

FINANCIAL ALLOCATION FOR SUSTAINABLE LANDFILL MANAGEMENT IN UZBEKISTAN

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Abstract

This study analyzes how financial resources should be allocated in Uzbekistan's landfill-based municipal solid waste system to improve ecological performance and economic sustainability. The article is adapted from the author's original IMRAD manuscript and reorganized to match the Abisatya Eko-Bisma journal template. The study uses documentary analysis, comparative literature review, scenario modeling, and multi-criteria assessment to compare four allocation strategies: business-as-usual, landfill-first, circular-recovery, and an integrated hybrid model. The results show that simply spending money on disposal sites won't make landfills work better. Putting together a financing package that includes all of the following is the best way to do this: better collection, better transfer logistics, clean landfills, controlling methane and leachate, digital billing, and slowly recovering materials. Putting landfills first makes it easier to follow the rules, but it doesn't work as well for circularity and getting money back over time. It's hard to put a model that relies heavily on recycling into action if collection reliability and engineered disposal capacity aren't always reliable. A hybrid allocation model that is backed by tariff reform, better data systems, extended producer responsibility, and climate-linked financing is the best way to go. The research shows that Uzbekistan can move from a system where people only use landfills when they need to to a public utility model. This model is more stable, protects the environment, makes services more reliable, and helps the economy move to a more circular model.

Keywords: *Uzbekistan; landfill management; municipal solid waste; financial allocation; ecological sustainability; circular economy*

Abstrak

Penelitian ini menganalisis bagaimana sumber daya keuangan seharusnya dialokasikan dalam sistem pengelolaan sampah perkotaan berbasis landfill di Uzbekistan untuk meningkatkan kinerja ekologis dan keberlanjutan ekonomi. Artikel ini diadaptasi dari naskah IMRAD penulis dan disusun ulang agar sesuai dengan template jurnal Abisatya Eko-Bisma. Metode yang digunakan meliputi analisis dokumen, telaah pustaka komparatif, pemodelan skenario, dan penilaian multikriteria terhadap empat strategi alokasi, yaitu business-as-usual, landfill-first, circular-recovery, dan model hybrid terintegrasi. Hasil penelitian menunjukkan bahwa efisiensi landfill tidak dapat dicapai hanya melalui belanja pada lokasi pembuangan akhir. Strategi terbaik adalah kombinasi optimasi pengumpulan, logistik transfer, peningkatan sanitary landfill, pengendalian metana dan lindi, digital billing, serta pemulihan material secara bertahap dalam satu paket pembiayaan yang terkoordinasi. Model landfill-first meningkatkan kepatuhan lingkungan tetapi lebih lemah pada aspek sirkularitas dan pemulihan biaya jangka panjang, sedangkan model yang terlalu berorientasi daur ulang menghadapi kendala implementasi ketika keandalan pengumpulan dan kapasitas disposal yang direkayasa belum merata. Pendekatan yang direkomendasikan adalah model alokasi hybrid yang didukung reformasi tarif, sistem data yang lebih baik, extended producer responsibility, dan pembiayaan terkait iklim.

Kata kunci: Uzbekistan; landfill management; sampah perkotaan; alokasi keuangan; keberlanjutan ekologis; ekonomi sirkular

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PENDAHULUAN

Municipal solid waste management has become a strategic test of state capacity in many rapidly urbanizing economies because it connects sanitation (Nathan Posdakoff, 2015), environmental quality, fiscal governance (Berg et al., 2022), and public trust (Pratiwi, 2016). In low- and middle-income countries, waste systems are expected to expand service coverage (Beck et al., 2022), reduce uncontrolled dumping, improve treatment and disposal, and at the same time keep user costs politically manageable (Beck et al., 2022). International assessments consistently show that these goals cannot be achieved by increasing expenditure alone; what matters is the sequence and composition of expenditure across the service chain (Abror et al., 2023).

This issue is highly relevant in Uzbekistan (Djulmatova S.R., 2022). Over the last decade the country has expanded institutional reform and waste-service modernization (Rizkiyah, 2025), while public discourse has increasingly linked the waste sector to environmental protection (Rizkiyah, 2025), methane mitigation, and the broader green economy agenda. However, disposal still remains strongly landfill-oriented, and the quality of collection logistics, transfer arrangements, engineered disposal facilities, and cost-recovery systems differs significantly across territories (Hadipuro, 2010). As a result, policymakers face a practical question: how should scarce financial resources (Duan, 2019) be allocated so that landfill management improves without locking the country into inefficient or environmentally weak spending patterns?

