

Financial Sustainability of the Municipal Waste Management System in Bulgaria

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Keywords: Sustainable waste management; municipal solid waste (MSW), "polluter pays" principle; financial indicators; circular economy; decoupling.

Abstract: Municipal waste management in Bulgaria is undergoing a transition toward a circular economy, seeking a balance between environmental goals and financial sustainability. This study analyzes the relationship between the dynamics of waste generation and the financial mechanisms for its management (2019–2024) to assess the effectiveness of the "polluter pays" principle. The assessment is based on official national statistics, using quantitative and comparative analyses, together with an analysis of operational and fiscal efficiency ratios. It has been established that a 'decoupling' effect is absent at the national level, as income growth and economic expansion continue to drive an increase in waste generation, reaching 496 kg per capita in 2024 – an indicator calculated based on the total volume of generated municipal waste, without differentiation by source of generation (households, commercial entities, or institutions). Simultaneously, a positive technological shift is observed, characterized by a persistent reduction in direct landfilling and expanded pre-treatment practices. Financially, the sector has transitioned from a deficit to full self-sufficiency, achieving over 110% cost coverage due to fee revenues growing faster than management expenditures. Despite the stability achieved at the macro level, the current charging model based on property valuation creates a structural imbalance – it generates fiscal surpluses but fails to provide sufficient economic incentives to reduce waste at the source, which necessitates the accelerated implementation of "pay-as-you-throw" (PAYT) systems. The obtained results outline a dual profile of the system – financially stable and infrastructurally modernizing, but still not fully oriented toward the prevention of waste generation. The current financial stability remains structurally incomplete without a parallel shift toward a consumption-based charging model that actively incentivizes waste reduction at the source.

1. Introduction

Waste management is among the key elements of contemporary environmental policy, transitioning from a linear model ("take-make-dispose") to a circular economy model ("use-repair-recycle"). In this sense, waste is not viewed as a useless residue, but as a potential resource that must be returned to the production cycle through recycling or recovery. The legal framework in the Republic of Bulgaria, defined by the Waste Management Act (WMA) and the Local Taxes and Fees Act (LTFA), theoretically establishes the "polluter pays" principle as the foundation for financing waste collection and treatment activities. However, the practical implementation of this principle and the achievement of strategic goals for reducing landfilling remain a serious challenge.

Increasing consumption, urbanization, and lifestyle changes lead to an increase in the quantity of generated waste, which poses significant challenges to public systems for its collection, treatment, and disposal. In this context, effective waste management is

regarded not only as an environmental issue, but also as an economic and managerial problem.

The present study aims to conduct a comprehensive comparison between the dynamics of municipal waste generation and the financial provision for its management activities, utilizing official statistical data in Bulgaria for the period 2019–2024, available at the time of conducting the research.

To achieve this objective, the study advances the following central thesis: Although the municipal waste management system in Bulgaria achieves financial sustainability and technological progress in treatment, it fails to curb the growing volume of generated waste. This shortcoming is due to the lack of a direct link between local fees and the actual amounts of waste disposed of by the end user.

To validate the central thesis, four working hypotheses are tested:

First hypothesis (H_1): A positive correlation exists between income growth and municipal waste volume, indicating that the goal of decoupling economic growth from waste generation has not yet been achieved.

Second hypothesis (H_2): The development of regional infrastructure leads to a sustained structural shift – an increasing share of pre-treated waste at the expense of direct landfilling.

Third hypothesis (H_3): The growth rate of municipal waste fee revenues outpaces that of operational costs, enabling a transition toward full financial self-sufficiency of the system.

Fourth hypothesis (H_4): The current taxation model secures the necessary fiscal revenues but fails to create economic incentives for waste prevention and reduction.

The present study is subject to several objective limitations that must be taken into consideration:

1) The analysis relies solely on official statistical and financial data, which means that waste generation in unregulated dumpsites and potential discrepancies in municipal reporting fall outside its scope.

2) The official data of the National Statistical Institute (NSI) on municipal waste do not disaggregate the quantities by source of generation (households, commercial establishments, institutions), but rather represent an aggregated value at the national level.

3) The examined time horizon (2019–2024) encompasses the effects of the COVID-19 pandemic, which caused temporary anomalies in economic growth and consumer behavior, potentially distorting short-term trends.

4) The conclusions regarding the lack of incentives for waste prevention are derived from macroeconomic fiscal imbalances.

2. Theoretical framework

2.1. Circular Economy and Fiscal Aspects of Waste

In contemporary scientific literature, municipal waste management is part of the circular economy concept, where waste is treated as a secondary resource (Reis et al., 2023). At the European level, strategic goals have been set for sustainable utilization and the minimization of landfilling (Awino & Apitz, 2024). Researchers note that the implementation of these policies and the pace of technological progress vary significantly across individual countries, with successful models typically integrating innovative solutions with comprehensive urban planning (Agócsová & Chodasová, 2021; Gökgöz & Yalçın, 2024).

At the global level, a sustained growth in municipal waste generation is observed, driven by economic development, urbanization, and the intensive consumption of goods and services (Chen et al., 2020). The scientific community pays significant attention to the concept of “decoupling” – severing the link between economic growth and environmental burden. While initial signs of this process are evident in some developed

economies, research in Eastern Europe and transition countries indicates that GDP growth still leads to a proportional increase in waste (Blagoeva et al., 2023). Similar structural difficulties in managing consumer pressure on waste collection systems have been identified in comparative studies of municipalities in Bulgaria and Kazakhstan (Todorova et al., 2025).

The European regulatory framework mandates strict adherence to the waste hierarchy, shifting the focus from direct landfilling to prevention and pre-treatment (Pouikli, 2020). Life Cycle Assessment in a number of studies demonstrates environmental benefits of this approach (Malindžáková et al., 2018; Laureti et al., 2024). According to some scholars, the delay in infrastructural reforms and the reliance on landfills entail secondary risks, ranging from direct pollution of ecosystems (Bashir et al., 2020; Castillo-Giménez et al., 2019) to the accumulation of hazardous substances in wastewater treatment plants (Gea et al., 2024). However, technological modernization achieves optimal results only when combined with the active participation of households in separate collection (Mihaliková & Lachytová, 2020).

The effective administration of infrastructure requires substantial capital and operational expenditures (Ezeudu & Bristow, 2024). The financial autonomy of management systems is regarded as a critical challenge (Abu-Qdais & al., 2023). Consequently, EU Member States should place greater emphasis on the efficient utilization of waste treatment expenditures in accordance with the priorities outlined in the Directive 2018/851 (Osińska, 2024). To ensure sustainable financing without compromising environmental objectives, scholars support the view that traditional taxation models, based on a flat tax or property valuation, are structurally ineffective, as they fail to incentivize households to reduce generated waste. Bulgarian practice corroborates this thesis: environmental taxation serves a predominantly fiscal function and does not stimulate more sustainable behavior (Vrachovska, 2026).

The strict application of the “polluter pays” principle through “Pay-As-You-Throw” (PAYT) systems is cited as the most effective tool for cost internalization, as these systems are proven to reduce mixed waste streams (Romano & Masserini, 2023; Emmanouil et al., 2022). In the corporate sector, this principle finds its equivalent in Extended Producer Responsibility (EPR), which closes the life cycle of specific products (Ferrão et al., 2008). The burden on public finances can also be optimized through the implementation of micro-level green practices in the private sector (Liçaj et al., 2025).

