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TRANSITIONING TO A CIRCULAR ECONOMY IN KAZAKHSTAN: AN ANALYSIS OF WASTE MANAGEMENT POLICY AND IMPLEMENTATION CHALLENGES

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ABSTRACT

This article analyses Kazakhstan's waste management policy in the context of increasing global environmental challenges and the country's transition to a circular economy. Methodologically, the study employs qualitative document analysis of the post-2021 governance framework, including laws, subordinate acts, policy programmes, and official institutional materials. It is complemented by descriptive analysis of official statistics, and the findings are synthesised through a SWOT framework. The analysis highlights that, despite regulatory modernisation following the 2021 Environmental Code, implementation remains uneven due to infrastructure gaps, weak incentives, limited citizen participation, and persistent data inaccuracies. Particular attention is paid to municipal solid waste and e-waste, with municipal-level dynamics illustrated through the Astana waste management programme (2024–2028). The SWOT-based discussion links these constraints to policy priorities, including digitalisation of waste-flow accounting and registers, strengthened local implementation capacity, enforcement, and investment-oriented instruments to expand sorting and recycling.

Keywords: Waste management, Kazakhstan, Circular economy, Public policy, Municipal waste.

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Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

INTRODUCTION

Effective environmental protection and waste management have become one of the most important tasks of modern society. Due to population growth and industrial development, there is an increase in the amount of waste, which in many cases is hazardous, thereby having a significant impact on the environment and human well-being. The United Nations Environment Programme (UNEP) predicts that municipal solid waste (MSW) generation will double to 3.8 billion tons by 2050 from 2023 (United Nations Environment Programme, 2024). Consequently, to reduce waste and promote recycling, many countries have recognized the need to develop and improve waste management policies and legislation.

The countries of Central Asia, including Kazakhstan, have also been actively working in this direction. A number of documents aimed at improving waste management policy have been introduced in Kazakhstan, including the development of legal acts regulating waste management issues. The strategic course of the waste management system until 2050 is based on the Concept of Kazakhstan's transition to a "Green Economy". The Concept includes the introduction of a separate waste collection system and an increase in the levels of recycling and reuse of both industrial and municipal waste. It also sets targets, according to which the share of recycling and utilization of municipal waste from the total amount of waste generated should reach 40% by 2030, 50% by 2040, and 60% by 2040 (Adilet, 2013). These strategic initiatives are aimed at improving the environmental situation and moving towards a more sustainable waste management system.

The main document regulating issues in the sphere of waste management is the Environmental Code of the Republic of Kazakhstan, which was adopted in 2021 (hereafter the Code). The Code differentiates the basic concepts of waste, accumulation, collection, transportation, recovery, waste disposal, etc. Additionally, the Code introduces the "hierarchy principle" of waste, thus waste holders in order to minimize waste generation and ensure sustainable development should adhere to the following step-by-step measures as waste prevention, preparation for reuse, recycling, recovery and then waste disposal (Adilet, 2021). More than 20 national standards in the field of management of certain types of waste have been adopted in the implementation of the Code since 2021 (Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, 2022). Thus, the Code has introduced significant changes to the waste management system and these measures will contribute to the improvement of environmental policy in Kazakhstan and the transition to more sustainable waste management practices.

At the international level, on the issue of waste management, Kazakhstan has ratified a number of conventions such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Adilet, 2003), the Stockholm Convention on Persistent Organic Pollutants (Adilet, 2007a), and the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, and others (Adilet, 2007b).

Despite the existing policy and adoption of relevant legal acts on waste management in Kazakhstan, the level of addressing waste issues remains insufficient. The presence of a large number of landfills throughout the territory of Kazakhstan, the lack of sorting of household waste at the sources of waste generation, an inefficient mechanism of e-waste accumulation, etc. make the waste man-

Eurasian
Research
Journal
Spring 2026
Vol. 8, No. 2

agement policy in Kazakhstan not quite acceptable for human life and health. Moreover, some regions of the country lack modern waste processing plants, which makes efficient waste management difficult (Zikrina et al., 2021: 125).

The importance of this study is due to a number of topical challenges facing modern society, including complex environmental challenges and the rapid pace of climate change. Particular attention is paid to the issues of assessing the effectiveness of the current policy in the sphere of waste management, as insufficient efficiency of these measures leads to systematic pollution of natural resources. This has a negative impact on soil, aquatic ecosystems, flora, and fauna, and also contributes to the deterioration of air quality, posing a threat to sustainable development and environmental security.

This article examines waste management policies and current waste generation in Kazakhstan, along with waste-disposal problems and approaches that may lead to more sustainable development. The purpose of the study is to understand and determine the level of the waste problem in Kazakhstan, and what is being done about it at the state level and by other stakeholders. The main focus is on the progress in waste recycling, the limitations of the existing system, and the prospects for its development. Also, prospects for the development of effective waste management have been identified through the development of appropriate recommendations and proposals.

METHODOLOGY

This study uses a qualitative document analysis as the main research strategy, complemented by descriptive analysis of official statistics. The qualitative component examines Kazakhstan's waste governance framework, including its legal, institutional, and programmatic arrangements, particularly in the post-2021 reform context following the adoption of the Environmental Code. Quantitative indicators are employed to contextualise the scale and structure of waste generation and to support trend descriptions. The findings are synthesised through a SWOT framework to structure internal system characteristics (strengths/weaknesses) and external drivers (opportunities/threats).

In practice, this paper includes the national official legal repository and official institutional portals and websites. The empirical base consists of:

a) regulatory and policy documents: national legislation and selected subordinate acts relevant to waste management, including the 2021 Environmental Code, along with strategic and programmatic documents addressing waste prevention, separate collection, sorting, recycling, disposal, and circular economy transition;
b) official institutional reports and analytical materials: documents from competent state bodies and oversight/evaluation sources addressing implementation challenges and performance signals;
c) international analytical sources used in the article to contextualise Kazakhstan's progress and constraints (e.g., UNEP and World Bank materials), alongside selected environmental and waste-related analytical publications;
d) official statistics on waste generation, composition, and treatment, used descriptively to support the discussion of MSW and other waste streams, including e-waste where relevant.