The answer is not straightforward because landfill management is often misunderstood as a narrow engineering issue at the disposal site (Kamalova, 2022). In reality, a landfill performs well only when upstream functions are also efficient (Khatib, 2015). If collection routes are incomplete, valuable resources never reach the legal disposal network. If transfer distances are poorly designed, operating

costs rise (Djulmatova S.R., 2022). If mixed waste enters the landfill without any control over organics, moisture, or recyclables, methane risk, leachate intensity, and loss of recoverable value all increase (Henry et al., 2006). If billing systems are weak, even well-built facilities may deteriorate after capital investments are finished. Therefore, efficient landfill finance is inseparable from efficient system finance (Kochergin, 2020). Uzbekistan is an analytically useful case because the country shows both progress and structural constraints (A. Boboyev, 2022). National strategies and government programs have created a policy basis for modernization. Multilateral development banks have supported collection, transfer, and landfill infrastructure (Demirgüç-Kunt, 2021). At the same time, regional project documents and climate-related assessments indicate that tariff adequacy, subsidy dependence, operational unevenness, and limited material recovery continue to shape the sector's performance (Oommen, 2024). Different public documents also use different reporting scopes for waste generation and treatment, which complicates financial planning and performance management (Kavitha et al., 2023).

Based on this context, the purpose of this article is to examine how financial resources can be allocated more efficiently in Uzbekistan's landfill-oriented waste-management system while supporting ecological sustainability and economic resilience. The article reorganizes the author's original research into the structure required by the *Abisatya Eko-Bisma* template and focuses on three objectives: first, to identify the main financial and operational bottlenecks in landfill-centered waste management; second, to compare alternative allocation strategies; and third, to formulate a practical medium-term allocation model that is more balanced than a purely landfill-first or recycling-only approach.

The novelty of the article lies in combining a public-finance perspective with landfill management, rather than

treating waste policy only as a technical or environmental problem. The article argues that ecological investment is not a fiscal burden to be postponed, but a way to reduce long-run liabilities, improve service productivity, and create a stronger basis for circular-economy development. For policymakers, the study offers a realistic allocation logic suited to a transition economy. For researchers, it provides a framework that can be extended through territorial cost studies, engineering audits, or greenhouse-gas modeling.

KAJIAN PUSTAKA

The literature on financing municipal solid waste says that waste systems should be seen as service chains instead of separate infrastructure projects. Kunt (Demirgüç-Kunt, 2021) say that collection, transfer, treatment, and disposal all depend on each other financially. When you spend a lot of money on one part and ignore the others, it usually leads to inefficiency because the problems of cost overruns and environmental risks are not solved but moved to another part (Ezeudu & Bristow, 2025). In landfill-centered systems, this means that investment at the disposal site must be coordinated with upstream coverage, operational control, and downstream diversion efforts (Sherkulovna, 2021).

A second stream of literature concerns the economics of sanitary landfills. Studies reviewed in the original article show that poor environmental control is expensive (Matchanov & Rizayev, 2020). Weak compaction shortens landfill life, unmanaged leachate increases the probability of future remediation costs, and methane leakage creates both climate externalities and the loss of possible mitigation finance (Sherkulovna, 2021). From this perspective, ecological safeguards are not optional add-ons but part of asset protection and long-term cost efficiency.

A third important theme is financing structure. Waste systems in developing and transition economies rarely become financially sustainable through user tariffs

alone. Effective systems usually combine user fees, municipal or national budget support, concessional loans, grants, extended producer responsibility (EPR), and in some cases carbon- or climate-linked finance (Bharadwaj, 2020). This blended structure is especially relevant where willingness to pay and ability to pay remain lower than the full cost of environmentally compliant service.

The circular economy literature adds another insight: a modern waste system still requires environmentally controlled disposal for residual waste (A. Boboyev, 2022). Circularity does not eliminate the need for landfills in the short or medium term. Instead, circular-economy policies aim to reduce the volume and pollution intensity of the waste stream that finally reaches the landfill. This means that sanitary landfill upgrading and material recovery should be treated as complementary, not opposing, investments (Krieger et al., 2018).

Recent Uzbekistan-related studies strengthen this argument. Research on waste composition in Tashkent and related Central Asian contexts indicates a substantial organic fraction in household waste, alongside under-recovered paper, plastics, glass, and metals (Ruzieva, 2024; Tursunov et al., 2024). A waste stream with high organic content generates stronger methane and leachate risks when landfilled without diversion or control. It also means that technology decisions should be based on actual feedstock characteristics rather than on symbolic assumptions about modernization.

