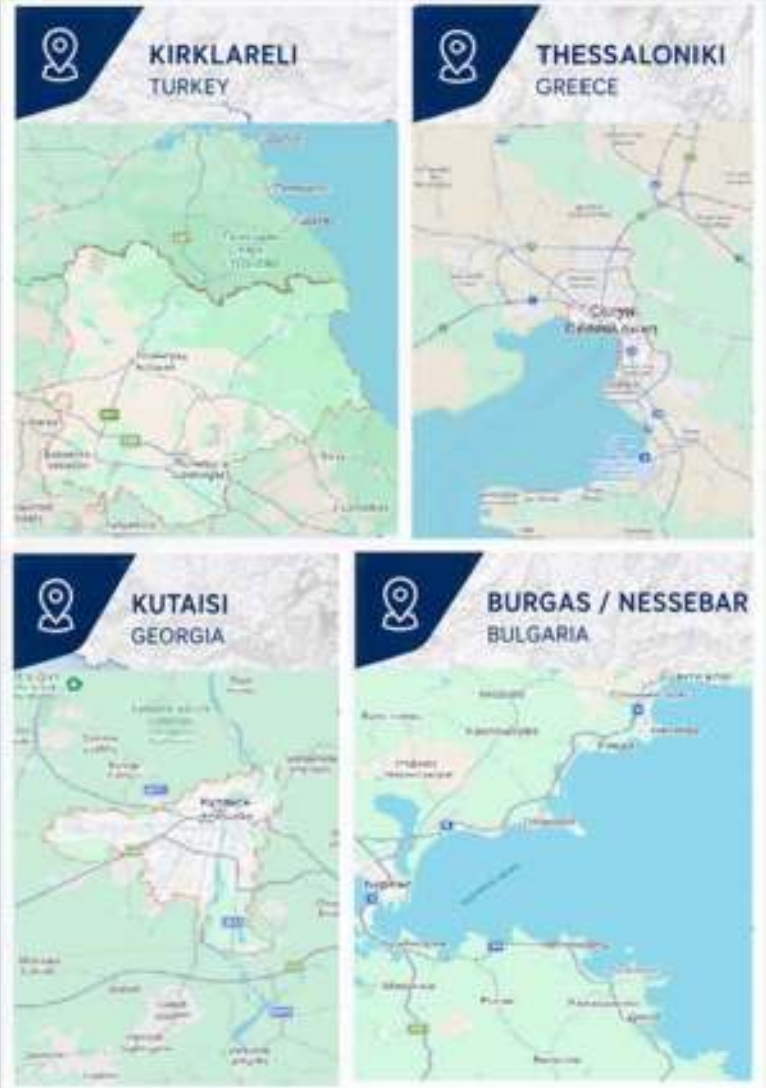
Interreg NEXT Black Sea Basin

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WISE WASTE

Cross-Border Waste Management Comparative Analysis



Project: "Collaboration for smart solutions for waste management and pollution reduction in urban, rural, and coastal areas of the Black Sea basin -WISE-WASTE"

Study period: 2023–2026
Responsible Partner for Activity: PP4 — Municipality of Nessebar
2026

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Cross-Border Comparative Technical & Strategic Analysis

1. Introduction and Project Context

1.1 Background and Institutional Framework

The final comprehensive joint report is developed under the auspices of the cross-border project "Collaboration for smart solutions for waste management and pollution reduction in urban, rural, and coastal areas of the Black Sea basin" (Acronym: WISE-WASTE). Environmental degradation, marine plastic accumulation, and inefficient municipal solid waste (MSW) logistics represent critical, shared micro-regional challenges across the Black Sea basin.

Traditional waste collection networks across the participating territories have historically relied on static, calendar-based collection frequencies. These rigid configurations are increasingly incapable of adapting to localized structural pressures, such as extreme tourism seasonality along coastal belts, low source-separation percentages, and significant geographical dispersion in rural hinterlands.

To bridge these operational vulnerabilities, the WISE-WASTE consortium advocates for an institutional and technical shift toward the deployment of Smart Solutions—specifically leveraging Internet of Things (IoT) ultrasonic fill-level container sensors, active Geographic Information System (GIS) asset mapping, vehicle telematics, and gamified citizen engagement platforms.

1.2 Methodological Objectives and Standardization

The primary directive of this comparative technical framework, led and compiled by PP4 – Municipality of Nessebar, is to establish uniform operational standards to harmonize data processing across the four distinct partner channels: Turkey, Greece, Georgia, and Bulgaria. By synchronizing multi-year local indicators, this analysis moves beyond a purely scientific review to operate as a practical, strategic management tool for regional policymakers and municipal service providers.

In strict compliance with the mandate of the project methodology, all quantitative parameters are integrated utilizing the metric system (metric tons per year, kilograms per capita per day) and aligned with the core taxonomy of the EU Waste Framework Directive (Directive 2008/98/EC) and its national transpositions within the non-EU partner territories.

To optimize strategic clarity, this document prioritizes high-utility operational conclusions over excessive global statistics. It focuses entirely on the unique technical realities, gaps, and transferable best practices discovered within the target pilot zones.