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

Documents were selected through purposive sampling, guided by the article's objectives: assessing the regulatory architecture of waste management; institutional responsibilities and implementation mechanisms; infrastructure and operational constraints (collection, sorting, recycling, and disposal); and the policy relevance of specific waste streams, including MSW and e-waste. Priority was given to documents that are officially issued and publicly accessible, directly applicable to waste governance and implementation, and explicitly relevant to the post-2021 policy context.

The analysis was conducted in four sequential steps: 1) "framework mapping – extraction of key provisions and governance elements from the selected legal and policy documents (definitions, responsibilities, instruments, requirements for separate collection and handling, and enforcement/monitoring aspects);" 2) "qualitative content analysis – thematic reading and coding of documents to identify recurring patterns related to implementation barriers (for example, infrastructure gaps, monitoring and data-quality issues, incentive design, public participation, and compliance);" 3) "descriptive statistical contextualisation – use of official statistics to contextualise the magnitude and composition of waste flows and to align institutional claims with observable trends;" 4) "regional implementation lens and illustrative cases – to capture implementation dynamics beyond the national level, the study analyses the Astana City Waste Management Programme for 2024–2028 as a focused regional policy example. In addition, the article uses an illustrative practice-oriented example to demonstrate how circular economy practices may operate in real settings, without treating such cases as nationally representative.

The SWOT analysis is an interpretive synthesis derived from the coded results of the document analysis and supported by the statistical context and referenced literature. Strengths and weaknesses reflect internal characteristics of the waste governance system evidenced in legislation, institutional arrangements, standards-related measures, and documented implementation signals, including the Astana programme. Opportunities and threats capture external drivers discussed in the sources, such as investment and technology prospects, digitalisation potential, and environmental and socio-economic risks affecting waste volumes and compliance. The SWOT in this study is not based on stakeholder interviews; rather, it is grounded in documentary evidence and the literature context used in the manuscript."

RESULTS

The analysis of legal acts has shown that Kazakhstan is actively working on the development of policy and relevant legal acts in the field of waste management. According to the Kazakhstan Waste Management Association 'KazWaste', currently more than 70 legal acts have been officially developed and adopted in Kazakhstan regulating the main issues of waste management (KazWaste, 2024). A new Environmental Code was developed in 2021. The Ecological Code, in force since 2007, covered the issues of waste regulation only in a fragmented manner, not providing a comprehensive and systematic approach to the management of this sphere.

The new Environmental Code, which came into force in 2021, is a qualitatively updated document reflecting modern environmental challenges and international standards of environmental protection activities. One of the most significant

Eurasian
Research
Journal
Spring 2026
Vol. 8, No. 2

elements of the Code is the systemic regulation of waste management oriented towards the implementation of circular economy principles. In particular, the document enshrines the waste management hierarchy, according to which priority is given to waste prevention, reuse, recycling, and then neutralisation and disposal. This approach is in line with the principles adopted within the framework of European environmental legislation and international practice (Adilet, 2021).

Considerable attention is paid to the issues of separate waste collection, which the Code treats not as a recommendation, but as a mandatory measure to be implemented at the level of local executive bodies and economic entities. The Code explicitly requires the provision of conditions for selective collection, including through the creation of appropriate infrastructure and informing the population about the rules of waste management (Adilet, 2021). The implementation of this practice should become an integral part of municipal management, especially in cities where waste volumes reach critical levels.

In addition, the new legal act introduces a clear categorisation of facilities that have a negative impact on the environment, including those whose activities are related to the production, storage, transportation, and disposal of waste. The facilities are categorised into four categories depending on the level of their impact, which allows for differentiated approaches to environmental control and regulation (Adilet, 2021).

The Code also reflects the "polluter pays" and "precautionary" principles, whereby legal entities are fully financially responsible for remedying environmental damage and are obliged to apply measures to minimise potential risks at the planning stage of their operations (Adilet, 2021). This, therefore, provides the basis for a shift from a reactive to a preventive approach in waste management.

The key task in this context is to mobilise investment in waste treatment and neutralisation infrastructure. The Code incentivises the introduction of the best available technologies and provides tax and regulatory relief for companies implementing environmentally friendly solutions (Adilet, 2021).

At the same time, the effectiveness of the implementation of these provisions will largely depend on the executive discipline at the regional level. As the data from the Ministry of Ecology show, in practice many akimats do not ensure full implementation of the Code provisions: there is no systematic waste accounting, mechanisms of economic incentives for recycling have not been introduced, and measures on public participation in decision-making are reduced to a formality (Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, 2022). Taken together, these findings point to an emerging implementation gap: ambitious regulatory provisions and standards are in place, yet their translation into routine enforcement, infrastructure roll-out and behavioural change remains uneven across regions. The empirical sections below therefore, distinguish between formal policy design and observed implementation signals.

Thus, the Environmental Code of 2021 fixed the most important normative vectors for reforming the waste management system and created a legal basis for Kazakhstan's transition to a circular model. However, successful implementation of these norms requires a systematic approach, including administrative

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

reforms, improvement of performers' qualification and formation of sustainable environmental culture in the society.

In the implementation of the Environmental Code, more than 20 national standards in the field of management of certain types of waste have been developed according to Table 1.

Table 1
List of national standards in the field of management of certain types of waste

	Waste category	**Normative document (ST RK/ GOST)**	**Summary and purpose of the standard**	**Expected Result**
1	Batteries and accumulators	ST RK 3132	Resource saving in the recycling of lead batteries	Reducing pollution from batteries, increasing recycling rates
2	MSW (Small capacity)	ST RK 3696	Requirements for landfills for low-capacity MSW	Compliance with sanitary norms, reduction of illegal dumpsites
3	Contaminated soils and subsoils	ST RK 3697	Remediation of contaminated land, water and structures	Cleaning of contaminated land, restoration of natural objects
4	Surrogate fuels	ST RK 3698-2020	Production of secondary fuels from waste	Reduction of disposal volumes, production of alternative fuels
5	Production and consumption waste	ST RK 3699-2020	Management hierarchy at all stages of the waste life cycle	Introduction of circular economy and resource conservation
6	MSW containers (flat lid)	ST RK EN 840-2-2020	Containers with flat lids up to 1.3 m^3	Improvement of separate collection conditions, standardisation of logistics
7	MSW containers (dome lid)	ST RK EN 840-3-2020	Containers with dome lid up to 1.3 m^3	Expansion of MSW collection system, convenience of waste management
8	Medical waste	ST RK 3498-2019	Collection, storage and disposal of medical waste	Preventing the spread of infection and contamination
9	Mercury-containing waste	ST RK 1513-2019	Handling of mercury-containing components	Safe handling of toxic components, health protection