In addition to economic and technical factors, studies highlight the role of social capacity. A lack of public engagement often lies at the core of the failure of otherwise well-designed technological projects (Azis, 2026; Armaki & Roudi, 2024). Environmental education and the accumulation of intellectual capital serve as a foundation for sustainable behavior (Akdim et al., 2025; Lenkauskaitė et al., 2020). At the macro level, the effectiveness of all these mechanisms is directly dependent on the quality of the institutional environment (good governance), with political stability, transparency, and the rule of law being decisive for the success of environmental policies, particularly in the Balkan region (Efeoğlu, 2025).

However, there remains a lack of sufficient research examining the financial and structural challenges during this transition, particularly in Eastern European countries.

2.2. Regulatory Requirements for Municipal Waste Management in Bulgaria

The etymology of the Bulgarian term for municipal waste (битови отпадъци/bitovi otpadatsi) stems from the combination of two words that describe the origin and state of the waste materials. The first word is bitovi (household/domestic), which originates from bit-a noun associated with the mode of living and the daily needs of households. The second word is “otpadatsi” (waste/residuals), deriving from the verb “otpadam” (to fall away). On the one hand, it is associated with superfluous materials left over after a certain activity is performed, and on the other, with products that have lost their utility value.

Municipal waste comprises the waste generated from human daily activities in households, administrative and public buildings, as well as waste of a similar nature from commercial establishments.

In the literature, considerable attention is devoted to the economic treatment of waste as a resource and the application of the “polluter pays” principle in municipal waste management (Di Foggia & Beccarello, 2023).

From an *economic perspective*, municipal waste is viewed as a by-product of the consumption of goods designed by manufacturers at earlier stages of the production chain (Braathen, 2004). Waste is not simply treated as “garbage” to be discarded, but as a potential source of value through several key concepts:

- Waste recovery – this concept encompasses recycling, composting, and incineration with energy recovery. Recovery enables materials to re-enter the economic system (Tietenberg and Lewis, 2012).
- Increasing the resource stock – recycling is viewed as a method for the economic replenishment of stocks, which effectively increases the amount of available resources (e.g., for metals such as copper and aluminum) and extends their useful life (Tietenberg and Lewis, 2012).
- Energy resource – the incineration of waste for energy production is presented as a means of substituting more harmful energy sources, such as petroleum.

From a *social perspective*, the “polluter pays” principle (PAYT) is central to discussions on responsibility and the equitable distribution of costs. It is explicitly cited as the basis for the introduction of environmental taxes to ensure that waste disposal is properly priced (Braathen, 2004). It is defined as a key instrument that shifts the responsibility for collection and recycling onto manufacturers, importers, and distributors. The aim is to internalize costs by compelling producers to consider the future treatment of the product as early as its design phase. PAYT systems apply this principle to individual citizens, holding them accountable for the costs they generate for society through the weight or volume of their waste.

The legislative framework underpinning municipal waste management in Bulgaria consists of the Waste Management Act (WMA) and the Local Taxes and Fees Act (LTFA). From a theoretical standpoint, they operationalize the European “polluter pays” principle.

The former act provides the official definition of the term “municipal waste” while data regarding such waste are published on the website of the National Statistical Institute (NSI) under the “Environment” section.

According to the Waste Management Act (WMA, 2024, Additional Provisions), “municipal waste” is defined as:

- a) mixed waste and separately collected waste from households, including paper and cardboard, glass, metals, plastics, bio-waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, and bulky waste, including mattresses and furniture;
- b) mixed waste and separately collected waste from other sources, where such waste is similar in nature and composition to waste from households.

Municipal waste does not include waste from production, agriculture, forestry, fishing, septic tanks and sewage networks and treatment, including sewage sludge, end-of-life vehicles or construction and demolition waste.

In the “Demographic and social statistics” section of the NSI, within the “Municipal waste” statistical domain (NSI, 2024), definitions for the following terms are also provided. It is specified that the terms and definitions used comply with the applicable legislation – the Waste Framework Directive (Directive 2008/98/EC) and Directive (EU) 2018/851 amending Directive 2008/98/EC on waste:

- “Generated municipal waste” is an aggregate indicator that characterizes the level of municipal waste. It is calculated as the sum of: (1) the quantities of municipal waste collected through organized waste collection systems; (2) the quantities of municipal waste collected through systems other than organized waste collection (predominantly recyclable materials, such as metal, paper, plastic, and others, which are collected at

designated sites and subsequently handed over directly for recycling); and (3) a statistical estimate of the waste generated by the population not covered by organized waste collection systems. The calculation approach is standardized and applied across all districts in the country.

- “Municipal waste submitted for pre-treatment/recycling/direct landfilling” refers to the waste received at the inlet of the corresponding treatment facility. To prevent the double counting of waste quantities, directly landfilled municipal waste excludes waste submitted for landfilling following pre-treatment.

- “Generated municipal waste per capita (municipal waste accumulation rate)” represents the quantity of municipal waste generated at the national level, divided by the average annual population for the respective year.

The Waste Management Act (WMA) establishes this principle as a fundamental management rule. It assigns responsibility to entities whose activities generate waste to cover the full costs of its treatment. Theoretically, the WMA establishes a waste management hierarchy, where prevention and recovery are prioritized, while the financial burden falls upon the polluter. In the Local Taxes and Fees Act (LTFA, 2026, Art. 62, Art. 66), this principle is transformed into a concrete revenue mechanism: the “Municipal Waste Fee” (MWF). The theory of the LTFA rests on the premise that the fee is not a tax, but a compensatory service; in other words, you pay exactly for what you “pollute” (in the ideal scenario). The MWF comprises three components (LTFA, 2026, Art. 62), meaning that payment is made for three types of activities:

- 1) collection and transportation – the responsibility of municipalities, including both mixed and separate collection, as well as the cleaning of public areas;
- 2) treatment (recovery/landfilling);
- 3) maintenance of cleanliness in public areas.

Until the end of 2025, the majority of Bulgarian municipalities determined the municipal waste fee proportionally based on the tax assessment of the property, which failed to reflect the actual quantity of waste generated. As of January 1, 2026, amendments to the LTFA entered into force, introducing a fee based on the actual quantity of waste – through bags of a specific capacity, the number and capacity of waste containers, or the number of property occupants. Thus, for the first time, the fee is directly linked to the actual amount of waste produced by each household or business.

Theoretically, the two acts function in symbiosis through the following instruments:

- Extended Producer Responsibility (EPR): Under the WMA, manufacturers of packaging, batteries, electronics, etc., are mandated to cover the costs associated with their collection and recycling. This represents a direct application of the “polluter pays” principle at the corporate level.

- Costs under Art. 66 of the LTFA: The law explicitly defines that the funds collected through the fee may only be utilized for sanitation activities. This ensures that revenues generated from the fee are directed exclusively towards covering waste management expenditures.