🟢 STAGE I: RESEARCH (Baseline Assessment)	🔵 STAGE II: ANALYTICS (Gap Identification)	🟠 STAGE III: INTEGRATION (Joint Harmonization)
• **Field & Desk Research:** Collection of recent multi-year indicators from official registries. • **Stakeholder Surveys:** Direct interviews with municipal enterprise managers and local ecologists. • **Readiness Audits:** Assessment of citizen and tourist willingness to adopt smart digital systems.	• **Local SWOT Matrix:** Application of customized local grids focused purely on smart waste integration. • **Data Gap Identification:** Technical analysis pinpointing critical real-time monitoring blind spots. • **Infrastructure Auditing:** Strict verification of container, vehicle fleet, and treatment facility assets.	• **Technical Analysis:** Cross-border comparative mapping of the four target Black Sea basin territories. • **Solution Catalog:** Synthesis of innovations into a transferable "Catalog of Solutions". • **Digital Brochure:** Final layout formulation of the policy guidance handbook for local providers.

Project Perimeter: Turkey (Kırklareli), Greece (Thessaloniki/Thermaikos), Georgia (Kutaisi), Bulgaria (Burgas/Nessebar)

2. Regional and Demographic Profiles (Territorial Perimeters)

The cross-border ecosystem features four diverse territorial archetypes with unique operational constraints:

- **PP4 Bulgaria (Burgas / Nessebar)**: The primary coastal-resort hub. It operates under a highly volatile demographic footprint, where a winter baseline population of ~230,000 jumps to a peak active summer population exceeding 450,000, creating an intense seasonal logistics barrier.
- **PP3 Greece (Thessaloniki / Thermaikos / Lagadas)**: A multi-tiered urban-coastal-rural cluster. Thessaloniki represents dense metropolitan management (319,045 permanent residents); Thermaikos mimics the Bulgarian model with a coastal resort profile that logged a massive **+92.2% waste surge** due to summer tourism; Lagadas represents an expansive rural territory covering 1,220.3 sq. km with low population density.
- **PP5 Georgia (Kutaisi)**: A major inland urban center (123.7 thousand permanent residents as of 2025). Interestingly, while its population shows a long-term decline (down from 147k in 2014), its waste metrics have grown to **~55,000 tons/year**, driven by increasing consumer packaging intensity and commercial development.
- **PP2: Turkey (Kırklareli Central District)**: A strategic, inland border-province template. The district center manages a highly stable, non-seasonal population of **47,000 inhabitants** dispersed across a mixed forestry and plains territory.

3. Quantitative Generation and Morphological Stream Matrix

All parameters are harmonized using the metric system as mandated by Chapter 2 of the project guidelines.

Table 2.1: Cross-Border Waste Statistics Comparison (2024–2026 Datasets)

Strategic Technical Indicator	PP4 Bulgaria (Burgas/Nessebar)	PP3 Greece (Thessaloniki Partner Cluster)	PP5 Georgia (Kutaisi)	PP2 Turkey (Kırklareli Municipality)
Annual Mass Generated (Tons)	~117,500 tn	208,858 tn (Consolidated Total)	~55,000 tn	~42,000 tn
Daily Generation (Tons/Day)	170 (Winter) —▶ 750 (Summer)	50 tn (Lagadas) —▶ 600 tn (Thessaloniki)	~150 tn/day	~115 tn/day (District only)
Per Capita Index (kg/capita/day)	0.9 kg (Winter) —▶ 1.6+ kg (Summer)	1.32 (Thessaloniki) —▶ 2.17 (Thermaikos)	~1.1 kg/capita/day	0.9 to 1.0 kg/capita/day
Organic Fraction Share (% w/w)	**52.0% – 55.0%** (Summer peak)	**44.3%** (Regional Baseline)	**43.7%** (Domestic matrix)	**39.0%** (Baseline)
Plastic Component Share (% w/w)	**24.0%** (High packaging surge)	**13.9%**	**13.5%**	**14.0%**
Unique Local Stream Element	Microplastics / Beach debris	Marine floating plastics (75%)	Cardboard bundle volume	**7.0% Domestic Heating Ash**

Note: The data for PP_3 (Greece) represents the consolidated metrics of the three pilot sub-regions (Thessaloniki, Thermaikos, and Lagadas) to balance urban, coastal, and rural waste generation behaviors within the Black Sea basin framework.

4. Infrastructure Assets and Treatment Discrepancies

The technical infrastructure across the Black Sea basin reveals a clear divide between advanced circular assets and traditional collection loops:

- **Primary Bin Fleet**: Bins range from standard above-ground steel 770-liter bins in Kırklareli, to widespread 1.1 m³ containers in Kutaisi and Burgas, up to high-aesthetic underground sub-surface installations in the historic town centers of Nessebar and Thessaloniki.
- **Organic and Biological Treatment Capacity**:
    - *Bulgaria (PP4)* leads with a fully operational, high-tech automated anaerobic digestion facility in Burgas designed for high-moisture organic fraction processing.
    - *Georgia (PP5)* features an exceptional best practice with the **Kutaisi Composting Center** (operating since 2021 in a 3,024 sq.m. facility), successfully utilizing aerobic windrows to convert green yard waste into certified organic fertilizer.
    - *Greece (PP3)* uses regional composting contracts via FODSA, while *Turkey (PP2)* relies exclusively on a central sanitary landfill with no advanced organic extraction lines listed.