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

10	Used oils	ST RK 3129-2018	Collection, storage and recycling of used oils	Reducing oil leaks, recycling of the resource
11	Tires	ST RK 2187-2012	Handling of car tires	Reduction of discarded tires, rubber recycling
12	Coal ash slag	ST RK 2458	Ash-and-slag processing	Reduction of dust and ash pollution from coal-fired power generation
13	Waste removal services	ST RK 2974	Unification of terms in legislation and documentation	Unification of terms in legislation and documentation
14	Containers for chemical sources	ST RK 2793-2015	Waste collection from chemical energy sources	Safe collection of chemical sources, avoiding spills
15	Housing and utilities sector	ST RK 2862-2016	Waste management in apartment buildings	Improving the quality of housing and communal services and waste collection in the residential sector
16	Cotton paper waste	ST RK 1161-2002	Disposal of cotton waste	Reduction of textile waste, increase in fabric recycling
17	Packaging	ST RK 1786-2008	Energy recovery of packaging	Reduction of packaging volumes in landfills, energy utilisation
18	Non-ferrous metals	ST RK/ GOST P 54564-2014	Handling of non-ferrous metal scrap	Recycling of high value-added metals
19	Textiles	GOST 4643-75	Textile waste management	Incentivising the processing of textile products
20	Wool and wool-blend	GOST 1220-76	Wool and wool-blend materials	Sorting and reuse of wool waste
21	Textile (mix)	GOST 1274-76	Sorting of mixed textile waste	Reduction of textile volumes in MSW, improved sorting
22	Cotton and textiles	GOST 4644-75	Sorting of cotton and textile materials	Increased recycling of mixed materials

Source: Compiled by the authors on the basis of data from the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, (2022)

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

An analysis of the current national standards shows that there is a clear desire for a systematic and differentiated approach to managing different waste streams. The standards cover a wide range of categories, from batteries and surrogate fuels to medical, textile, packaging, and even cotton waste.

It should be emphasised that the focus in the development of standards is shifting towards resource conservation, reuse, and environmental safety. For example, documents on waste oils, mercury-containing and medical wastes are primarily oriented towards minimising the toxicological load and preventing negative impacts on public health. At the same time, standards regulating textiles, packaging, non-ferrous metals, and tyres are aimed at the economic involvement of secondary resources in the production cycle, which is consistent with the principles of the circular economy.

Particular attention is paid to the regulation of conditions for waste storage, transportation, and sorting, which indicates the desire to unify waste management processes and improve technological discipline at all stages of the product life cycle. An important element is also the standardisation of container facilities – with specific dimensions, designs, and lid variants, which contributes to the logistical efficiency of collection and separate accumulation of solid waste (Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, 2022).

Thus, the structure and content of the national standards indicate Kazakhstan's endeavour to move closer to international environmental practices by integrating both sanitary-hygienic and resource-economic aspects into the regulatory framework. However, despite the availability of a variety of regulations, further development of this regulatory platform should aim to include not yet covered waste categories (e.g. e-waste) and strengthen mechanisms for implementing standards in the real sector through economic incentives and enforcement.

At the regional level, the results of the waste management policy analysis showed that local executive bodies have taken a course to resolve waste management problems for the relevant medium-term period. In particular, the regional centres of Kazakhstan have adopted and approved respective programmes on municipal waste management for 2024-2028. For example, according to the programme for Astana for 2024-2028 (hereinafter the Programme), key problems are identified and promising areas for the development of the waste management system are outlined. It is noted that despite the introduction of certain measures and a regulatory framework, the waste management system in Astana remains at the formative stage. In general, the Programme sets ambitious goals, including achieving 100% coverage of separate waste collection by 2028 and increasing the level of waste recycling to 80%. However, the realisation of these objectives is complicated by a number of factors, including insufficient infrastructure, low levels of recycling, and environmental awareness among the population (Akimat of the city of Astana, 2024).

Moreover, the current waste collection and recycling infrastructure requires significant modernisation. Approximately 16.000 waste collection containers are installed in Astana, but their wear and tear, and lack of compliance with modern standards, seriously limit the efficiency of the system. Separate waste collection is only partially implemented, covering mainly the central districts of the city. Yellow and green containers have been installed for the "dry" and "wet" fractions, but their number remains insufficient, and the transport system does

Eurasian
Research
Journal
Spring 2026
Vol. 8, No. 2

not ensure proper efficiency. The outdated fleet of refuse collection vehicles requires renewal, as the existing fleet cannot cope with the increasing volumes of waste (Akimat of the city of Astana, 2024).

The city's waste processing plants are also facing problems. In 2022, only 13-15% of waste was diverted for recycling, far from the targets. Wear and tear of equipment and lack of capacity in the left-bank part of the city increase transport costs and the carbon footprint. The municipal solid waste landfill is 80% full, highlighting the need to accelerate the construction of new landfill capacity. Meanwhile, unauthorised landfills continue to be an acute problem despite measures being taken. The management of hazardous waste, including medical, mercury-containing, and electronic waste, is also a problem. The lack of specialised recycling facilities leads to violations of environmental legislation, as evidenced by numerous cases of unauthorised dumping of hazardous waste. The problem requires a systematic approach, including stricter control and development of processing facilities (Akimat of the city of Astana, 2024).

Article 321 of the Code defines the procedure for waste collection and defines the concept of separate collection. It is clear from the definition that the responsibility to separate waste is imposed only on legal entities engaged in waste collection. The Code lacks a responsibility and a norm obliging individuals to separate household waste at the source of waste formation. Article 331 of the Code provides for the principle of liability of business entities only (Adilet, 2021). This means that individuals are not responsible for separate waste collection, which creates a legal gap. This approach limits the effectiveness of the waste management system, as the bulk of rubbish is precisely household waste generated by individuals. Thus, more effective implementation of the principles of separate waste collection will require changes in the legislation obliging individuals to also participate in the process of waste separation at the stage of waste generation.