Although theoretically established, a critical discrepancy exists between the legal framework and its practical application. Currently, in Bulgaria, the municipal waste fee is predominantly calculated as a per mille rate of the property tax assessment rather than based on the actual quantity of waste generated. This can be defined as a failure to comply with the “polluter pays” principle, as the fee is not linked to the actual volume of waste produced. In other words, while the theoretical concept is “the polluter pays” in practice, it is “the property owner pays” regardless of the waste generated. This raises questions regarding the extent to which the “polluter pays” principle is effectively implemented within the Bulgarian context. This is precisely the rationale behind the ongoing reform of the LTFA, aimed at transitioning toward PAYT systems.

The Ministry of Environment and Water published the “National Waste Management Plan 2021–2028” (NWMP) (MoEW, 2021), stating that its primary strategic objective is to decouple economic growth from the automatic increase in the quantity of generated waste – a phenomenon known as decoupling.

The success of waste management will be measured by the indicator “municipal waste generated per capita” with the objective that by 2028 its value will be lower than that of 2020 (MoEW, 2021). New mandatory streams for separate collection are expected to be introduced, specifically for biowaste and textile waste, with a view to reducing the generation of mixed waste (MoEW, 2021).

The Waste Management Act also establishes stages for the preparation for re-use and recycling of municipal waste relative to their total weight: a minimum of 55% by 2025, 60% by 2030, and 65% by 2035 (Quantitative recycling targets).

According to the “National Waste Management Plan 2021–2028” waste management no longer focuses solely on disposal but on transforming municipal waste into secondary resources and implementing resource-efficient technologies (MoEW, 2021), thereby facilitating a transition towards a circular economy. The long-term objective is to reduce the quantity of landfilled municipal waste to 10% or less of the total generated municipal waste by 2035, or by 2040 under specific conditions (WMA, 2021, Art. 31; MoEW, 2021: 7). The Plan envisions investments in infrastructure, such as the construction of re-use and repair centers, as well as facilities for the composting and stabilization of the biodegradable fraction. It further mandates that municipalities develop their own programs in accordance with the NWMP, which must include prevention measures and the provision of sites for the free-of-charge handover of separately collected waste (WMA, 2021, Art. 19; MoEW, 2021). Furthermore, large-scale information campaigns are planned to engage the public as a key stakeholder in waste management. Thus, the theoretical and regulatory framework establishes ambitious goals to decouple economic growth from the volume of waste generated. The extent to which these strategic intentions are reflected in real statistical data for Bulgaria during the 2019–2024 period is the subject of the next part of this report.

Alongside the environmental aspects of the issue, scientific literature increasingly emphasizes the financial sustainability of waste management systems. The effective functioning of these systems requires a balanced ratio between fee-based revenues and the costs of service provision. Numerous studies analyze the economic efficiency of public waste collection and treatment services, seeking opportunities to optimize expenditures and enhance the financial sustainability of the system.

3. Materials and Methods

To achieve the objectives set out in this report, an integrated analytical approach was employed (Fig. 1).

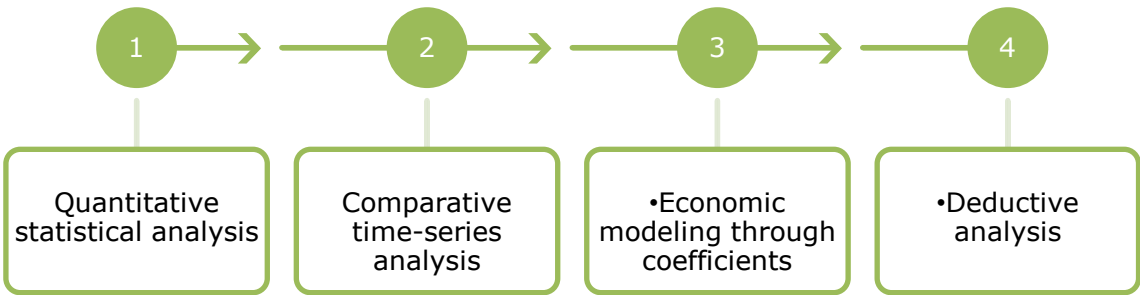


Figure. 1. Research design and methods

As is shown in Fig. 1, the research is conducted in four stages, utilizing the following data

- 1) Quantitative statistical analysis: Utilizes official data from the National Statistical Institute (NSI) and specialized data regarding revenues and expenditures under Art. 66 of the LTFA.

2) Comparative time-series analysis: Examines the dynamics of indicators over a six-year period (2019–2024), enabling the identification of stable trends and anomalous deviations.

3) Coefficient analysis: Key performance indicators (KPIs) are calculated, such as the cost of managing one tonne of waste (an indicator of operational efficiency), the revenue from the municipal waste fee per tonne (an indicator of fiscal efficiency), and the self-financing ratio (an indicator of sustainability and autonomy).

4) Deductive analysis: The obtained results are interpreted through the prism of the current regulatory framework (WMA, LTFA) and the strategic objectives set forth in the National Waste Management Plan (NWMP) 2021–2028.

The application of the described methodology provides the necessary empirical reliability for conducting an assessment and formulating scientifically grounded conclusions regarding municipal waste management in Bulgaria.

4. Results and discussion

Statistics for the 2019–2024 period reveal not only the total burden on the ecosystem but also the methods of waste management employed – whether through direct landfilling or by diversion toward pre-treatment and recycling.

The figure presented below systematizes the data on municipal waste generation for the 2019–2024 period and reflects shifts in the structure of waste treatment. This quantitative analysis serves as a fundamental basis for evaluating the effectiveness of national waste management policy and the transition toward higher recovery rates. According to the annual statistical yearbooks of the NSI, the share of the population covered by organized waste collection systems has increased to 99.9% as of 2023–2024. This implies that virtually the entire quantity of generated waste is now officially reported, ensuring a high degree of data representativeness.

