift not only fosters higher levels of environmental awareness but also strengthens global efforts to address climate-related challenges. Ultimately, the circular economy can be understood as an integrated and dynamic system that promotes efficient resource management, substantially lowers waste volumes, and supports long-term sustainable development. Its distinguishing strength lies in its capacity to harmonize economic progress with environmental stewardship and social welfare, thereby offering a balanced pathway toward future development.

In their research, economists J. Kirchherr, D. Reike, and M. Hekkert formulated the foundational “3R” concept—reduce, reuse, recycle—and subsequently expanded it into more sophisticated frameworks such as the 4R, 9R, and 10R models [1]. These advanced hierarchies incorporate a broader set of strategies, including refusing unnecessary consumption, redesigning products, repairing and refurbishing items, repurposing components, remanufacturing goods, and recovering materials. Collectively, these approaches aim to optimize resource

[1] Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. Resour. Conserv. Recycl. 127, 221–232. https://www.sciencedirect.com/science/article/pii/S0921344917302835

use by making flows more efficient, extending the functional lifespan of products, and ensuring that materials are continuously cycled back into production systems. The overarching goal is to maintain the utility and economic value of products, components, and raw materials for as long as possible, thereby reducing reliance on virgin resources and limiting waste generation.

At the same time, scholars such as N. M. Bocken, I. De Pauw, and C. Bakker highlight the critical role of contemporary design strategies in accelerating the transition toward a circular economy[2]. They particularly stress the importance of designing products with high repairability and standardized components, enabling longer use and adaptability across varying conditions. From their perspective, such design principles represent a cornerstone of strategic innovation. Additionally, they draw attention to a conceptual shift from ownership to access, where the value lies not in possessing products but in utilizing their functions. This shift has given rise to service-oriented business models, including Product-Service Systems (PSS), leasing schemes, and rental arrangements, all of which contribute to more sustainable consumption patterns.

Moreover, research conducted by M. Geissdoerfer, M. P. Pieroni, and D. C. Pigosso underscores the necessity of adopting a life-cycle perspective when evaluating products and systems[3]. Their work emphasizes the importance of analyzing every stage—from initial design and production to usage and eventual disposal or regeneration. Frameworks such as “cradle-to-grave” and “cradle-to-cradle” are applied to assess environmental impacts across these stages. To support such comprehensive evaluations, analytical tools like Life Cycle Assessment (LCA) and Material Flow Analysis (MFA) are widely employed. These methodologies provide a systematic basis for measuring environmental

[2] Bocken, N.M., De Pauw, I., Bakker, C., Van Der Grinten, B., 2016. Product design and business model strategies for a circular economy. J. Ind. Prod. Eng. 33 (5), 308–320. https://www.tandfonline.com/doi/full/10.1080/21681015.2016.1172124

[3] Geissdoerfer, M., Pieroni, M.P., Pigosso, D.C., Soufani, K., 2020. Circular business models: A review. J. Clean. Prod. 277, 123741. https://www.sciencedirect.com/science/article/abs/pii/S0959652620337860

performance, enabling more informed decisions that align with the principles of sustainability and circularity.

The perspectives advanced by the aforementioned scholars provide a clear framework for identifying the most practically viable pathways within the circular economy. From our standpoint, their focus on recycling, refurbishment, and prolonging product lifecycles is both logical and empirically grounded, as these measures enable more intensive and efficient use of available resources. In particular, the notion of alleviating environmental pressure by limiting the scale of new production is especially pertinent in the context of escalating global climate challenges. However, it is important to recognize that the effectiveness of such strategies is not universal; rather, it varies significantly depending on the industry and the specific conditions under which they are implemented. For example, in the construction sector, the reuse of structural components may not consistently meet stringent technical and safety standards. Issues such as material strength, regulatory compliance, and long-term durability necessitate rigorous testing and continuous monitoring. Consequently, environmental considerations must be balanced with strict adherence to safety requirements.

At the same time, the integration of advanced digital technologies—including the Internet of Things (IoT), blockchain systems, and additive manufacturing—has the potential to substantially improve the efficiency and transparency of circular processes. Nevertheless, the adoption of such technologies entails considerable financial investment, the development of sophisticated infrastructure, and the availability of highly qualified specialists. These prerequisites can slow down implementation, particularly in developing economies. In addition, an overdependence on digital systems may give rise to new risks, especially in the areas of cybersecurity and data privacy.