On the other hand, the implementation of a waste separation system at the source, i.e. for individuals, is difficult due to the lack of tradition or habit of waste separation, as well as the lack of appropriate infrastructure for separate collection of MSW (no appropriate containers for: food, cardboard, glass, plastic, etc.). There are only two types of containers, green and yellow, where all household waste is put together, which is not a solution to the problem of effective accumulation of waste at the source.

Another dilemma affecting inefficient management, including MSW, is low tariffs for collection, disposal, and recycling, a lack of recycling technologies, a lack of tax benefits, and budget incentives for waste processing enterprises, and lack of private capital investment.

From an institutional-capacity standpoint, the Astana case illustrates how municipal delivery constraints (tariff setting, procurement cycles, fleet renewal, data collection and enforcement at the street level) can undermine nationally set targets. This reinforces the need to interpret waste policy outcomes through the interaction between central policy steering and local administrative capacity.

Thus, the analysis of waste management at the regional level, taking into account the case of Astana city, shows that the main problems of municipal waste management can be explained by the following factors: insufficient funding, a low level of business participation, and a lack of long-term tariff regulation. The existence

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

of a regulatory framework, including the Environmental Code, is an important step forward, but its effective implementation requires a comprehensive approach. This includes revision of tariff policy, stimulation of private investments and intensification of educational work among the population. This requires, firstly, modernisation of the entire waste collection and recycling system, including renewal of the container fleet and vehicles. Secondly, public-private partnerships should be strengthened to attract investment in recycling enterprises. Thirdly, educational and awareness programmes should be introduced to raise the level of environmental culture of the population. Special attention should be paid to separate collection, recycling of hazardous waste, and prevention of unauthorised dumps.

Analysing waste management data

According to the statistical data of the Bureau of National Statistics (2024a) for 2023, an increase in the total volume of collected municipal waste was recorded at the level of 8%, which in absolute terms amounted to about 4.1 million tonnes. This trend indicates a continuing increase in the anthropogenic load on the natural environment, which, in turn, necessitates an integrated analysis of waste management processes at all stages – from collection to final disposal. The waste composition of the Republic of Kazakhstan in 2023 is presented in Table 2.

Table 2
Waste composition of the Republic of Kazakhstan in 2023

Waste composition for 2023	Mass
Waste generated as a result of street collection	282.500 tonnes
Waste paper, cardboard and other paper fractions	119.900 tonnes
Waste generated during the functioning of markets	107.200 tonnes
Plastic and polymeric materials	84.400 tonnes
Food waste	60.300 tonnes
Glass sludge	31.700 tonnes
Metal waste	5.000 tonnes
Textiles and clothing	1.200 tonnes
End-of-life electronic and electrical equipment	296 tonnes
Other unsorted and mixed wastes accounted for the largest share	over 2.6 million tonnes

Source: Compiled by the authors on the basis of data from KazWaste, (2024)

In addition, according to official statistics (Bureau of National Statistics, 2024b), the volume of sorted waste in 2023 increased by 6.8% compared to 2022, which can be considered as a moderately positive indicator of the effectiveness of the implementation of the principles of separate collection and recycling. Territorially, the highest sorting rates were recorded in such urbanised areas as Almaty

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

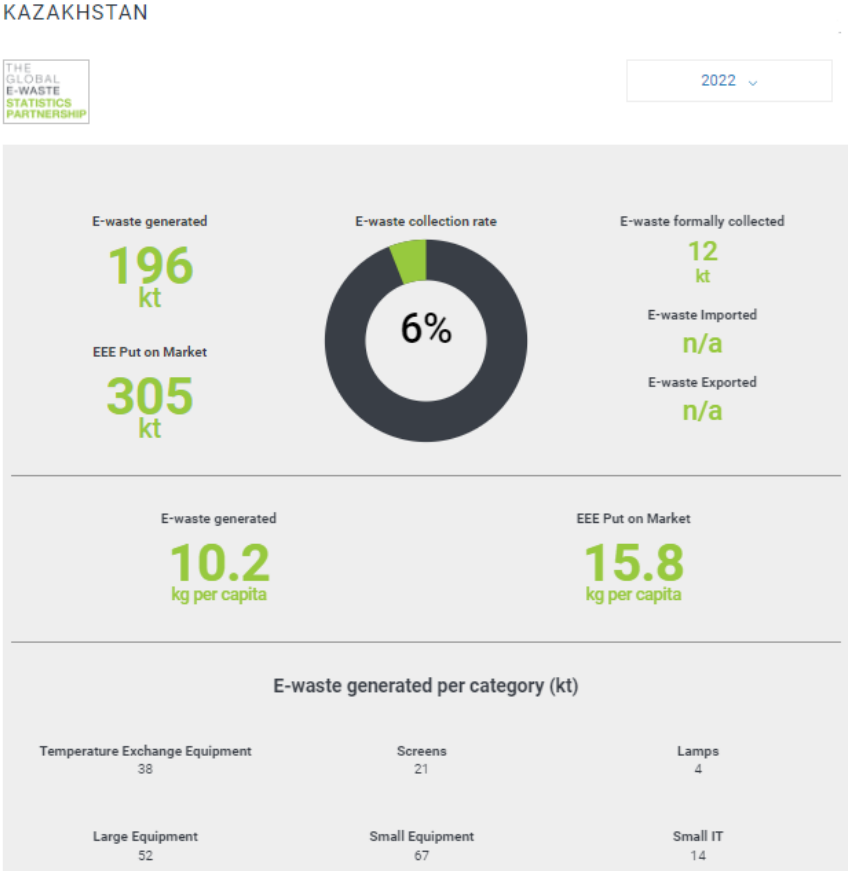
city (412.6 thousand tonnes), Astana city (372.1 thousand tonnes), as well as in Karaganda region (193.8 thousand tonnes), which indicates that these regions are more involved in the processes of sustainable waste management.