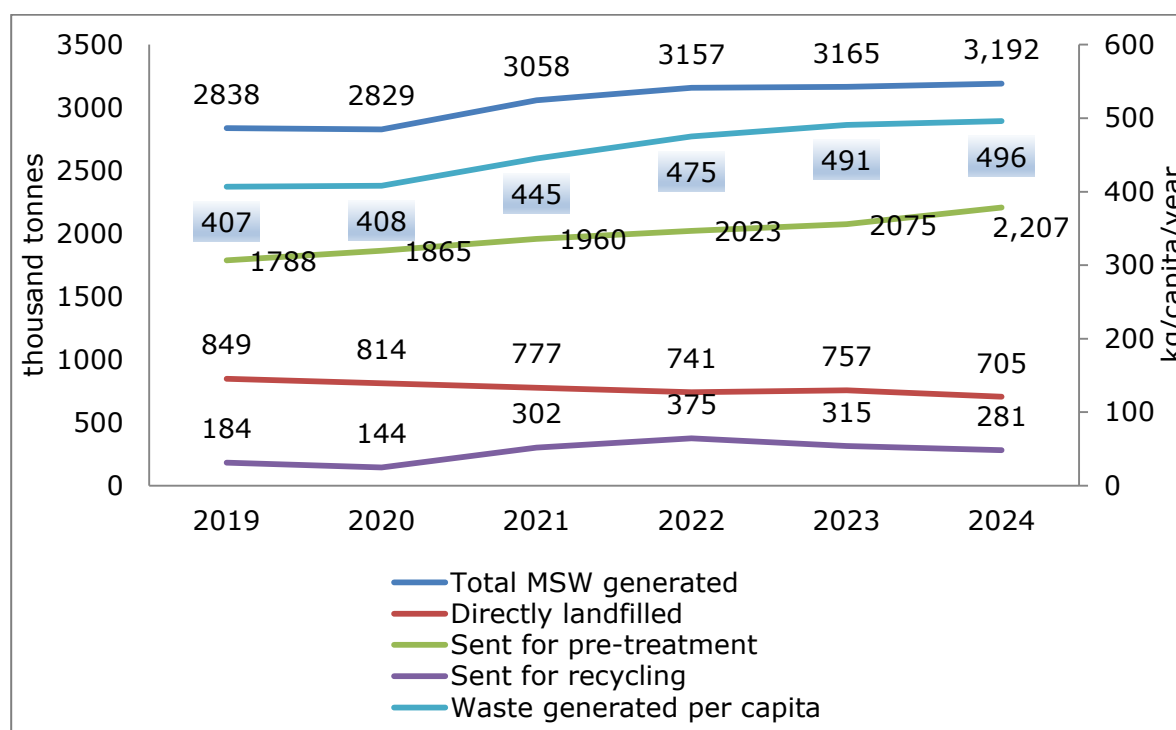


Figure 2. Dynamics of generated municipal waste and waste treatment structure in Bulgaria, 2019–2024 (thousand tonnes)

Source: NSI

The data in the figure reveal a trend of steady growth in the total quantity of generated waste (approximately 12.5%), rising from 2,838 thousand tonnes in 2019 to

3,192 thousand tonnes in 2024. Concurrently, the indicator “municipal waste generated per capita” has increased to nearly 500 kg by 2024, indicating heightened pressure on the environment and signaling the need for more effective policies for waste prevention at the source.

There is also a gradual decrease in directly landfilled waste (from 849 thousand tonnes in 2019 to 705 thousand tonnes in 2024), offset by an increase in the quantities submitted for pre-treatment (from 1,788 thousand tonnes to 2,207 thousand tonnes over the same period). This demonstrates that the policy of diverting waste toward pre-treatment facilities is yielding results.

By considering data on total household income (the broadest indicator, encompassing all income sources such as wages, pensions, benefits, etc.) and household consumption expenditure (comprising only expenditures on goods and services) and reflecting the actual consumption of goods and services that directly generates waste), several key correlations between economic development, household income, and municipal waste management can be outlined:

First interrelationship: The interrelationship between income, consumption, and waste generation.

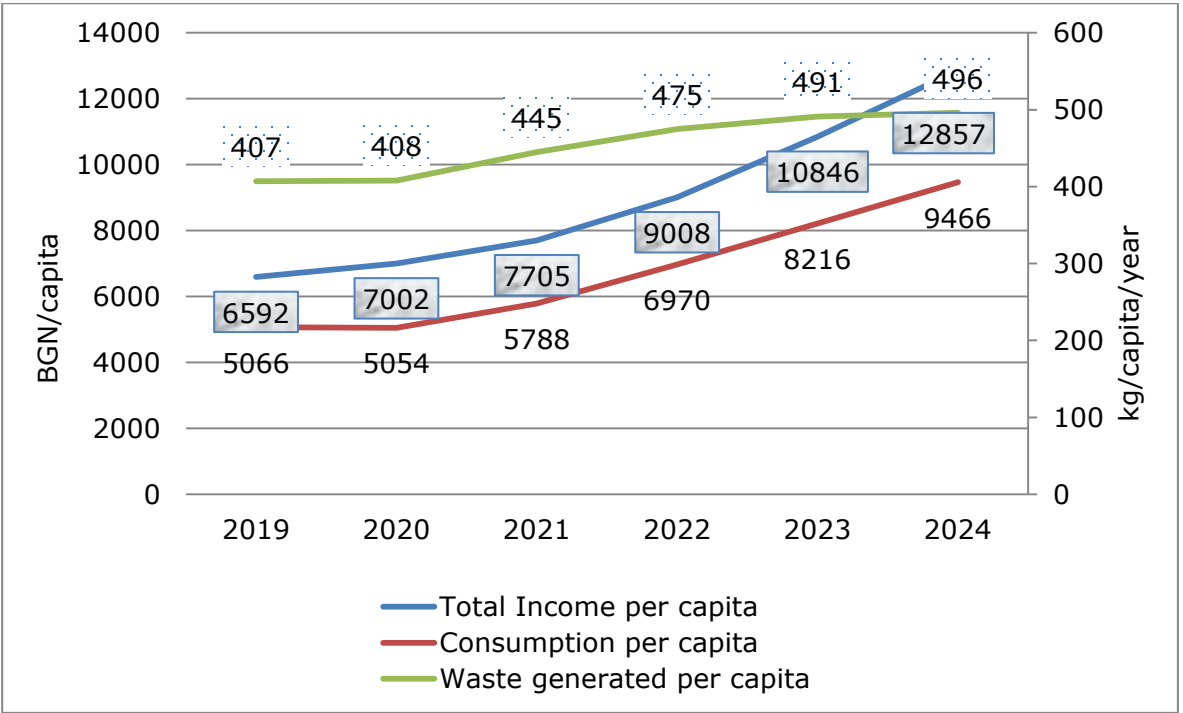


Figure 3. Interrelationship between income, consumption, and municipal waste generation per capita in Bulgaria, 2019–2024

Source: NSI

A direct correlation is observed between the rise in household income and the quantity of municipal waste generated per capita. The average annual total income per household member increased significantly from 6,592 BGN in 2019 to 12,857 BGN in 2024 (NSI, 2024, 2025). Concurrently, the accumulation rate (municipal waste generated per capita) rose from 407 kg in 2019 to 496 kg in 2024. The data confirm the economic phenomenon that higher prosperity leads to increased consumption and, consequently, a greater volume of waste.

To scientifically validate and quantify these interrelationships, the Pearson correlation coefficient (r) is applied, reflecting the nexus between household economic activity and the generated environmental footprint (Table 1). The specific ratios between income, consumption expenditure, and the volume of municipal waste generated are illustrated in Fig. 3.

As previously noted, the per capita waste generation indicator also includes waste from non-residential sources; therefore, the correlation reflects the overall relationship between increasing consumption and waste streams, without isolating the contribution solely of households.

Table 1. Pearson correlation matrix of income, consumption, and municipal waste generation per capita (2019–2024)

	Total income	Total consumer expenditure	Waste generation per capita (kg/capita/year)
Total income	1		
Total consumer expenditure	0,996	1	
Waste generation per capita (kg/capita/year)	0,910	0,942	1

Source: Author's calculations

The correlation coefficient between total income and total consumer expenditure is high ($r = 0.996$), indicating that the growth in household financial resources is accompanied by a proportional increase in consumption. The correlation between waste generation per capita and income is also strong ($r = 0.910$), confirming that a higher standard of living leads directly to the generation of a larger volume of municipal solid waste. The third interrelationship is between consumer expenditure and the volume of disposed waste ($r = 0.942$), revealing that the consumer behavior of the population is a leading factor in the physical accumulation of waste streams. Overall, the data illustrate the economic trend that higher prosperity leads to increased consumption and, consequently, greater waste generation.