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5. Smart Technologies Matrix and Shared Digital Gaps

An evaluation of current digitalization states reveals that all partners are stuck in a transitional phase, moving away from manual operations but lacking automated data-driven optimization:

Smart Technology Asset	PP4 Bulgaria (Burgas/Nessebar)	PP3 Greece (Thessaloniki Partner Cluster)	PP5 Georgia (Kutaisi)	PP2 Turkey (Kırklareli Mun.)
IoT Fill-Level Sensors	**Pilot Stage:** (<5% deployment) restricted to select underground bins.	**Pilot Stage:** Planning sensor integration for 75 new underground units.	**Introduced/Active:** Smart sensor-equipped recycling points via UNDP Eco-Smart City.	**Absent:** No sensor infrastructure deployed.
Fleet GPS & Telematics	**100% Fleet Coverage:** Used strictly for passive, retroactive log audits.	**Uneven Deployment:** 75 active routes tracked retrospectively; no dynamic scheduling.	**Data Gap:** Fleet coverage unverified; route planning remains completely static.	**Limited Level:** Used for basic retroactive mileage auditing.
Citizen Mobile Applications	**Absent:** No unified waste app or gamification platform exists.	**Operational Baseline:** *anakyklosi anThess* active, but lacks automated routing links.	**Absent:** Identified as a short-term development priority.	**Limited Level:** No interactive citizen reporting portals active.

6. Cross-Border Catalyst Proposals (Synthesis of Innovations)

In strict alignment with Section 4 of the project methodology, this joint framework highlights three key strategic guidelines for cross-border implementation:

🚀 **Innovation A: The "Report-to-Route" Citizen Link (PP4 + PP3)**

- **The Blueprint**: Take the existing Greek mobile app baseline (*anakyklosi anThess*) and upgrade it to include a real-time citizen ticket tracking interface. This allows coastal tourists in both Nessebar and Thermaikos to report beach litter hotspots directly to a central dashboard, instantly re-routing collection trucks via optimized navigation.

🚜 **Innovation B: Specialized Agro-Waste Networks (PP5 + PP2 + PP3-Lagadas)**

- **The Blueprint**: Replicate Kutaisi's UNDP "Eco-Smart City" container box model across the rural Ergene plain in Kırklareli and the vast territory of Lagadas. Deploy smart above-ground collection bins dedicated to agricultural plastics (greenhouse films, pesticide containers). Sensors will automatically alert regional unions when bins hit 80% volume, preventing hazardous dumping in local streams and natural forests.

📜 **Innovation C: Smart Contract Procurement Frameworks (Unified Policy Action)**

- **The Blueprint**: All four Black Sea partners must transition municipal procurement models away from simple routine servicing. Future contracts with private concessionaires must mandate the integration of open-source IoT hardware, digital weighbridge logging, and measurable recycling KPIs, effectively eliminating vendor lock-in risks across the basin.

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7. Strategic Guidelines and Best Practices

In accordance with Step 3 of the integration process defined in the project methodology, this section synthesizes European and local best practices into actionable guidelines. These guidelines serve as the structural framework for the upcoming **Digital Brochure** tailored for local service providers across the Black Sea Basin.

7.1 Benchmark Analysis of European Best Practices

To transition from transitional to fully circular systems, the partnership adopts three proven operational models from advanced European contexts:

- **The "Pay-As-You-Throw" (PAYT) Quantity Baseline**: Implementing quantity-based taxation (variable rates per bin volume or weight) instead of flat square-meter municipal fees. European documentation shows that aligning costs with actual waste generation leads to an immediate 20% to 30% reduction in mixed residual waste and a surge in clean source separation.
- **Aesthetic Sub-Surface IoT Integration**: Replicating Mediterranean coastal city models, where historical or high-density pedestrian corridors utilize underground hydraulic or crane-lifted container systems. These systems isolate organic components from ambient heat, eliminating odors and pest access (seagulls/stray animals), while using ultrasonic sensors to automate collection scheduling.
- **The Circular Green Center Model**: Establishing fenced, citizen-facing smart "Green Spots" (Civic Amenity Sites) with digital access control. Residents sort hazardous, electronic, and bulky waste into distinct compartments, receiving automatic rewards or tax discounts through a verified municipal credit system.

7.2 Matrix of Transnational Best Practices (The Catalog of Solutions)

The table below maps the specific, field-tested innovations identified within the WISE-WASTE partnership that are suitable for cross-border transfer:

Best Practice / Asset	Originating Partner	Operational Mechanism & Indicators	Cross-Border Transfer Destination
Centralized Bio-waste Composting	**PP5 — Kutaisi (Georgia)**	Large-scale closed composting center processing green yard waste via aerobic windrows. Gained **85.3 tons of certified organic fertilizer** output (2023–2026).	**PP2 (Kırklareli)** to process Ergene agricultural plain yard fractions; **PP4 (Burgas/Nessebar)** to complement anaerobic food plants.
Targeted Marine Waste Alliances	**PP3 — Thessaloniki Partner Cluster (Greece)**	Public-private-NGO contracts with specialized actors (*iSea*, *BlueCycle*) and Mussel Farm Associations to intercept and recycle single-use plastic beach debris.	**PP4 (Nessebar Municipality)** to secure protected marine zones, UNESCO shorelines, and holiday beaches.
Advanced High-Moisture Anaerobic Digestion	**PP4 — Burgas/Nesebar (Bulgaria)**	Industrial-scale methanization and energy recovery from organic kitchen fractions, capturing nutrients from heavy commercial food waste lines.	**PP3 (Thessaloniki city center)** to divert the massive 570 tons/day of urban organic mixed fractions.
Source-Separation Institutional Certification	**PP2 — Kırklareli (Turkey)**	Strategic rollout of the national "Zero Waste" framework, backed by massive local administrative capacity and training of over 21,000 citizens.	**PP5 (Kutaisi)** and **PP4 (Nessebar)** to build localized civic separation readiness indices before smart device installation.