Despite these opportunities, scholars such as T. Makov and D. Font Vivanco have highlighted several inherent constraints associated with circular economy practices. Although recycling is often regarded as a cornerstone of circular

systems, it is not without limitations, including the gradual decline in material quality (downcycling), significant energy requirements, and inefficiencies in material recovery processes. Furthermore, as emphasized by J. Warmington-Lundström and R. Laurenti, the so-called "rebound effect"—where efficiency gains lead to reduced costs and subsequently increased consumption—can diminish or even negate the intended environmental benefits. In light of these challenges, other researchers argue that priority should be given to high-impact strategies, such as designing products for extended use, while also ensuring that circular initiatives are supported by comprehensive and reliable sustainability assessment methodologies.

Modern Trends and Evaluation

The large-scale reforms carried out in 2025 led to a profound transformation of Uzbekistan's waste management system and the sanitary services sector. These changes not only improved the overall quality of services but also significantly broadened their reach among the population. Notably, sanitary cleaning services were extended to more than 23.9 million residents living in 8,105 of the country's 9,452 mahallas, reflecting a substantial expansion in service coverage and demonstrating the system's growing inclusivity. During the same period, waste generation remained considerable, with total household waste reaching 15.1 million tons by year-end. Despite the population paying 1.304 trillion soums for these services, outstanding receivables amounted to 622.7 billion soums. At the same time, the application of advanced digital tools enabled the detection and elimination of 211.9 billion soums in invalid debts, marking a significant step toward greater financial transparency and accountability within the system.

Parallel to these developments, notable advancements were achieved in the digital transformation and technological upgrading of waste management processes. The full implementation of the unified electronic billing platform "Toza Makon" has streamlined financial operations by automating accounting and

oversight functions. In addition, efforts are ongoing to establish eco-industrial zones across six regions, alongside the construction of 14 waste transfer facilities in 11 regions. The country is also witnessing the development of modern plants designed to generate electricity through thermal waste processing in regions such as Andijan, Kashkadarya, Namangan, Samarkand, Tashkent, and Fergana. Moreover, initiatives focused on producing thermal energy through the incineration of medical waste are being introduced in Tashkent city as well as in the Samarkand and Bukhara regions. These initiatives represent important practical steps toward embedding circular economy principles into the national system.

Another key priority has been the reinforcement of the technical and material capacity of sanitary service providers. Throughout 2025, these enterprises received 79 specialized waste collection vehicles and 220 additional containers to improve operational efficiency. Furthermore, 3,230 vehicles were equipped with GPS tracking systems, enabling real-time monitoring and better logistical coordination. A structured performance evaluation framework has also been introduced for 113 sanitation enterprises, ensuring continuous assessment of their operational effectiveness. The processing of more than 21,300 обращения from citizens and organizations further illustrates the system's increasing openness and the rising level of public engagement. Additionally, 23 solid waste landfills, occupying nearly 100 hectares in total, have been officially decommissioned.

Studies analyzing waste composition reveal that plastic waste constitutes a considerable proportion of total waste. While some estimates place this figure at 10.3 percent, others suggest it approaches 15 percent. Such variations indicate that recycling capacities are still underdeveloped and highlight the need for further systemic improvements. Infrastructure development has also progressed significantly: between 2024 and 2025, 42 landfills were closed and rehabilitated, with plans underway to gradually shut down an additional 18 sites. These efforts are widely regarded as critical steps toward modernizing the waste management system and strengthening environmental protection measures.

Enhancing waste collection mechanisms remains a vital element in advancing circular economy practices. In this regard, the efficient utilization of specialized waste collection equipment is of paramount importance. Consequently, recent policy efforts have focused on expanding the fleet and increasing the availability of such machinery. This expansion facilitates the timely collection of waste and ensures its more effective transfer to recycling and processing stages.

Statistical data clearly demonstrate a consistent upward trend in the number of waste collection vehicles over time. For example, the fleet increased from 1,461 units in 2017 to 1,893 in 2018. This growth trajectory continued in subsequent years, reaching 2,565 units in 2020 and 3,044 in 2022. By 2024, the number had risen further to 3,390 units, providing clear evidence of the tangible outcomes of modernization reforms within the sector. Overall, this steady expansion plays a crucial role in widening service coverage, improving operational efficiency, and supporting the effective implementation of circular economy mechanisms in practice.