Second interrelationship: Economic growth and decoupling.

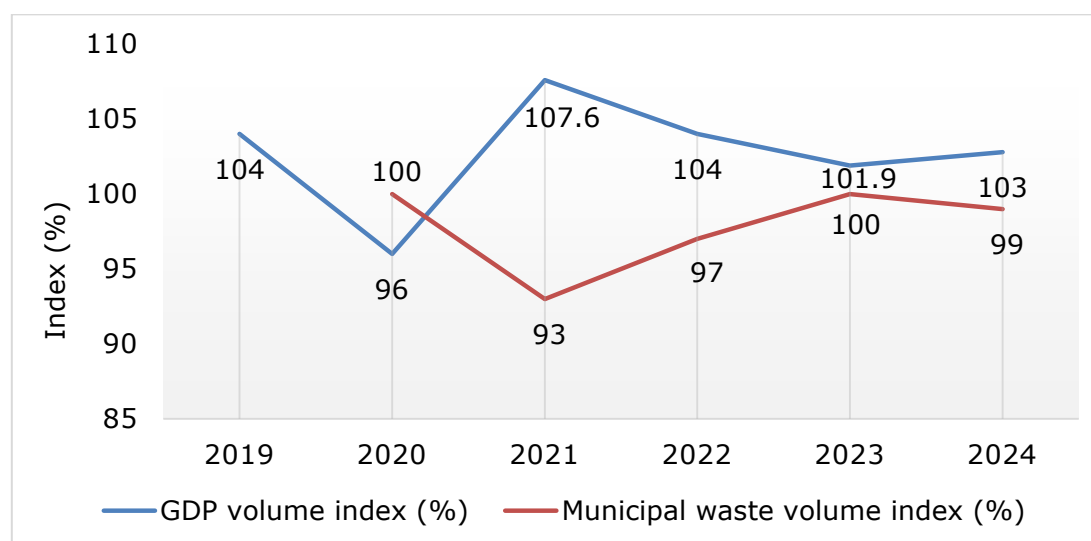


Figure 4. Comparative Dynamics of the GDP volume index and the municipal waste volume index in Bulgaria, 2019–2024 (%)

Source: Author's calculations based on NSI data

As previously was mentioned, a strategic goal of the National Waste Management Plan (NWMP) is to decouple economic growth from waste generation. To compare this dynamic with actual processes, the quantities of municipal solid waste were converted into comparable chain-linked indices. The data indicate that the GDP volume index

recorded a decline in 2020 (index 96.0) due to the pandemic, but subsequently registered growth – 107.6 in 2021, 104.0 in 2022, 101.9 in 2023, and 103.0 in 2024. The nearly 22% increase in waste generated per capita over the period serves as an indirect indicator of increased consumption, while economic stability creates conditions for municipalities to allocate more resources to pre-treatment facilities. The analysis shows that the strategic goal of decoupling economic growth from waste generation remains only partially achieved.

The existence of this interrelationship is confirmed by Pearson's correlation coefficient ($r = 0.840$) between the GDP volume index and the generated waste index. These data confirm the first working hypothesis (H_1), demonstrating that the economic recovery post-2020 is accompanied by an increase in waste streams, which implies that full decoupling has not been achieved, necessitating even more intensive waste prevention measures in the future.

Third interrelationship: Waste pre-treatment versus landfilling.

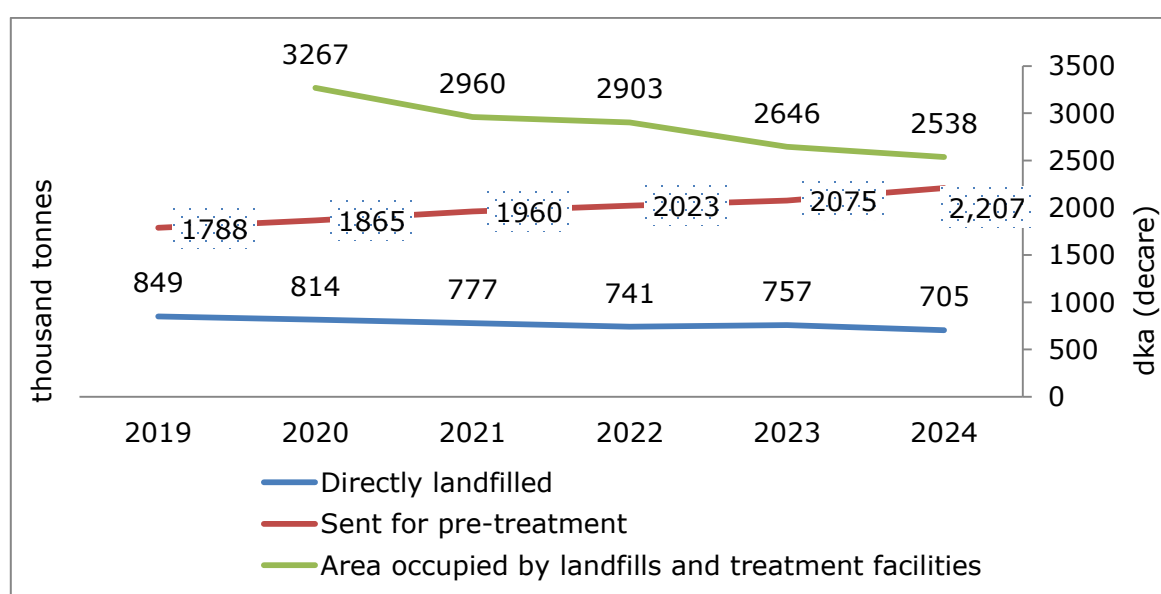


Figure 5. Landfilling versus treatment of municipal solid waste in Bulgaria, 2019–2024

*Note: 1 dka (decare) = 1,000 m²

Source: NSI

The third interrelationship reveals an inverse correlation between the development of treatment infrastructure and the quantities of waste sent directly to landfills. The quantities delivered for pre-treatment increased from 1,788 thousand tonnes in 2019 to 2,207 thousand tonnes in 2024 (+23.4%), while directly landfilled waste decreased from 849 thousand tonnes to 705 thousand tonnes over the same period (-16.9%). The existence of this strong inverse interrelationship is statistically confirmed by the calculated Pearson correlation coefficient ($r = -0.973$). In parallel, the land area occupied by landfills and treatment facilities decreased from 3,267 decares in 2020 (data are available from this year onwards) to 2,538 decares in 2024, reflecting the closure of old sites and a more efficient use of capacity. The close connection between the reduction in landfilled quantities and the physical decrease in land usage is statistically corroborated by the high linear correlation coefficient ($r = 0.888$) between the two indicators.

These trends signal a structural change in municipal solid waste management in Bulgaria – a gradual shift from landfilling to treatment, in accordance with the waste management hierarchy laid down in the Waste Management Act (WMA) and European legislation. NSI online data (latest available for 2024) show that the residual capacity of landfills decreased from 15,769 thousand m³ in 2020 to 12,828 thousand m³ in 2023,

which signals increasing pressure on disposal infrastructure and underscores the need for the accelerated development of alternative treatment methods (NSI, n.d).