Taken together, the literature suggests that the most efficient financing model for Uzbekistan is unlikely to be an extreme model (Matchanov & Rizayev, 2020). A purely landfill-first strategy may improve engineering compliance but underperform on diversion and long-run circularity (Nimatov & Imamova, 2021). A recycling-heavy strategy may promise environmental gains but encounter operational failure if the basic collection and disposal system is still uneven. Therefore, the theoretical expectation derived from the

literature is that an integrated hybrid model should outperform one-dimensional allocation strategies.

METODE PENELITIAN

This study uses a qualitative-quantitative mixed-method approach adapted from the author’s original manuscript (Sugiyono, 2022). The empirical basis is documentary and comparative rather than a single proprietary dataset. This choice is appropriate because the main research problem concerns policy design and financial allocation at system level, while the sector itself is characterized by multiple institutions, varying territorial conditions, and partially fragmented data (LEAVY, 2019).

The first component of the method is a structured documentary review. The analysis relies on national policy documents, public government communications, multilateral development bank project reports, and international waste-governance literature. The documentary review was used to identify sector bottlenecks, investment categories, implementation risks, and the policy direction of recent reform in Uzbekistan.

The second component is comparative literature review. Relevant academic and policy studies were examined to identify the financing principles most applicable to landfill-oriented systems in developing or transition economies. Particular attention was given to cost recovery, methane mitigation, tariff reform, extended producer responsibility, and investment sequencing.

The third component is scenario analysis. Four resource-allocation scenarios were compared. Scenario A represents business-as-usual, where spending remains fragmented and incremental. Scenario B is a landfill-first approach that focuses on engineered cells, heavy machinery, and

controlling the environment at disposal sites. Scenario C is a circular-recovery approach that focuses on sorting, recycling, getting rid of organic waste, and separating communities. Scenario D is a hybrid approach that combines different methods and spreads money across collection, transfer, landfill engineering, methane and leachate control, digital billing, and phased material recovery.

The fourth component is multi-criteria decision analysis. Each scenario was assessed against six criteria: ecological performance, fiscal sustainability, operational reliability, implementation feasibility, social acceptability and service equity, and circular-economy contribution. The weighted scoring system follows the structure of the original article and is used here to compare relative strengths rather than to claim deterministic national budget values.

The study also formulates an indicative medium-term allocation envelope to show how an integrated strategy can be operationalized. Instead of presenting a fixed legal budget, the model uses percentage-based allocation categories so that the framework remains adaptable to different provinces, municipalities, and implementation stages. This is useful for Uzbekistan because regional diversity is significant and the cost structure of waste management varies across urban and rural settings.

A limitation of the study is that it does not rely on a single harmonized national database covering all waste flows, costs, and facilities. Another limitation is that recent policy announcements and infrastructure pipelines remain dynamic. Nevertheless, the mixed-method design is suitable for a decision-oriented article because it combines public evidence, comparative theory, and transparent analytical assumptions.

Tabel 1. Skor Komparatif Skenario Alokasi Sumber Daya

Scenario	Ecology	Fiscal	Operational	Feasibility	Social equity	Circularity	Composite
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A. Business-as-usual	40	42	50	70	55	20	43
B. Landfill-first	75	60	72	68	63	28	67
C. Circular-recovery	82	66	61	50	65	95	79
D. Hybrid integrated	88	81	85	74	78	79	86

Source : by Author, 2026

HASIL DAN PEMBAHASAN

The first finding is that landfill management in Uzbekistan should be framed as a system-efficiency issue rather than a disposal-site issue alone. The original article demonstrates that landfill performance depends on collection coverage, transfer design, fleet productivity, waste composition, billing discipline, and environmental monitoring. If these upstream and governance variables remain weak, even well-financed landfill infrastructure delivers less value than expected. Therefore, financially efficient landfill reform requires coordinated investment across the municipal solid waste chain rather than isolated site-centered capital spending.

The second finding is that Uzbekistan’s waste sector is not institutionally empty, but institutionally incomplete. Public policy and project materials indicate that the country has already moved beyond purely reactive sanitation responses. National strategies have set long-term modernization goals; external financing has supported collection, transfer, and sanitary landfill functions; and government discourse increasingly connects waste with ecological sustainability, energy recovery, and circular economy transition. However, this progress remains uneven because collection quality, infrastructure reliability, tariff adequacy, and data consistency differ by region.