8. Conclusions and Transnational Outlook

The comparative cross-border audit conducted across the partner perimeter demonstrates that the transition toward a smart circular economy inside the Black Sea basin is heavily dependent on systemic integration rather than isolated technology acquisition. While distinct localized starting baselines exist—ranging from the high-capacity mechanical sorting lines in Burgas (PP_4) to the operational composting infrastructure in Kutaisi (PP_5) — all participating territories share critical structural vulnerabilities. Chief among these is the lack of real-time, data-driven optimization loops to actively steer fleet logistics and minimize seasonal container overfills.

By linking the lessons learned from individual regional profiles, this joint framework establishes that the "Summer Spike" volumetric shocks experienced by coastal resort zones like Nessebar (PP_4) and Thermaikos (PP3) require a flexible operational shift. Static, calendar-based collection frequencies must

systematically give way to predictive analytics and sensor-responsive scheduling. Furthermore, the high organic fraction dominance across the cross-border waste stream emphasizes the necessity of replicating Kutaisi's certified composting protocols and expanding source-separation infrastructure before implementing extensive software architectures.

Ultimately, the strategic guidelines and the structural design of the Digital Brochure outlined in this report provide local utility operators with a practical, field-tested roadmap. Moving forward, the true catalyst for cross-border sustainability will rely on breaking down isolated data silos, implementing performance-based digital procurement models, and fostering active citizen co-management. Through these joint modernizations, the WISE-WASTE consortium successfully establishes a standardized benchmark for environmental protection, pollution reduction, and smart municipal waste management across the wider Black Sea basin.

Appendices

Annex I: Comprehensive Individual Territory Reports

The following attached documents constitute the primary evidence base and national research baselines compiled individually by each project partner under the WISE-WASTE methodology, serving as the technical foundation for this joint comparative analysis:

- **Appendix A –** PP2 Turkey: Individual Report on Municipal Waste Infrastructure, Morphological Characterization, and Zero Waste Certification: Kırklareli Central District. Prepared by the Municipality of Kırklareli;
- **Appendix B –**. PP3 Greece: Individual Report on Regional Waste Profiles, Marine Debris Alliances, and Multi-Tiered Territorial Challenges: Thessaloniki, Thermaikos, and Lagadas Cluster. Prepared by ANTIGONE – Information and Documentation Centre on Racism, Ecology, Peace and Non-Violence.
- **Appendix C –** PP4 Bulgaria: Individual Report on Waste Management System Analysis and Digital Gaps: Burgas and Nessebar Regions (2023–2025). Prepared by the Municipality of Nessebar.
- **Appendix D –** PP5 Georgia: *Individual Report on Waste Management Comparative Analysis, Tech Pilots, and Certified Bio-Waste Composting Processes: Kutaisi Region (2022–2026).* Prepared by the Imereti Scientists' Union "Spectri".

LOCAL ANALYSIS REPORT

BSB00825

Cooperation for Smart Waste Management Solutions and Pollution Reduction in the Urban, Rural and Coastal areas of the Black Sea Basin



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1. Regional Profile: Kırklareli

Kırklareli is a strategic border province located in the northwestern part of Türkiye, in the Marmara Region, with approximately 180 km of border with Bulgaria. Thanks to its coastline on the Black Sea and its proximity to Tekirdağ and Edirne provinces, the region combines both coastal and inland characteristics. Covering an area of approximately 6,550 km², the province consists of the forested Yıldız (Istranca) Mountains in the north and east, and the fertile Ergene Plain in the south, creating a balanced yet diverse structure in terms of natural resources and land use.

The climate of the province also varies by region. While the coastal areas are influenced by the Black Sea climate, the inland parts experience a continental climate. This affects both agricultural production patterns and settlement distribution. At the same time, the presence of different climate types requires seasonal variations in waste generation and waste management practices to be taken into consideration. Kırklareli has a population of approximately 361,737, with a significant share of the population living in district centers.

Kırklareli Central District is an important settlement area located in northwestern Türkiye and stands out due to its strategic position close to the Bulgarian border. The district center has a population of approximately 47,000 and serves as the administrative, economic, and social center of the region. Its proximity to border gates opening to Europe provides significant advantages in terms of trade and logistics.

Geographically, Kırklareli Central District is situated in a transition zone between the Yıldız (Istranca) Mountains and the Ergene Basin. The area is characterized by extensive forestlands, fertile agricultural areas, and natural water resources. The district has a transitional climate, with hot summers and cold and rainy winters during certain periods. This natural structure offers important opportunities for agriculture and rural development.

The local economy is mainly based on agriculture, livestock breeding, the service sector, and small-scale industrial activities. Wheat, sunflower production, and viticulture are particularly important for the regional economy. Fertile agricultural lands make agricultural production one of the main economic resources of the district. In addition, the service sector and commercial activities contribute to the economic vitality of the central district.