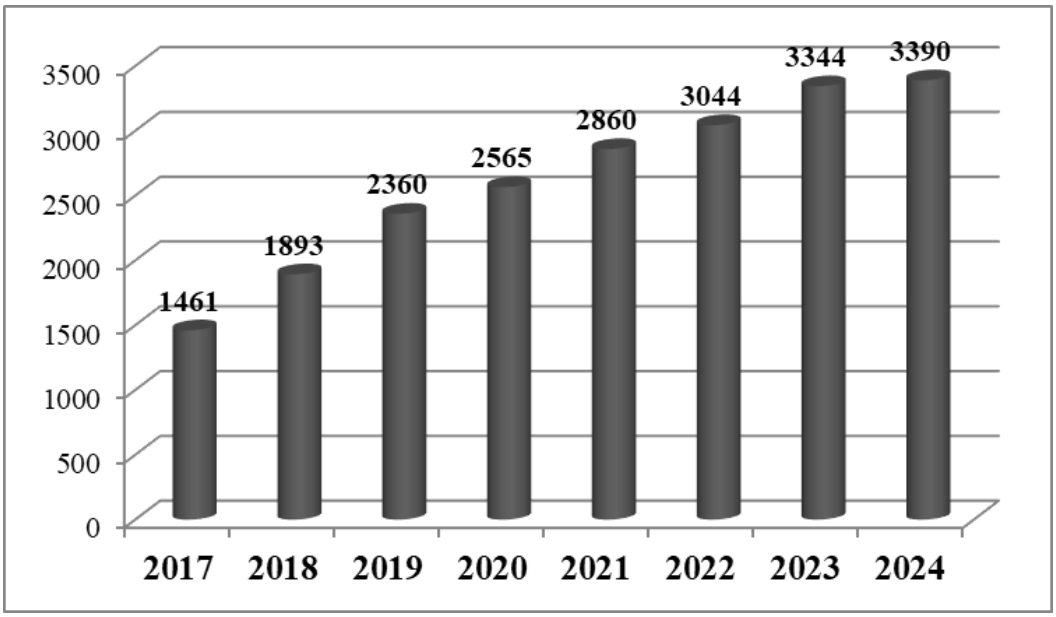


Figure 1. Number of special waste collection vehicles in the Republic of Uzbekistan [4]

In general, the large-scale transformation of Uzbekistan's waste management system and the systematic integration of circular economy principles are increasingly consolidating as a strategic priority of state policy. A number of key regulatory and legal acts adopted in this area, including Presidential Decree No. 5 dated January 4, 2024, and Presidential Decree No. 56 dated March 24, 2025, have established targeted measures aimed at the comprehensive modernization of the sector, strengthening environmental protection, and expanding waste recycling capacities. Based on these documents, oversight of landfill operations has been intensified, while their governance mechanisms are being further streamlined and optimized.

At present, a total of 228 waste disposal sites are functioning across the country, covering an overall area of 1,824 hectares. Among them, 199 sites are allocated for municipal household waste, 15 for hazardous chemical and toxic waste, and 14 for construction-related waste. In parallel, efforts to improve environmental safety and enhance system efficiency have led to the gradual closure of several landfills in recent years. Specifically, during 2024–2025, 47 household waste landfills were rehabilitated and officially decommissioned, resulting in the restoration of approximately 243 hectares of land to its natural ecological condition.

Ensuring proper sanitary conditions at landfill sites is also considered a key priority. In this regard, waste covering operations using soil are being systematically carried out at 132 landfills. This practice contributes to reducing the emission of harmful gases into the atmosphere, ensuring compliance with sanitary standards, and mitigating negative environmental impacts. Statistical data show

[4] https://gov.uz/oz/sanitation

that during January–October 2025, approximately 2.6 million tons of waste were delivered to landfill sites. Strengthened monitoring mechanisms have increased the daily waste intake capacity from 8.5 thousand tons to 13 thousand tons, thereby enabling the processing of an additional 4.5 thousand tons per day.

The enhancement of the material and technical base plays a decisive role in improving overall system efficiency. In this context, 22 additional specialized waste management vehicles were supplied to regional authorities, increasing the total fleet to 333 units. These include vacuum trucks, dump trucks, loaders, bulldozers, compactors, excavators, and other heavy machinery. Furthermore, during the reporting period, 154 units of equipment were repaired using funds amounting to 1.7 billion soums, while GPS tracking devices were installed on 218 units, enabling real-time digital monitoring. These measures have significantly improved logistical coordination and operational efficiency.

Large-scale initiatives are also being progressively implemented in the field of waste recycling and energy recovery. In particular, projects aimed at generating electricity through thermal processing of waste are being introduced in nine regions of the country. To support these initiatives, total investments of 1.3 billion USD are planned for the 2025–2027 period. As a result, it is expected that 13,000 tons of waste will be processed daily, around 2 billion kWh of electricity will be generated annually, and approximately 1,400 new employment opportunities will be created.