This proves that although we generate more waste, the system is becoming technologically more mature and manages to “save” a larger portion of it from landfills. This optimization of the infrastructure provides grounds to consider the second hypothesis (H_2) proven, confirming that a lasting structural shift in favor of pre-treatment has occurred.

The analysis continues by examining certain financial aspects of municipal solid waste management. The primary focus is on the alignment between the collected revenues from local taxes and fees, including the municipal solid waste fee, and the actual expenditures incurred by municipalities for sanitation, collection, and treatment.

The financial framework of municipal solid waste management is a key indicator of the sustainability of public services. Table 2 synthesizes the main financial flows in the sector nationwide for the period 2019–2024, enabling the tracking of the correspondence between the generated revenues from the “municipal solid waste fee” and the actual expenditures incurred under Article 66 of the Local Taxes and Fees Act. Analyzing this balance is necessary to assess the efficiency of municipal administrations in managing waste streams within a dynamic economic environment.

Table 2. Data on the municipal solid waste management system in Bulgaria, 2019–2024 (thousand BGN)

Year	Total revenues from local taxes and fees	Total revenues from the MSW fee	Share of the MSW fee in municipal revenues	Expenditures under Art. 66, Para. 1 of the LTFA	Financial deficit/surplus
	<i>thousand BGN</i>	<i>thousand BGN</i>	<i>%</i>	<i>thousand BGN</i>	<i>thousand BGN</i>
2019	1967326	612900	31%	624708	-11808
2020	1938173	636794	33%	641276	-4482
2021	2942204	699195	24%	650077	49118
2022	2350737	752126	32%	690814	61312
2023	2472460	782201	32%	693033	89168
2024	2721739	842075	31%	759116	82959

Source: Author's calculations based on NSI data

Based on the statistical data for the analyzed period, the following interrelationships can be identified:

First interrelationship: Financial autonomy and sustainability – Cost Recovery Ratio.

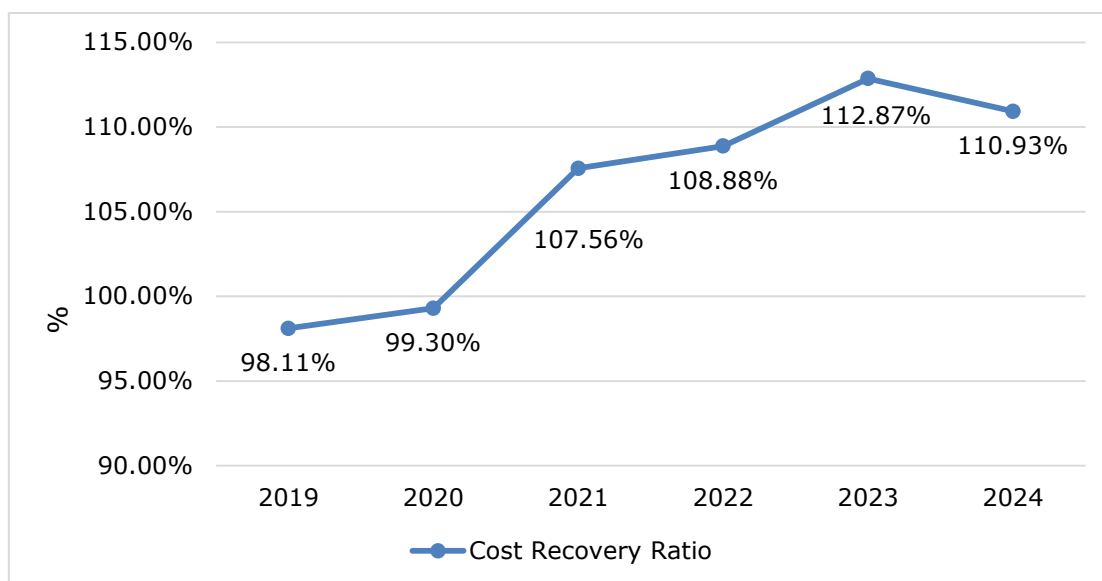


Figure 6. Cost Recovery Ratio of the municipal solid waste fee in Bulgaria (%), 2019–2024

Source: Author's calculations based on NSI data

The Cost Recovery Ratio is a key indicator of the financial sustainability of a public service. In the context of the LTFA and the NWMP, this indicator is directly linked to the “polluter pays” principle, but it measures one of its aspects, namely its comprehensive implementation at a systemic level. According to Art. 8, Para. 1 of the LTFA, the municipal council determines the fee rates in compliance with the principle of “*full cost recovery for the municipality in providing the service*”.

This interrelationship demonstrates whether the revenues from the municipal solid waste fee are sufficient to cover the direct expenditures under Art. 66 of the LTFA. Values of the indicator below 100% mean that the system is cross-subsidized by other municipal revenues. This was precisely the situation at the beginning of the period – in 2019, the ratio was 98.1% (revenues of BGN 612.9 million against expenditures of BGN 624.7 million), and in 2020 – 99.3% (revenues of BGN 636.8 million against expenditures of BGN 641.3 million). After 2020, a steady transition toward a surplus is observed, with the ratio reaching 110.93% by 2024, which means that the fees not only cover the expenditures but also generate an additional resource. The reported transition from a deficit to a surplus confirms the third hypothesis (H_3) regarding the achieved financial autonomy of the municipal solid waste management system at the national level.

Second interrelationship: Dynamics of the “scissors effect” between revenues and expenditures.

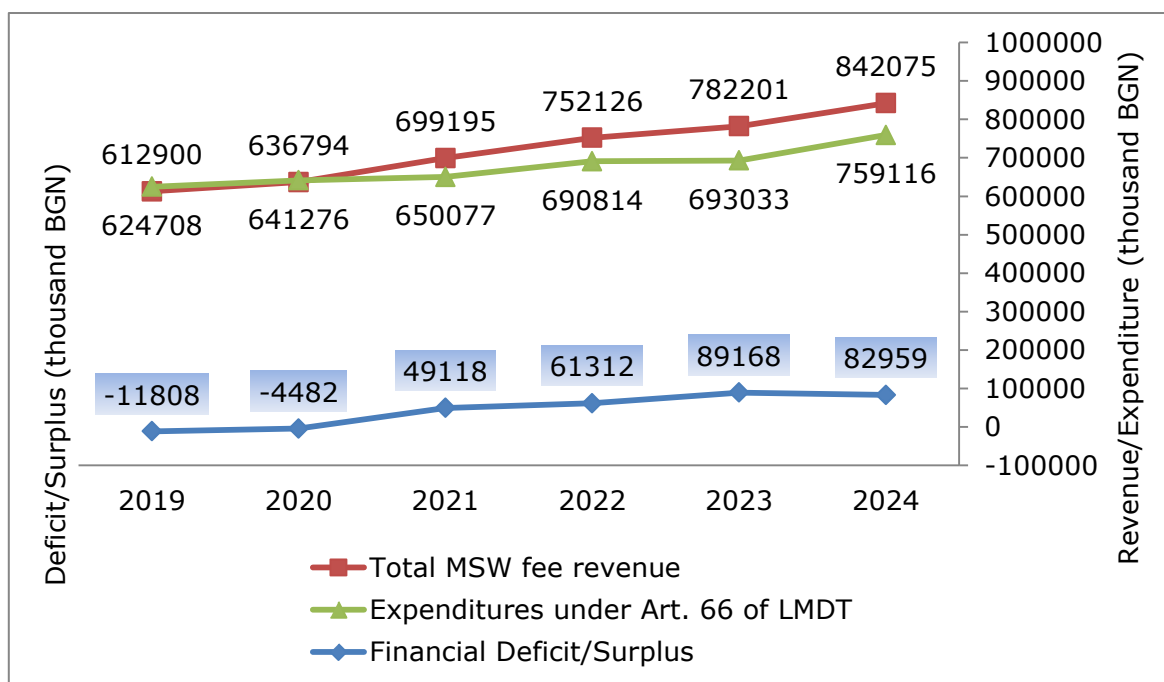


Figure 7. Dynamics of the “scissors effect” between revenues and expenditures for municipal solid waste in Bulgaria, 2019–2024 (thousand BGN)