Also worth mentioning is the fact that during the mentioned period, there were 808 specialised organisations operating in the country, carrying out activities on the collection and transportation of municipal waste. Of these, 261 enterprises carried out direct treatment, including sorting, utilisation, and disposal, which confirms the existence of a certain institutional and logistical potential in the sphere of waste management, although its distribution by regions remains uneven.

Thus, the summarised waste management indicators for 2023 suggest that Kazakhstan is making gradual progress towards an effective MSW management system, but further infrastructure and regulatory efforts are required to achieve long-term environmental objectives.

In addition, according to the study "Global E-waste Statistics" (2022), as shown in Figure 1, the volume of e-waste generation in Kazakhstan in 2022 was 196 thousand tonnes, of which about 12 thousand tonnes were officially collected, which is 6% of the total.

Figure 1
E-waste generated per category in Kazakhstan (kt), 2022



Source: The Global E-Waste Statistics Partnership (2022)

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

According to the presented data for 2022, Kazakhstan demonstrates an extremely low level of efficiency in the field of e-waste management, with a total volume of e-waste generation of 196 thousand tonnes. Only 12 thousand tonnes were formally collected, which is only 6% of the total. Against this background, consumption of electronic and electrical equipment remains high – 305 thousand tonnes of products were put on the market, equivalent to 15.8 kg per capita, while waste generation per inhabitant was 10.2 kg.

The largest share in the structure of e-waste is occupied by small equipment (67 thousand tonnes), large equipment (52 thousand tonnes) and devices with heat exchange (38 thousand tonnes), while environmentally sensitive categories such as screens, lamps, and small IT equipment are also represented, but in smaller volumes. The lack of data on the import and export of e-waste makes it difficult to monitor transboundary waste flows, and the low level of collection indicates the need to implement a systemic government policy, including extended producer responsibility, development of collection and recycling infrastructure, and strengthening public awareness campaigns to minimize the environmental risks associated with the uncontrolled growth of e-waste (The Global E-Waste Statistics Partnership, 2022).

DISCUSSION

Despite institutional and regulatory efforts, the issues of effective organisation of the waste management system in Kazakhstan continue to be among the priority environmental and management challenges. Against the background of formal progress in the development of standards and legal support, in practice there is fragmented implementation, insufficient coordination between management levels, as well as limited involvement of the private sector and the population, which together reduce the effectiveness of the reforms undertaken.

Public administration perspectives help explain why implementation lags behind the formal quality of the legal framework. In classic implementation research, an "implementation gap" emerges when policy intent and statutory design do not translate into consistent administrative routines and service delivery outcomes. In the waste sector, the gap is especially visible when centrally adopted rules require coordinated actions by multiple actors (central ministry, akimats, operators, businesses, and households), while incentives, capacities, and monitoring arrangements remain misaligned.

The Kazakhstani case reflects a recurring top-down versus bottom-up tension. While top-down instruments such as codes, standards, targets, and mandatory requirements provide legal clarity, many practical levers are bottom-up: local tariff policies, procurement of containers and vehicles, contracting and supervision of operators, enforcement practices, and day-to-day citizen compliance. When local delivery systems are under-resourced or when responsibilities are fragmented, compliance can become formalistic and implementation selective, which is consistent with the patterns observed in regional programmes and landfill performance indicators.

An institutional-capacity lens complements this explanation. Central authorities typically have stronger agenda-setting and norm-setting capacities (drafting regulations, issuing standards, defining national targets), whereas local governments must operationalise policy through budgets, staff skills, infrastructure management, inspections, and data systems. Evidence from the Astana pro-

Eurasian
Research
Journal
Spring 2026
Vol. 8, No. 2

gramme illustrates capacity constraints in core delivery functions (infrastructure wear, fleet renewal needs, limited recycling performance), while national-level indicators show persistent deficits in landfill compliance and the prevalence of unauthorised dumps. These patterns suggest that strengthening local administrative capacity, alongside clearer accountability and a more reliable data architecture, is a prerequisite for closing the implementation gap.

Moreover, the analysis revealed that municipal waste management practices in Kazakhstan currently often do not meet modern environmental standards and sustainable development principles. According to the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, as of the first quarter of 2022, there were 3.005 municipal solid waste (MSW) landfills in the country, of which only 635 (21%) met environmental and sanitary standards. This means that about 79% of landfills did not meet regulatory requirements, which represents a significant environmental problem. In addition, 7.328 unauthorised MSW landfills were identified in Kazakhstan in 2021 and 2.748 in 2022, indicating the continued presence of unauthorised waste storage and disposal facilities. These facilities represent sources of historical environmental pollution and a threat to public health (CABAR.asia, 2022). Thus, despite the measures taken, a significant portion of municipal waste continues to be sent to unauthorised dumps and landfills, which highlights the need to further improve the waste management system in the country.

In addition, the Concept for the transition of the Republic of Kazakhstan to a "green economy" notes that, despite the positive dynamics within the framework of regulatory and institutional reforms in the formation of an integrated waste management system, in practice it still does not fully meet the criteria of the "green economy" and the objectives of sustainable development. The analysis of territorial indicators shows that the average regional coverage of municipal waste collection does not exceed 82%, which indicates a persistent imbalance between the volume of waste generation and its actual removal from the habitat (Adilet, 2013).

Also, of particular concern are the so-called "historical pollutants" – accumulations of toxic and radioactive industrial waste generated in previous decades, which continue to have a destructive impact on ecosystems and pose a potential threat to public health. At the same time, municipal solid waste management methods are in some cases far from environmentally acceptable practices. As of 2021, about 74% of all municipal waste collected – equivalent to about 61% of the total volume – was sent to landfill without prior sorting and recovery of secondary resources, thereby eliminating the possibility of its reintroduction into the production cycle. Most alarmingly, about 80% of landfills and spontaneous dumps used for waste disposal did not comply with current sanitary, hygienic, and environmental standards, indicating a chronic structural failure of current waste management mechanisms (Adilet, 2013).

Corruption risks issues also influence inefficiencies in waste management. Between 2017 and 2022, approximately 1.1 thousand offences related to environmental crime were recorded annually in Kazakhstan. Environmental offences in 2020 cost Kazakhstan 5.3 billion tenge, which is the highest compared to 2017 (Newtimes.kz, 2022). Violations of environmental requirements for waste management under Article 344 of the Environmental Code numbered 162 and 182 in 2023 and 2024, respectively (Ranking.kz, 2024).