At present, around 300 waste recycling enterprises operate in Uzbekistan. Collectively, they process approximately 800,000 tons of waste annually, which constitutes about 5.2 percent of the total waste generated. Therefore, ensuring strict compliance with environmental regulations, minimizing harmful emissions, and protecting public health remain pressing challenges. In parallel, ecological infrastructure development is being expanded, including large-scale landscaping around landfill areas. Within the framework of the “Yashil Makon” program, during 2024–2025, 1.2 million trees and shrubs were planted, nearly 10 kilometers of irrigation networks were cleaned, and 36,000 square meters of internal roads

were gravelled. These measures significantly contribute to improving environmental conditions across regions.

In order to raise environmental awareness among the population, the "Cleanliness and Sanitation Month" campaign has also delivered tangible results. Between October 15 and November 15, 2025, more than 422,000 tons of waste were collected, over 95,000 mahallas and 61,000 public areas were cleaned. Approximately 369,000 personnel and more than 66,000 units of specialized equipment were involved in these activities. Monitoring results revealed that over 448,000 violations were detected during this period, with appropriate administrative actions taken in response.

The performance evaluation system for sanitary service providers has also been significantly improved. A total of 105 enterprises were assessed using a rating-based classification system, resulting in 41 being categorized as "green," 53 as "yellow," and 11 as "red." Disciplinary and corrective measures were applied to underperforming organizations, including fines imposed on 14 enterprises over a six-month period, termination of contracts, or transfer to alternative management structures. Additionally, mechanisms have been introduced to discontinue cooperation with persistently inefficient service providers. Overall, improvements in waste collection infrastructure, regulation of landfill operations, adoption of recycling and energy recovery technologies, and initiatives to enhance environmental awareness collectively strengthen the foundations of a circular economy in Uzbekistan. This serves as a key factor in ensuring rational resource utilization, ecological balance, and a healthier environment for future generations.

Conclusions

In summary, the large-scale implementation of circular economy principles in Uzbekistan is increasingly recognized as a fundamental strategic driver of long-term sustainable development. This direction holds high importance in terms of efficient use of natural resources, preservation of ecological balance, and improvement of economic productivity. In the future, consistent and

comprehensive reforms in this field will establish a strong institutional and organizational framework for significantly increasing recycling rates, reducing pressure on landfill infrastructure, and forming a modern, resource-efficient economic system.

Scientific and applied research confirms that the circular economy model is capable of generating not only environmental benefits but also wide-ranging socio-economic advantages. In particular, the expansion of recycling systems enables the development of secondary raw material markets, reduction of import dependence, improvement of resource efficiency in production processes, and creation of new employment opportunities. At the same time, the adoption of advanced technologies enhances the competitiveness of the national economy and accelerates the ecological transformation of industrial sectors.

Accordingly, several priority strategic directions must be further strengthened to accelerate circular economy development. These include the full establishment of source-level waste separation systems and expansion of their geographical coverage, increasing the number and technological level of recycling enterprises, and promoting public-private partnership mechanisms to encourage private sector participation. In addition, the introduction of digital monitoring systems and improvement of environmental incentive mechanisms are essential for increasing overall system effectiveness.

Recent empirical evidence indicates positive structural changes in this direction. In particular, the growth of specialized waste collection and transport vehicles from 1,461 units in 2017 to 3,390 units in 2024 reflects significant progress in logistical infrastructure development. Furthermore, the ongoing rehabilitation of landfills, introduction of modern management approaches, and implementation of waste-to-energy projects demonstrate the active integration of innovation into the sector.

At the same time, statistical analysis shows that waste generation in the country continues to rise annually. Currently, approximately 14.8–15.1 million tons

of household waste are produced each year, while only 5–5.2 percent is recycled. This gap clearly indicates insufficient development of infrastructure and technological capacity, making the broader implementation of circular economy principles even more urgent. At the same time, it highlights substantial untapped potential for innovation and more efficient resource utilization.

A comprehensive analysis of these developments demonstrates that Uzbekistan has been consistently implementing wide-ranging institutional, legal, and technological reforms aimed at modernizing the waste management system and embedding circular economy principles into practice. Within the framework of a strategic shift toward a “green economy,” a series of important policy documents have been adopted, defining clear objectives for improving waste management systems, expanding recycling infrastructure, reducing landfill loads, and increasing the use of renewable energy sources.

Thus, the analysis clearly shows that the formation of a circular economy model in Uzbekistan is progressing in a gradual and structured manner, supported by increasingly strong legal, institutional, and technological foundations. The continued and consistent implementation of these reforms will contribute to enhancing environmental sustainability, improving resource efficiency, and strengthening the long-term competitiveness of the national economy.

Foydalanilgan adabiyotlar ro‘yxati

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