Source: Author's calculations based on NSI data

This interrelationship tracks the growth rates of the two main financial flows within the municipal solid waste management system. Revenues from the MSW fee increased from BGN 612.9 million in 2019 to BGN 842.1 million in 2024, representing an increase of over 37%. Expenditures under Art. 66 of the LTFA also grew, but at a slower pace – from BGN 624.7 million to BGN 759.1 million (approximately 21.5%), which explains the gradual widening of the “scissors gap” in favor of revenues.

Notably, while in the baseline year (2019) expenditures exceeded fee revenues by nearly BGN 12 million, a steady financial surplus emerged starting in 2021. From 2021 onwards, the system entered a zone of sustained surplus, peaking in 2023 at nearly BGN 89 million, before stabilizing at BGN 83 million in 2024. This, in turn, acts as a financial buffer that allows municipalities to invest in infrastructure modernization without relying solely on external funding.

This trend of an increasing financial surplus is corroborated by the cost recovery and operational efficiency ratios presented below. While the “scissors effect” between revenues and expenditures visualizes the total volume of financial resources, the per-unit waste efficiency indicators reveal the internal optimization of the system. The increase in the cost recovery ratio from 98% in 2019 to 111% in 2024 demonstrates that municipalities have achieved full financial autonomy under Art. 66 of the LTFA, while simultaneously managing to balance expenditure growth through economies of scale and technological optimization.

Table 3. Key indicators of financial and operational efficiency (2019–2024)

Year	Cost Recovery Ratio (%)	MSW Fee Revenue per Tonne (BGN)	MSW Management Expenditure per Tonne (BGN)
2019	98.11	215.96	220.12
2020	99.30	225.10	226.68
2021	107.56	228.64	212.58
2022	108.88	238.24	218.82

2023	112.87	247.14	218.97
2024	110.93	263.81	237.82

Source: Author's calculations

The achieved financial stability, evidenced by the cost recovery ratios, is a fundamental prerequisite for future investments in the circular economy. The transition from a deficit to a surplus is an indicator of the successful implementation of the waste management hierarchy on a national scale.

Third interrelationship: Importance of the MSW fee for municipal budgets (fiscal burden).

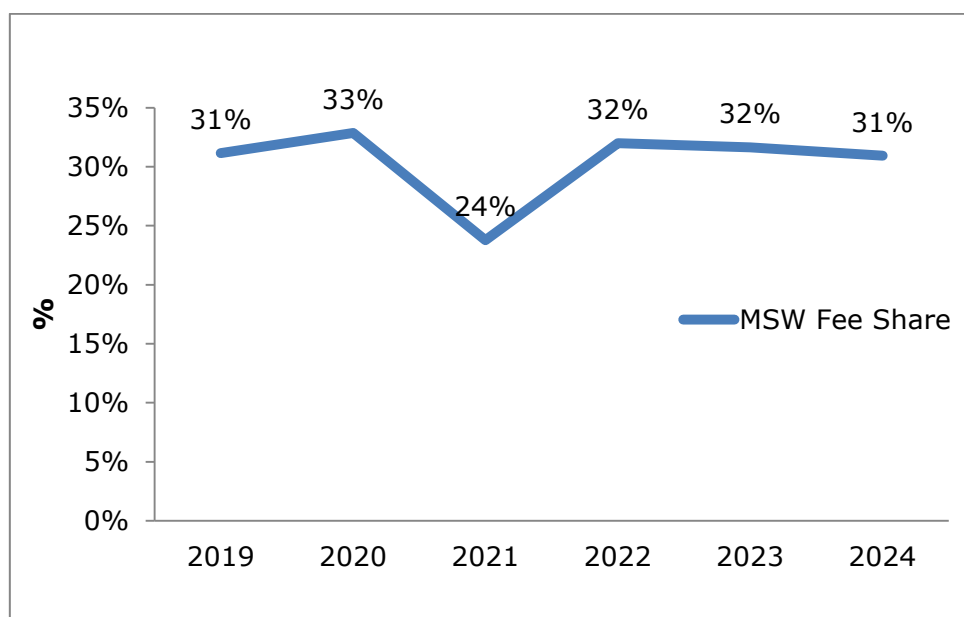


Figure 8. Share of municipal solid waste fee revenue in total municipal tax and fee Revenue in Bulgaria, 2019–2024 (%)

Source: Author's calculations based on NSI data

This interrelationship demonstrates what portion of municipal own revenues (from local taxes and fees) is generated by waste management. The data can be observed in Fig. 8. They indicate stability, as the share of the MSW fee in total local revenues remained at levels around 31–33% throughout the entire period, with the exception of 2021, when a drop to 24% was recorded. This decline is due not to a decrease in MSW fee revenues, but rather to a substantial increase in overall revenues from local taxes and fees during that year (from BGN 1,938 million to BGN 2,942 million). It can be concluded that the stability of this indicator highlights the role of the MSW fee as a main pillar of municipal financing – nearly 1/3 of municipal revenues from local taxes and fees stem from waste management, making the system both fiscally significant and sensitive to changes in fee-setting policies.

The following two interdependencies link the physical volumes of waste to the financial resources allocated for their management (analytical indicators of economic efficiency).

Fourth and fifth interrelationships: Cost of managing one ton of (operational efficiency) and revenue from municipal solid waste fees per ton (fiscal efficiency).