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

Another problem in waste management in Kazakhstan, as noted by international experts, is the distortion of official statistical data. For example, when comparing the reporting data of local executive bodies with independent field studies of environmental non-governmental organisations, significant discrepancies in the volumes of both total accumulation and processing of municipal solid waste are revealed (United Nations Economic Commission for Europe, 2019). In a number of cases, the real figures of unauthorised dumps and spontaneous waste accumulation are two or even three times higher than those recorded in the state registers. The situation is especially critical in rural and remote areas, where there is no centralised accounting and monitoring system, and violations are usually recorded sporadically (United Nations Economic Commission for Europe, 2019).

Also, a significant amount of waste generated by small and medium-sized businesses – such as construction, catering, and car repair – is often not included in official statistics because it is not accompanied by the necessary documentation. Such hidden waste generation creates a "grey zone" in which there is virtually no control over transportation, disposal and recycling. Analysts emphasise that without digitalisation of the waste accounting system and introduction of a unified national register of waste generators and operators, it is impossible to talk about reliable environmental reporting (United Nations Economic Commission for Europe, 2019). Thus, a comprehensive review of statistical approaches, including independent auditing and the introduction of transparent digital tools, becomes a key prerequisite for improving the effectiveness of environmental regulation and developing sound public policy in the field of waste management.

Another dilemma in waste management issues is energy utilisation. In the context of the intensification of the state environmental policy and reform of the waste management system, the practice of energy recovery of municipal solid waste was introduced in Kazakhstan as one of the directions of implementation of the provisions of the new Environmental Code of 2021. At first glance, this measure demonstrates a desire to diversify approaches to waste management and increase utilisation rates. However, according to the opinion of a number of national ecologists and specialists in the field of sustainable development, as well as based on the results of the audit by the Supreme Audit Chamber of the Republic of Kazakhstan, it was revealed that this approach is not unconditionally environmentally justified and requires a comprehensive assessment of its consequences for the environment and public health (Supreme Audit Chamber of the Republic of Kazakhstan, 2023).

Thus, experts emphasise that thermal processing of MSW (including combustion for energy production) in the current conditions of Kazakhstan involves a number of challenges. First of all, we are talking about insufficient pre-sorting of waste, which leads to the introduction of toxic components into the fuel, including plastics containing chlorine, heavy metals and medical residues. As a result, emissions of dioxins, furans and other carcinogens become inevitable, especially in the absence of high-tech filtration facilities. As pointed out in a number of analyses, this practice contradicts the principles of the circular economy, as it actually encourages the accumulation of waste rather than its reduction or reuse (KazWaste, 2025).

In addition, given the current level of technological equipment and the lack of transparent monitoring of emissions from incinerators, the introduction of energy recovery can lead to negative consequences for both urbanised agglomerations and ecosystems in the vicinity of such facilities. It is for this reason

Eurasian
Research
Journal
Spring 2026
Vol. 8, No. 2

that alternative models, ranging from mechanical-biological recycling to deep sorting with the involvement of the private sector, are becoming increasingly common in international practice.

Thus, despite the declarative attractiveness of energy recovery as a way to reduce MSW disposal volumes, in the national context, it cannot be considered as a priority without ensuring proper conditions – both technological and regulatory. Moreover, sustainable solutions should focus on minimising waste generation and encouraging economic mechanisms to recycle resources, which should be the basis for an effective waste management model.

For the countries of Central Asia, including Kazakhstan, according to the World Bank's Summary Report (2024), the introduction of a circular economy is one of the main solutions for systemic waste management. An integrated approach to resource management in sectors such as construction and waste management can not only minimise the burden on the environment but also become a catalyst for socio-economic growth. Kazakhstan, which is in the early stages of implementing closed-loop principles, is already taking concrete institutional and regulatory steps, including the development of sectoral action plans to encourage the development of recycling infrastructure, investment in innovation, and the introduction of economic incentives. In particular, the construction sector is expected to achieve a 54% reduction in waste generation and an 8% reduction in resource consumption by 2030, which is an important precedent on a regional scale. In this way, the Closed Loop Economy forms a strategic vector for environmental and economic modernisation, integrating the principles of resource conservation, emission reduction and the promotion of green entrepreneurship into the policy discourse in Central Asia. The findings of the report underline the need for a systemic and cross-sectoral approach: only in this way will Kazakhstan and its Central Asian neighbours be able to combine economic growth with environmental security, moving closer to the goals of sustainable development and full-fledged ecological transformation (World Bank, 2024).

One of the successful cases within the framework of the circular economy is the project "Ecohub" implemented in Almaty city, which is focused on popularisation of an ecological lifestyle. This project, among other things, is actively working on sorting and recycling of household waste such as plastic and aluminium bottles, packaging from shampoos and household chemicals, batteries, light bulbs, etc. Plastic bottles and aluminium cans can be donated to collection points and remunerated (Econetwork, 2024). The results of this project show clearly that the culture of sorting and collecting waste among the population is making significant progress. People are becoming more interested in taking their rubbish to the collection machines for a special reward, thus minimising waste to landfills. The disadvantages of this project are that there is no scale within the state, the project is private in nature and requires significant funding and support from the state to expand.

SWOT analysis

In order to implement an effective and institutionally sustainable waste management policy in the Republic of Kazakhstan, a detailed analysis of its key characteristics, including dominant advantages, internal disadvantages, as well as external risks and potentials, is a critical prerequisite. In this connection, the analytical decomposition, presented in Table 3, allows us to demonstrate the structured correlation of these factors that, in turn, form the necessary basis for

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

making strategic management decisions and the formation of adaptive regulatory mechanisms in the conditions of modern ecological transformation.