Kırklareli Central District also has development potential in terms of tourism thanks to its natural and cultural assets. The region’s natural areas, forest structure, and cultural heritage create an attractive destination for visitors. Furthermore, institutional structures working in the fields of environmental management, sustainability, and waste management play an important role in the district. In this context, expert staff are actively involved in environmental protection, waste management, and technical inspection processes.

With all these characteristics, Kırklareli Central District stands out as one of the important regional centers with its natural resources, agricultural capacity, strategic location, and developing service infrastructure.

2. Institutional Framework

Waste management in Kırklareli is mainly carried out by municipalities, while the coordination process is managed by the Kırklareli Local Administrations Solid Waste Facilities Construction and Operation Union (KIRK-KAB). Across the province, municipalities, the Special Provincial Administration, and licensed private sector companies play active roles in waste collection, transportation, and disposal processes. In addition, the Provincial Directorate of Environment, Urbanization and Climate Change is the competent authority responsible for inspections and compliance with environmental legislation(1).

The urbanization rate in Kırklareli remains below the national average of Türkiye, and rural settlements still constitute an important part of the province's settlement structure. This situation requires waste management systems to be planned in a way that addresses both urban areas and dispersed rural settlements efficiently(1).

3. Compliance with National and EU Legislation

Waste management practices in Kırklareli are carried out within the framework of the "Waste Management Regulation" and the "Regulation on the Landfilling of Waste" currently in force in Türkiye. This legislation has been prepared in line with the European Union Waste Framework Directive. In the province, inspections are regularly conducted to ensure compliance with the legislation, particularly regarding the transfer of hazardous waste to licensed facilities and the implementation of sanitary landfill practices(1).

4. Kırklareli Municipality Technical Infrastructure

Containers and Collection System

Domestic waste collection services in Kırklareli Central District are regularly carried out by the Cleaning Affairs Directorate of Kırklareli Municipality. Across the district, waste collection services are provided through a total of 3,219 above-ground containers with a capacity of 770 liters each. Approximately 115 tons of municipal waste are generated daily, and these wastes are collected by municipal teams within the scope of the regular waste collection system(2).

Within the Directorate, 7 administrative staff members are employed, together with 109 manual workers under the Cleaning Affairs Unit and 48 manual workers under the Parks and Gardens Unit. With this personnel structure, waste collection, environmental cleaning, and container services are carried out sustainably throughout the district(2).

Vehicles

Different types of waste collection vehicles with varying capacities are used for the collection of municipal waste generated in Kırklareli Central District. The waste collection fleet includes(2):

- 1 waste collection truck with a capacity of 6.5 m³
- 4 waste collection trucks with a capacity of 9 m³
- 1 waste collection truck with a capacity of 15 m³
- 4 waste collection trucks with a capacity of 13 m³

In addition, the following vehicles are used to support cleaning services and environmental hygiene activities:

- 1 waste container washing and disinfection vehicle
- 2 street sweeping vehicles with a capacity of 3.5 m³
- 1 street sweeping vehicle with a capacity of 7 m³

These vehicles enable the municipality to regularly carry out container cleaning, street sweeping, and environmental hygiene activities(2).

Disposal Facilities

Municipal waste collected in Kırklareli Central District is transported to the sanitary landfill facility operated by the KIRK-KAB Solid Waste Management Union. This facility serves the entire province and ensures that waste is disposed of without causing harm to the environment. Through the sanitary landfill system, uncontrolled dumping is prevented, and waste management processes are implemented in compliance with environmental legislation(2).

5. Kırklareli Quantitative Data

Municipal Waste Service Statistics for Kırklareli Province(3).

Year	Total Municipal Population	Total Number of Municipalities	Number of Municipalities Providing Waste Services	Collected Waste Amount (Tons)
2022	307.853	21	21	111.986,50
2024	317.057	21	21	119.467,60

Waste Generation

As of 2024, the total municipal waste generation across the province is approximately(1):

- 256–270 tons/day
- Per capita waste generation ranges between approximately 0.9–1.0 kg/day

Waste Composition

According to the 2024 waste characterization(1):

- Organic (kitchen) waste: 39%

- Plastic: 14%
- Paper: 3%, cardboard: 6%
- Glass: 8%
- Other waste: 16%
- Ash: 7%

Packaging Waste (2022)

Total packaging waste: 11,307,149 kg

- Paper/cardboard constitutes the largest share
- Plastic: approximately 1.47 million kg
- Glass, metal, and composite materials account for lower shares

6. Smart Systems and Digitalization
    a. Zero Waste Management Practices

Kırklareli Municipality carries out significant activities within the scope of environmentally friendly waste management practices. In 2024, the Municipality became the first and only municipality within the borders of Kırklareli Province to receive the “Zero Waste Certificate”. Through the Zero Waste Management System established by the Municipality, it is aimed to separate waste at the source, integrate recyclable waste into recycling processes, and reduce environmental impacts. These practices contribute both to the recovery of recyclable materials into the economy and to sustainable environmental management. These initiatives demonstrate the institutional capacity of Kırklareli Municipality in the fields of environmental protection and sustainability(1).

    b. Others

Smart waste management systems in Kırklareli are at a limited level:

- Sensor-based systems: Not widespread
- GPS tracking systems: Although no specific data is available, limited use in municipal operations is possible
- Mobile applications: Systems aimed at citizen participation are limited

However, the following practices are already in place:

- Waste collection centers
- Zero Waste system
- Educational and awareness-raising activities (more than 21,000 people were trained in 2021)

Therefore, there is significant potential for digital transformation in the waste management sector(1).