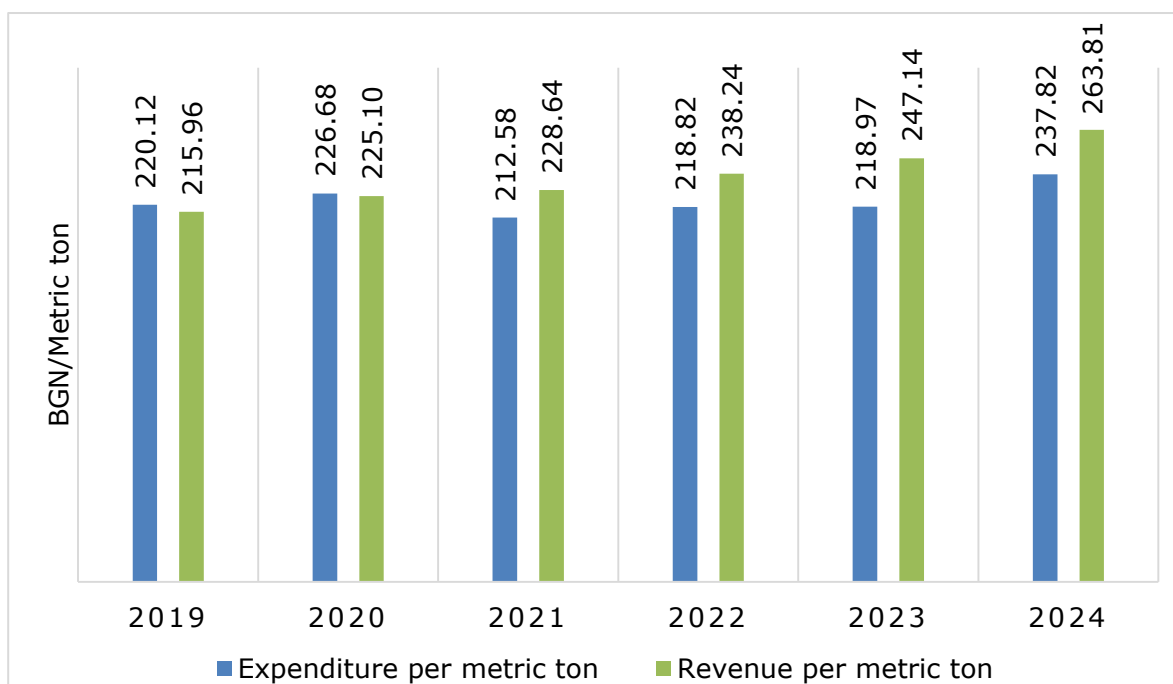


Figure 9. Expenditure and revenue for the management of 1 tonne of waste, 2019–2024

Source: Author's calculations based on NSI data

The “cost of managing one ton of waste” indicator provides information on the societal (municipal) cost of treating a single unit of waste, allowing for the monitoring of whether the deployment of new infrastructure (pre-treatment facilities) leads to a decrease or an increase in per-ton costs. It is calculated by relating the total expenditures incurred under Article 66 of the LTFA to the total volume of generated municipal solid waste.

The data indicate that the cost of managing one ton of municipal solid waste has increased by approximately 8.04% over the entire period. This represents a relatively modest increase considering the inflationary pressure and the investments in new pre-treatment facilities, which signals achieved operational efficiency in municipal waste management at the national level.

The “revenue from municipal solid waste fees per ton” indicator provides a more accurate representation of the interrelationship between the volume of waste generated and the payment amount, thereby approximating the economic essence of the “polluter pays” principle. It does not measure the principle itself, but rather the revenue efficiency relative to the waste volume. It yields information regarding the proportion of costs actually covered by the generated waste per unit of mass. It is calculated by establishing the ratio of municipal solid waste fee revenues to the total volume of generated waste. It should be noted that since the municipal waste fee during the period under review is linked to the tax assessment of the property rather than to the actual volume of waste generated, the indicator reflects the average fiscal efficiency at the national level, without capturing the individual discrepancies between the fee paid and the actual quantity of waste disposed of by distinct households. The future implementation of new charging mechanisms is expected to align this indicator more closely with the core of the “polluter pays” principle.

The data indicate that the revenue from municipal solid waste fees per ton of generated waste has increased by 22.16% over the entire period. This represents a significantly higher growth rate compared to the increase in the cost per ton (8.04%). This confirms the trend towards improved fiscal efficiency and explains the transition from a deficit to a surplus after 2020.

For the purpose of a comprehensive assessment of the system's financial sustainability, Table 4 summarizes the key dynamic indicators. The growth rate of revenues relative to the 2019 baseline and the cost recovery ratio reveal two characteristic stages: a period of “financial deficit” (2019–2020) and a period of “sustainable autonomy” (2021–2024). Achieving a cost recovery ratio above 100% confirms that fiscal efficiency has been relatively permanently stabilized.

Table 4. Dynamics of growth rates and the Cost Recovery Ratio in municipal solid waste management (2019–2024)

<i>Year</i>	<i>Revenue Growth Rate (%)</i>	<i>Cost Recovery Ratio (%)</i>
2019	100,00	98,11
2020	103,90	99,30
2021	114,08	107,56
2022	122,72	108,88
2023	127,62	112,87
2024	137,39	110,93

Source: Author's calculations

The financial analysis of municipal solid waste management for the period 2019–2024 confirms the hypothesis of increasing economic resilience in the sector. The achieved positive balance and the fact that the growth rate of revenues per unit of waste has outpaced that of expenditures demonstrate that municipalities in the Republic of Bulgaria are successfully implementing the “polluter pays” principle at a systemic level.

At the same time, the proven lack of correlation between the actual quantity of waste generated and the size of the individual fee confirms the fourth working hypothesis (H_4): that the current model successfully generates fiscal revenue but fails to create sufficient economic incentives for waste prevention and reduction at the end user.

This generated financial resource provides the necessary prerequisites for a smooth transition to the new fee-determination methodology based on actual quantity, as outlined in national strategic documents.

This study opens up several avenues for future research:

Upon the full implementation of the new charging methodology, it would be valuable to investigate whether the PAYT principle truly motivates consumers to minimize waste. This will determine whether ecological awareness has been integrated into the daily routines of households and businesses in Bulgaria.

A future comparative analysis between different municipalities could reveal which local models perform best and in which regions the most significant challenges are encountered.

An examination of the link between tourism flows and peaks in waste generation would provide added practical value for municipalities that must plan their resources for summer or mountain resorts.

Future research could build upon this publication through micro-level empirical sociological studies to directly assess the behavioral attitudes of end-users (households and businesses) towards different charging models.

4. Conclusions

The analysis of data for the 2019–2024 period indicates that municipal solid waste management in Bulgaria is currently in a transitional stage, where infrastructure modernization is outpacing changes in consumer behavior. The absence of a “decoupling” effect is evident, as economic growth and rising household incomes continue to drive up the volume of generated waste, which is approaching nearly 500 kg per capita annually. The positive trend here is purely technological: the established regional pre-treatment facilities successfully divert these waste streams, leading to a steady decline in direct

landfilling. The system now demonstrates higher operational maturity, but environmental pressure at the source remains critically high.

In financial terms, stabilization has been observed, marked by a transition from an initial deficit to sustained surpluses, by 2024, revenues from the municipal solid waste fee covered over 110% of operating expenditures. This growth in revenue, which outpaces the cost per tonne of managed waste, provides municipalities with fiscal autonomy and the opportunity to build investment buffers. At a macro level, the “polluter pays” principle appears to be successfully implemented, as the public service is now fully self-sustaining and no longer requires co-financing from other municipal revenue streams.

This macroeconomic stability conceals a serious flaw in the charging mechanism. Since the MSW fee remains largely linked to the tax valuation of properties rather than to the actual volumes disposed of, it functions as an additional property tax rather than an environmental regulator. Under the current model, households lack sufficient economic incentives to reduce waste or engage in separate collection. The financial surplus accumulated by municipalities in recent years provides a favorable starting point for the technical implementation of the upcoming reform, but the transition to PAYT systems must be accelerated to achieve the real goals of the circular economy.

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