Table 3

SWOT analysis of waste management in Kazakhstan

Strengths	Weaknesses
1. The waste management sector is characterised by a high degree of institutional and technological sophistication at the international level, due to the wide range of tested solutions and adaptable technology platforms applicable to its modernisation. 2. The industry has an attractive investment environment characterised by relatively low barriers to entry and accessibility to various forms of private capital, including public-private partnership mechanisms. 3. There is significant energy potential in the direction of waste recovery – in particular, through the introduction of technologies for thermochemical recycling of MSW and integration of recycling processes into green energy models. 4. Secondary material resources extracted from the municipal solid waste stream have a high level of technological and economic suitability for re-involvement in the production cycle, which reduces the pressure on natural resources and promotes the development of a circular economy.	1. The municipal solid waste (MSW) collection system, including separate collection infrastructure, remains fragmented and institutionally unsustainable, which prevents efficient sorting and subsequent recycling of secondary resources. 2. In the overwhelming majority of territories of the Republic of Kazakhstan, the practice of direct waste disposal without preliminary sorting and technological preparation prevails, which contradicts the principles of circular economy and environmental safety. 3. Waste treatment and recycling rates remain extremely low despite the existence of regulatory prerequisites and investment programmes, indicating an institutional gap between policy and its implementation in practice. 4. The majority of operating landfills do not meet established sanitary-epidemiological and environmental requirements, including standards of waterproofing, emission monitoring and groundwater protection, which form sustainable pockets of environmental risk. 5. The absence of a full-fledged digital system for monitoring waste flows and registers of generators, operators and disposal facilities leads to distortion of statistical data and lower quality of state control. 6. The lack of environmental awareness and low level of citizen participation in the waste management system limit the opportunities for implementing progressive practices such as separate collection, composting and consumer responsibility.

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

Opportunities	**Threats**
1. Development of an integrated MSW collection system with elements of automation and digital monitoring allows for optimising the logistics of waste management and significantly reducing losses at the stage of primary accumulation. 2. The potential for large-scale expansion of waste processing and utilisation capacities creates prerequisites for increasing the share of secondary resources in the economy, as well as attracting investment in the "green" technology industry. 3. Technological modernisation of logistics and recycling processes helps to achieve economically feasible models of waste collection, transportation and disposal with simultaneous reduction of environmental impacts. 4. Recultivation of degraded territories and unauthorised dumps throughout the country opens up opportunities for ecological rehabilitation of landscapes, restoration of biodiversity and involvement of these areas in economic turnover. 5. Construction of modern, environmentally safe landfills that meet international technical and sanitary standards creates an infrastructural basis for sustainable management of residual waste fractions. 6. Strengthening intersectoral co-operation involving business, NGOs and civil society offers prospects for introducing Extended Producer Responsibility (EPR) and stimulating a culture of responsible consumption. 7. Development of international co-operation, including cross-border projects, exchange of experience and attracting technical assistance, provides Kazakhstan with an opportunity to integrate into global environmental chains and strengthen the regulatory framework.	1. Against the background of insufficient reclamation and lack of proper monitoring at the sites of accumulated environmental damage, there is a high probability of localised environmental disasters associated with contamination of soil, surface and groundwater, as well as risks to public health. 2. Sustained growth of consumption, urbanisation and intensification of the construction sector contribute to an exponential increase in the volume of generated waste, including difficult to dispose of fractions, which may lead to overloading of the existing infrastructure. 3. Long-term operation of obsolete landfills is accompanied by emissions of methane and other greenhouse gases that contribute to global climate change and pose risks to the achievement of national carbon-neutral targets. 4. Lack of proper institutional control over unauthorised waste disposal and shadow activities in this sphere contributes to the spread of 'grey' disposal schemes, which reduces the effectiveness of the state environmental policy. 5. Insufficient resistance to external economic and political shocks (including disruptions in the supply of equipment, materials and technologies) may slow down the implementation of key reforms in the waste management sphere, especially when oriented towards import-dependent solutions. 6. Delay in digitalisation of waste flow accounting and tracking, including the lack of a single platform for integration of data on generators, transporters and disposal facilities, increases the level of information and management risks. 7. The aggravation of social conflicts associated with the location of new landfills, waste sorting facilities and incinerators near residential areas can hinder the implementation of large infrastructure projects and reduce public support for environmental initiatives.

Source: Compiled by the authors on the basis of data from KazWaste (2024) and Adilet (2021)

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

The value of the SWOT exercise lies not only in describing strengths and constraints, but also in clarifying which policy levers can realistically convert opportunities into measurable implementation improvements. In Kazakhstan's waste governance, the SWOT points to a recurring pattern: regulatory and strategic intentions exist, yet operational delivery is constrained by infrastructure gaps, weak incentives, and an unreliable database. This subsection therefore, links selected SWOT elements to targeted policy recommendations.

Firstly, digitalisation (Opportunity) as a remedy for data distortion (Weakness) and control deficits. A central weakness identified in Table 3 is the absence of a full-fledged digital monitoring system and registers, which contributes to distorted statistics and weaker state control. At the same time, the SWOT highlights digital monitoring and automation as an opportunity to optimise collection logistics and reduce losses at the primary accumulation stage.

To translate this opportunity into an implementation fix, digitalisation should be operationalised through a sequence of governance measures such as:

a) unified national waste information system – create an integrated platform linking registers of generators, transporters, operators and disposal/recovery facilities, with clear data ownership rules and mandatory reporting fields;
b) electronic traceability of waste flows (e-manifest) – requires digital manifests for municipal and selected commercial streams, connecting collection points, transfer stations, landfills and recycling plants; this reduces "grey zone" disposal and improves accountability.
c) objective measurement points – expand the use of weighbridges, GPS-tracking and time-stamped route logs for collection fleets, enabling cross-checks between declared volumes and physical throughput.
d) verification and auditing – introduce periodic independent audits and automated anomaly detection (e.g., implausible reporting patterns), which directly address statistical distortion and strengthen regulatory enforcement capacity.

In practical terms, this package converts the "digitalisation opportunity" into a control-and-performance mechanism: better data quality reduces informational asymmetry, enables credible KPI monitoring (collection coverage, sorting volumes, landfill compliance), and supports evidence-based adjustment of tariffs, contracts and investment priorities.