7. SWOT Analysis – Kırklareli Waste Management System

Strengths

- Existence of an institutional waste management structure coordinated by municipalities and KIRK-KAB.
- Presence of a sanitary landfill facility serving the entire province.
- Regular domestic waste collection system and widespread container infrastructure.
- Availability of sufficient vehicle fleet and technical personnel capacity within Kırklareli Municipality.
- Alignment of national legislation with EU waste management directives.
- Kırklareli Municipality being the first and only municipality to receive the “Zero Waste Certificate”.
- Implementation of environmental awareness and educational activities.
- High potential for regional cooperation due to its location in a border region.

Weaknesses

- Smart waste management systems being at a limited level.
- Sensor-based systems and digital monitoring infrastructure not being widespread.
- Insufficiency of mobile applications and digital systems aimed at citizen participation.
- Rural and dispersed settlement structure increasing collection and transportation costs.
- Lack of data regarding GPS tracking and digital operation systems.
- High share of organic waste within total waste composition.

Opportunities

- Existence of high potential for digital transformation and smart waste management investments.
- Opportunities for alignment with EU environmental policies and circular economy practices.
- Opportunity to benefit from cross-border cooperation and EU-funded projects.
- Increasing public awareness regarding recycling and sustainability.
- Possibility to improve waste separation, recycling, and recovery systems.
- Applicability of smart sensors, route optimization, and digital monitoring technologies.

Threats

- Increase in waste quantities due to population growth and urbanization.
- Environmental risks that may arise from improper waste disposal and illegal dumping.
- Insufficient financial resources for advanced technology investments.
- Seasonal increases in waste generation depending on climate conditions and tourism mobility.
- Increasing environmental pressure on natural areas, forests, and agricultural lands.
- Rising fuel, transportation, and operational costs.

8. Kırklareli Atık Yönetim Sistemine İlişkin Genel Değerlendirme ve Yorumlar

Kırklareli has an organized and institutionally coordinated waste management system carried out mainly by municipalities and the KIRK-KAB Solid Waste Management Union. Waste collection and transportation services are regularly implemented throughout the province, while municipal waste is disposed of at the sanitary landfill facility serving the entire region. The existing system generally operates in compliance with national environmental legislation and EU-aligned waste management regulations.

In Kırklareli Central District, the municipality has sufficient operational capacity in terms of waste containers, technical personnel, and waste collection vehicles. Regular waste collection services and environmental cleaning activities contribute positively to urban environmental management. In addition, Kırklareli Municipality's implementation of the Zero Waste Management System and receiving the "Zero Waste Certificate" demonstrate the municipality's commitment to sustainable environmental practices.

At the same time, the province still has development needs regarding smart waste management applications and digital infrastructure. Sensor-based systems, digital monitoring technologies, and citizen-oriented mobile applications are not yet widely used. Considering the increasing importance of digital transformation in environmental services, Kırklareli has significant potential for improving smart waste management practices in the future.

The province's rural settlement structure and seasonal changes in waste generation create certain operational challenges for waste collection and transportation services. In addition, the high proportion of organic waste within the waste composition indicates the importance of improving waste separation and recovery practices. Nevertheless, existing environmental awareness activities and recycling efforts provide a positive basis for future improvements in sustainable waste management.

References

1. TÜRKİYE CUMHURİYETİ KIRKLARELİ VALİLİĞİ ÇEVRE, ŞEHİRCİLİK VE İKLİM DEĞİŞİKLİĞİ İL MÜDÜRLÜĞÜ KIRKLARELİ İLİ 2024 YILI ÇEVRE DURUM RAPORU(2024).
2. Kırklareli Belediyesi Temizlik İşleri Müdürlüğü. (2026). Sözlü görüşme ve kurumsal bilgi paylaşımı.
3. https://veriportali.tuik.gov.tr/tr/databrowser/tuik/categories/3/3_1/TR,DF_ATIK_BELEDIYE_HIZMET_V1,1.0

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WISE WASTE

Analysis of the current situation and waste management practices in the target area of Central Macedonia, Greece

Thessaloniki, April 2026

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Introduction

Objective of the Report

The present report was developed within the framework of the **WISE WASTE** project (Activity 1.1), focusing on the comparative analysis of municipal solid waste (MSW) management systems. The research area covers the **Region of Central Macedonia** in Greece, specifically focusing on three distinct municipalities: the **Municipality of Thessaloniki**, the **Municipality of Thermaikos**, and the **Municipality of Lagadas**.

The primary objective of this study is to assess the current state of waste management while identifying technological and infrastructure gaps. By analyzing data from the 2020–2024 period, this report aims to establish a baseline for the integration of **Smart Solutions** and **technologies** in waste collection and processing, aligning with the EU Waste Framework Directive and the Greek National Waste Management Plan (ESDA 2020-2030).

Methodology

The report was prepared using a mixed-method approach combining desk research, review of official municipal and regional documents, analysis of available waste statistics, and qualitative input from local stakeholders.

The study focused on the three selected municipalities and used the most up-to-date information available at the time of writing. Where official municipal data were incomplete or unavailable, verified proxy data, estimates, or regional reference values were used to support the analysis.

The methodology also included a review of waste management infrastructure, regulatory frameworks, current service practices, smart technology readiness, and citizen engagement potential. This approach was used to provide both quantitative and qualitative insight into current waste management conditions and opportunities for improvement.