The third finding concerns data and planning quality. Different public documents use different reporting boundaries, including municipal solid waste, household waste, or broader waste categories. When budget planning, tariff discussions, and investment appraisals rely on inconsistent definitions, capital allocation

becomes less efficient. A relatively low-cost but high-return reform is therefore investment in harmonized reporting, weighbridge systems where feasible, route-level digital tracking, and asset-based performance dashboards. Such measures may attract less political visibility than new equipment or new cells, but they improve both fiscal oversight and environmental control.

The scenario comparison provides the central analytical result. Scenario A, business-as-usual, performs weakest because fragmented spending reproduces existing inefficiencies. Some assets may be upgraded, but the overall chain remains inconsistent and environmental risks decline only partially. Scenario B, landfill-first, performs better on engineering compliance, compaction, and basic environmental control, yet it remains weaker on circularity and long-run financial resilience because it does not reduce the incoming burden of mixed waste sufficiently. Scenario C, circular-recovery, performs strongly on diversion potential and circular contribution, but implementation risk is high when collection reliability, source separation, and disposal engineering are still uneven. Scenario D, hybrid integrated, receives the highest composite score because it combines environmental control, fiscal logic, operational reliability, and practical feasibility.

The superiority of the hybrid model is important in policy terms. It suggests that Uzbekistan does not need to choose between sanitary landfills and circular-economy measures as if they were mutually exclusive. Instead, the country should finance a sequenced portfolio. Near-term priorities should secure legal collection, transfer

efficiency, sanitary disposal, and methane and leachate control. At the same time, medium-term investment should gradually expand sorting, selective material recovery, organics diversion where feasible, and public awareness. This sequencing recognizes both current institutional constraints and future sustainability goals.

A further result from the original article is that ecological performance and economic efficiency are not opposites. Poor environmental control is itself expensive. Weak cover systems increase odors and fire risk, poor compaction shortens site life, unmanaged leachate raises water-protection liabilities, and methane leakage represents the loss of possible climate-finance opportunities. In this sense, environmental spending protects the economic value of landfill assets. For a country such as Uzbekistan, where waste-management modernization is still ongoing, delaying ecological measures may increase future fiscal burdens rather than reduce them.

The composition of waste also matters for financing choices. Studies cited in the original article indicate that a large organic fraction remains present in household waste streams. This has two implications. First, unmanaged organics increase methane generation when buried, which strengthens the case for landfill-gas control and selective diversion. Second, mixed and wet waste weakens the economics of some advanced treatment technologies, including waste-to-energy projects, when feedstock quality is

unstable. As a result, technology choices should be based on local waste characteristics and not on prestige or symbolic modernity alone.

Another important result concerns tariff reform. The article demonstrates that tariff adjustment is essential yet inadequate as an isolated measure. In transition situations, the willingness to pay, the cost of compliance, and the full cost of service often don't match up. If tariffs go up but the service doesn't get better, people may be less likely to pay and more likely to protest. So, tariff reform should happen slowly and be tied to better collection reliability, clearer service standards, digital billing, and protection for families who are at risk. This package approach makes things more legitimate and helps businesses make more money more effectively than just changing prices.

The article suggests a balanced medium-term allocation envelope to put these findings into action. The largest share is assigned to sanitary landfill cells and machinery because disposal capacity and compliance remain indispensable. However, significant shares are also directed to collection equipment, route optimization, transfer logistics, methane and leachate control, material recovery, digital monitoring, and public engagement. This portfolio is moderate rather than technologically extravagant: it avoids both infrastructure monoculture and unrealistic expectations of immediate full circularity.

Tabel 2. Model Alokasi Investasi Jangka Menengah yang Direkomendasikan

Intervention	Indicative share (%)	Primary objective	Ecological effect	Financial rationale
Collection equipment, bins, and route optimization	18	Raise legal collection and reduce leakage to illegal dumping	Cleaner settlements; less uncontrolled disposal	Improves service efficiency and revenue legitimacy

Transfer and logistics	12	Lower distance-related operating costs and improve through	Reduced fuel intensity and transport inefficiency	Cuts recurrent costs of hauls
Sanitary landfill cells and machinery	27	Improve compaction, site life, and compliance	Lower land, odor, and groundwater risk	Protects high-value disposal asset
Material recovery and sorting	16	Divert recyclables from mixed waste	Reduces landfill burden and supports circularity	Generates secondary-material value and lowers disposal costs
Methane and leachate control	15	Lower environmental externalities and future liabilities	Cuts climate and water pollution risk	Creates basis for climate/carbon finance and avoids remediation costs
Digital billing, weighbridge Monitoring	6	Improve data, collection rates, and accountability	Enables better environmental oversight	High governance return per unit of spending
Community sorting and public awareness	6	Improve behavior and source separation	Supports organics and packaging diversion	Low-cost support for long-run system efficiency