Secondly, investment and PPP potential (Strength/Opportunity) to overcome infrastructure fragmentation (Weakness). The SWOT notes investment attractiveness and the availability of tested technological solutions as strengths, alongside opportunities for expanding processing capacities and modernising logistics. However, the system remains constrained by a fragmented separate-collection infrastructure and low recycling rates despite formal prerequisites. A policy-consistent way to connect these points is to strengthen the bankability of waste infrastructure through: 1) longer-term municipal contracting models (performance-based service contracts); 2) tariff predictability mechanisms (multi-year tariff regulation with transparent cost structure); 3) targeted PPP pipelines for sorting and material recovery facilities in high-volume regions; 4) alignment of EPR instruments with municipal collection systems to ensure stable inflows of recyclable fractions and financing for collection/sorting. This linkage ensures that the "investment opportunity" is not treated as a general statement, but as a

Eurasian
Research
Journal
Spring 2026
Vol. 8, No. 2

concrete institutional design aimed at closing the infrastructure gap that blocks separate collection and recycling.

Thirdly, citizen participation and behavioural compliance (Weakness) addressed through incentives and service design (Opportunity). The SWOT identifies low environmental awareness and limited citizen participation as a structural weakness. The policy implication is that separate collection cannot be scaled by infrastructure alone; it requires a combined approach of service design and behavioural incentives. Practical measures include: a) standardised multi-fraction collection schemes in dense urban areas (moving beyond only two fractions where feasible); b) incentive instruments such as deposit-return pilots for high-value packaging streams, or reward mechanisms aligned with verified returns; c) gradual tightening of compliance requirements through municipal rules once adequate infrastructure is in place, paired with intensive public communication campaigns. This approach links the opportunity for intersectoral cooperation (business/NGOs/civil society) to a measurable behaviour change pathway.

Finally, risk management: preventing "digitalisation delay" from becoming a systemic threat. The SWOT explicitly frames delays in digitalisation and the absence of an integrated platform as a threat that increases information and management risks. This implies that digital reforms should not be treated as optional "modernisation", but as a core implementation safeguard. A staged rollout (large cities → regional centres → rural areas) with minimum viable reporting requirements can reduce transition costs while steadily improving national data integrity.

Hence, analysis of strengths and weaknesses, as well as external opportunities and threats in the sphere of waste management in Kazakhstan, allows us to state that this direction has both a significant development potential and a number of persistent institutional and infrastructural barriers. On the one hand, the availability of internationally tested solutions, investment attractiveness of the industry, as well as the growing interest in 'green' energy and secondary resources form a favourable basis for environmental modernisation of the sector. On the other hand, the poorly developed separate collection system, limited recycling capacity and the operation of outdated landfills point to systemic gaps that require immediate transformation. In addition, with increasing volumes of waste and the high proportion of waste disposed of without pre-sorting, the introduction of regionalised MSW management models oriented to local environmental and economic contexts is of particular relevance. The possibility of building facilities that meet international standards and the digitalisation of waste flow monitoring open up prospects for increased transparency and efficiency of environmental policy.

At the same time, it is necessary to take into account external risks, among which we should particularly note the threat of environmental incidents in areas of historical pollution, methane emissions from landfills as a factor of climatic pressure, as well as institutional instability associated with the lack of a unified system of waste accounting. Without taking these factors into account, the implementation of progressive solutions may be fragmented and ineffective. Meanwhile, the SWOT results should be interpreted as a documentary-based synthesis rather than as a stakeholder-perception study. Because the analysis relies on officially available documents, programmes, reports and statistics, it captures formal commitments and recorded performance signals; it may under-represent informal practices and local-level perceptions that would require interviews or fieldwork.

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

Thus, achieving sustainable results in waste management requires a systemic and cross-sectoral approach, integration of digital solutions, strengthening public participation and interagency coordination. Only in the case of synergy of political, technological and public efforts, Kazakhstan will be able to realise the transition to a circular economy model and ensure environmental safety in the long term.

CONCLUSION

A comprehensive analysis of the current state of the waste management system in the Republic of Kazakhstan allows us to conclude that there is both certain institutional progress and remaining structural and regulatory-organisational limitations. The adoption of the new Environmental Code in 2021 was an important milestone in the reform of the national environmental policy: the document initiated the introduction of a hierarchical approach to waste management, emphasised the principles of circular economy and extended producer responsibility, and laid the legal foundations for selective collection, recycling and safe disposal of waste.

Significant development of the regulatory framework, including the adoption of more than twenty national standards, is evidence of systemic efforts to unify the procedures for handling different categories of waste. Nevertheless, the practical application of these norms faces a number of challenges: from low enforcement discipline at the regional level to the lack of investment and infrastructure support. Particularly acute is the problem of non-compliance of existing landfills with sanitary requirements, as well as the limited coverage of separate waste collection, which is actually implemented only in urban centres and covers mainly central areas.

Particular attention should be paid to the e-waste sector, where recycling rates remain critically low – less than 6% of generation. This situation not only emphasises the weakness of the existing infrastructure but also points to insufficient education and regulatory work in this area. Similarly, institutional weaknesses are reflected in the lack of a unified digital system of waste stream accounting, which distorts statistics, reduces the manageability of the industry and limits the opportunities for effective monitoring.

In this regard, the implementation of a multi-level approach to reforming the sector becomes extremely important. It should include the development of public-private partnerships, promotion of environmental innovation, introduction of digital tools for accounting and analysis, as well as large-scale environmental education of the population. As cases like the EcoHub project in Almaty show, increasing citizens' motivation to participate in waste sorting has yielded tangible results, but institutionalised support and engagement mechanisms are needed for large-scale transformation.

In summarizing the results of the SWOT analysis, it should be emphasized that Kazakhstan has both internal resources and internationally recognized mechanisms to implement the transition to a sustainable, environmentally friendly waste management model. However, a sustainable result can only be achieved if regulatory gaps are eliminated, infrastructure is modernized, transparency in accounting and control is increased, and a sustainable dialogue between the state, business and society is built. Ultimately, effective waste management is not only an environmental responsibility, but also a strategic element of national competitiveness and social sustainability.

Eurasian
Research
Journal
Spring 2026
Vol. 8, No. 2

Ethical Commission Approval

This study did not require approval from an ethics committee as it did not involve human participants, animals, or sensitive personal data. All data used in this research were obtained from publicly available sources.

Conflict of Interest Statement

There is no conflict of interest with any institution or person within the scope of this study.

Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

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Eurasian Research Journal
Spring 2026
Vol. 8, No. 2

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