The report aims to support the preparation of comparable outputs within the wider Black Sea basin project framework.

Data Quality and Limitations

The data used in this report come from different organizations, municipalities, and reporting periods. As a result, not all figures are fully comparable, since they may have been collected using different methods, definitions, or timeframes.

In several cases, the most recent official data were not available, so the report relies on the latest accessible information, which may cover different years across the three

municipalities. Where precise municipal data were missing, the analysis used reasonable estimates, proxy indicators, or regional reference values. These should be understood as indicative rather than absolute values.

The findings therefore provide a broad and practical picture of the waste management situation, but they should not be interpreted as fully harmonized statistics. This limitation is important to consider when comparing municipalities and when drawing strategic conclusions.

Contextual Overview of the Municipalities

The three municipalities under study represent diverse geographical and demographic profiles within the broader region:

Thessaloniki serves as the largest urban municipality in the area and is the second-largest city in Greece. Its dense population and extensive infrastructure present unique challenges and opportunities for waste management, particularly in terms of volume, diversity of waste streams, and the need for innovative solutions.

Thermaikos is a coastal municipality located in close proximity to Thessaloniki. Its waste management strategies must account for both urban influences and the environmental sensitivities associated with coastal ecosystems, including tourism-related waste and marine pollution risks.

Lagadas exemplifies a rural municipality, characterized by its inland location and lack of sea access. Despite its lower population density, Lagadas covers a large territorial expanse, necessitating tailored approaches to waste collection, recycling, and disposal that address logistical and geographical constraints.

Integration into the Black Sea Basin Framework

This individual analysis is conducted within a broader, collaborative framework designed to ensure that findings are not only locally relevant but also contribute to a comprehensive, high-value joint report for the Black Sea basin. The standardized data collection and analysis processes will facilitate cross-border comparisons, promote best practices, and support regional cooperation in addressing shared environmental challenges. The ultimate goal is to foster sustainable waste management systems that align with both national priorities and international environmental standards.

In this context, the report provides the municipality-level evidence needed to support the wider Black Sea Basin comparative assessment.

List of Acronyms & Abbreviations

List of Acronyms & Abbreviations	
MSW	Municipal Solid Waste
NWMP	National Waste Management Plan
PESDA	Regional Waste Management Plan
Fo.D.S.A.	Solid Waste Management Agency (Regional Association of Solid Waste Management Agencies for Central Macedonia)
RU	Regional Unit
tn	tons
kg	kilograms
WTS	Waste Transfer Station
GPS	Global Positioning System
SWOT	Strengths, Weakness, Opportunities, Threats
ELSTAT	Hellenic Statistical Authority

1. Framework of the research - Regional profiles:

1.1 Central Macedonia and the Prefecture of Thessaloniki

Population
Central Macedonia is home to almost 1.8 million people, making it the second most populous region in Greece. The largest city and capital is Thessaloniki, followed by Serres, Katerini, Veria, and Giannitsa.

Area Size
The region spans approximately 18,810 square kilometers, making it the largest of Greece's thirteen regions by land area.

Main Economic Activities
Central Macedonia is highly developed in both the primary (agriculture) and secondary (industry) sectors. The region is known for its rich farmland, producing a significant portion of Greece's agricultural output, including tobacco, olives, cotton, and rice. The coastal areas and river valleys are particularly fertile and productive.

There is also a significant industrial sector, with activities ranging from food processing, textiles, and chemicals to automotive parts and energy production. The region's strategic location and infrastructure support trade and logistics, and it is a popular tourist destination, especially the Chalkidiki peninsula.

Central Macedonia



Map 1: Central Macedonia

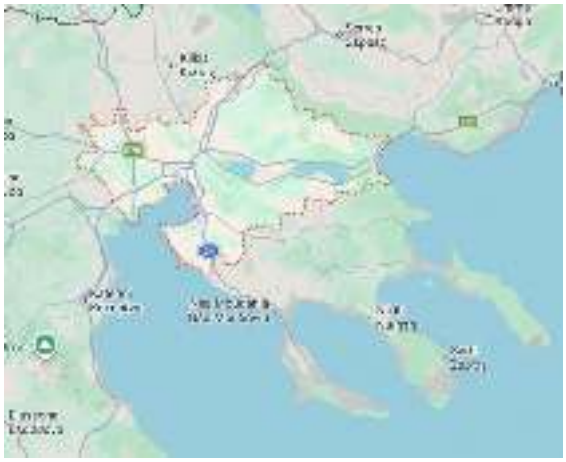
Prefecture of Thessaloniki



Map 2: - Prefecture of Thessaloniki

source: wikipedia/ wikipedia





Map 3: Central Macedonia **Map 4: Prefecture of Thessaloniki**

Source: maps.google.com

The Prefecture of Thessaloniki, now known as the Thessaloniki Regional Unit, is a key administrative division within the Central Macedonia region of Greece. Here's an overview based on the latest information:

History & Administration

The Thessaloniki Prefecture was established after the area was annexed by Greece during the First Balkan War in 1912–1913. Over time, parts of its territory were split off to form new prefectures (Pella, Kilkis, Imathia, Pieria), but Thessaloniki remained the largest and most populous in northern Greece. With the 2011 Kallikratis administrative reform, the prefecture was transformed into a regional unit, maintaining its boundaries and administrative role within Central Macedonia.