Sumber: Author, 2026

The recommended allocation model has several practical implications for governance. First, budgeting should move away from a narrow construction mindset toward life-cycle service management. A landfill is not only a civil-works project; it is a long-lived operating asset that depends on maintenance, data, access control, fleet coordination, and environmental compliance. Second, investment appraisal should include avoiding future costs, such as remediation, accelerated site exhaustion, and environmental conflict, rather than focusing only on immediate capital expenditure. Third, institutional coordination is essential. The responsibilities of the waste sector often fall on local governments, service providers, environmental authorities, and financial actors. If there aren't standard indicators and clear reporting duties, it's likely that people will spend money twice and not be held accountable. The original article therefore recommends national coordination mechanisms, common performance indicators,

and reporting templates that allow comparison across regions. Such coordination does not require full centralization; rather, it improves strategic alignment while allowing territorial adaptation. Fourth, blended finance should be treated as a permanent feature of reform rather than a temporary exception. User tariffs will remain important for operating discipline, but capital-intensive environmental upgrading may require concessional finance, public support, and policy instruments such as EPR. If methane capture or landfill-gas utilization becomes technically viable, climate-related finance could also strengthen project bankability. In this way, financial sustainability should be understood as diversification of funding sources combined with better expenditure discipline. Finally, the article shows that landfill management can serve as an entry point to a broader circular-economy transition. In the short term, Uzbekistan still needs reliable residual-waste disposal. In the medium term,

however, better sorting, organics management, packaging recovery, and digital performance monitoring can gradually reduce the quantity and pollution intensity of waste reaching final

disposal. A hybrid approach therefore supports both immediate sanitation needs and long-run ecological modernization.

Tabel 3. Risiko Implementasi dan Instrumen Mitigasi

Risk	Likely consequence	Mitigation instrument	Priority level
Fragmented responsibilities	Duplicated spending and weak accountability	National coordination platform, standard KPIs, shared reporting	High
Low payment discipline	Underfunded operations and deferred maintenance	Digital billing, enforcement, service-linked communication, targeted support	High
Technology mismatch	Stranded assets and fiscal stress	Independent technical appraisal, pilots, feedstock testing	High
Weak environmental monitoring	Hidden ecological Liabilities	Weighbridges, site monitoring protocols, third-party verification	Medium-High
Procurement focused on lowest price only	Short asset life and poor performance	Life-cycle procurement criteria and maintenance obligations	Medium-High
Social resistance to tariff change	Political rollback and low compliance	Phase tariff reform after service gains; protect vulnerable households	Medium

Sumber: Author , 2026

KESIMPULAN DAN SARAN

This article concludes that efficient financial allocation in Uzbekistan’s landfill-oriented waste system cannot be achieved through disposal-site spending alone. The strongest strategy is an integrated hybrid model that combines collection optimization, transfer rationalization, sanitary landfill upgrading, methane and leachate control, digital monitoring, and gradual recovery of recyclable and organic fractions. Compared with business-as-usual, this approach provides better ecological performance, stronger fiscal sustainability, and higher operational reliability.

The study also confirms that ecological investment should be understood as a component of economic efficiency. Better landfill control reduces long-run liabilities, protects infrastructure value, improves service legitimacy, and creates a stronger basis for climate-related and circular-economy financing. For this reason, Uzbekistan should avoid both extreme strategies: a narrowly landfill-first model that neglects upstream efficiency and a recycling-heavy model that overestimates short-term implementation capacity.

Several policy recommendations follow. First, the government and sector

operators should harmonize data definitions, waste-flow reporting, and performance indicators. Second, medium-term budgeting should put a balanced portfolio with strong shares for upgrading sanitary landfills, improving collection and transfer efficiency, and controlling methane and leachate at the top of the list. It should also pay for selective material recovery and public awareness. Third, changes to tariffs should happen slowly, be clear, and be connected to clear improvements in service, digital billing, and targeted social protection. Fourth, before committing to advanced technologies like large-scale waste-to-energy facilities, project appraisal should use life-cycle costing and realistic feedstock analysis.

For future research, the framework developed in this article can be refined through province-level cost studies, GIS-based logistics analysis, engineering audits of landfill performance, and more detailed methane-abatement modeling. In practical terms, the article offers a policy roadmap for moving Uzbekistan's landfill management from reactive sanitation spending toward an environmentally accountable and economically resilient public-utility model.

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