Geography & Economy

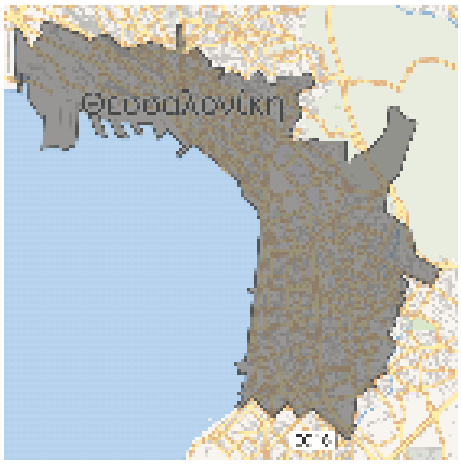
The regional unit stretches from the Thermaic Gulf in the southwest to the Strymonic Gulf in the east, encompassing both coastal and inland areas. It includes important lakes (Koroneia, Volvi) and mountainous regions (Chortiatis, Vertiskos). The area is a major economic hub, contributing significantly to Greece's GDP through industry, trade, logistics, and tourism. Thessaloniki's port and its role as a transportation and commercial hub are central to its economy.

Recent years have seen growth in logistics, real estate, life sciences, and technology sectors, supported by national and EU funding. The city is also a cultural and educational center, hosting major universities and festivals.

We selected three municipalities to represent the Thessaloniki Regional Unit:

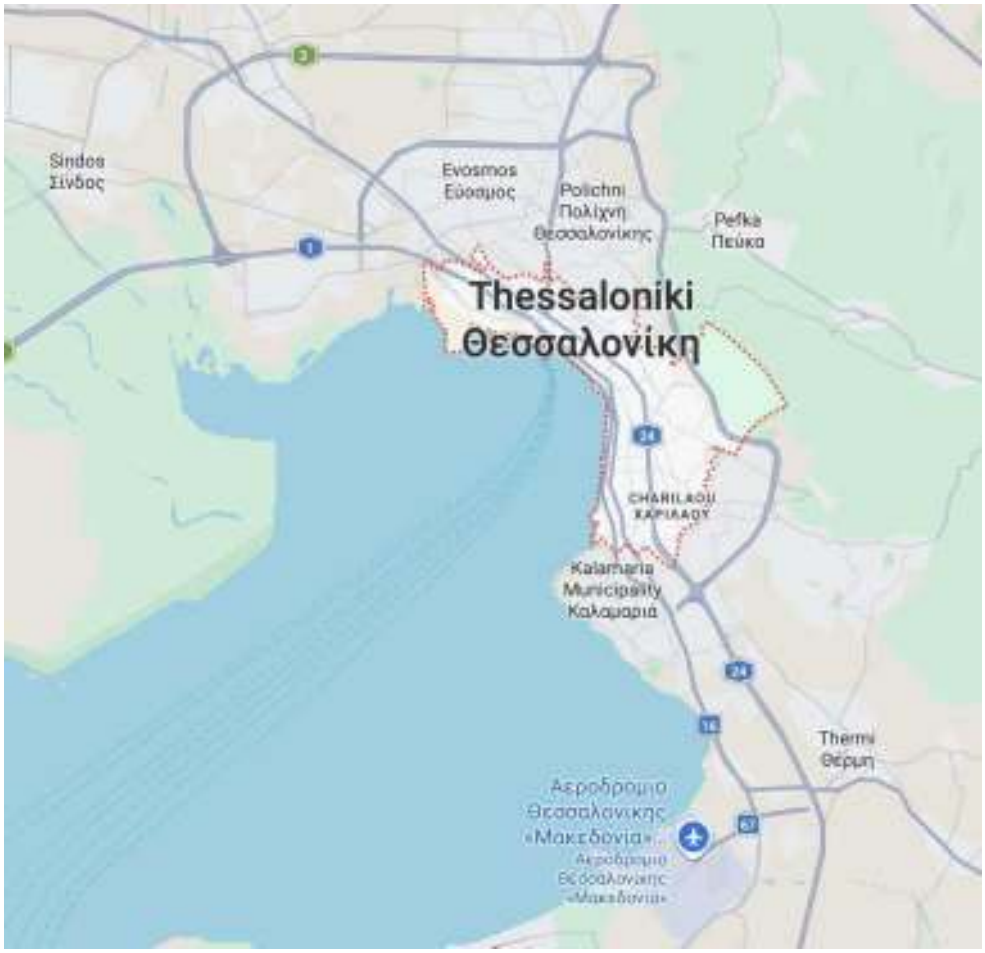
- **Thessaloniki**, as an urban municipality;
- **Thermaikos**, a coastal municipality near Thessaloniki, with a focus on tourism and fishing;
- **Lagadas**, a rural municipality with no sea access and a primary emphasis on agriculture.

1.2 Municipality of Thessaloniki



Map 5: Municipality of Thessaloni

source: wikipedia



Map 6: Municipality of Thessaloniki

source: maps.google.com

The Municipality of Thessaloniki has a population of 319,045 inhabitants, according to the official 2021 census data from EL.STAT.
Its area is 19.3 square kilometers.
The Municipality of Thessaloniki is the second most populous in Greece, with a resident population of about 319,045 inhabitants, according to the official 2021 census data from EL.STAT.
The city itself is much larger when including the metropolitan area, which has over 1 million inhabitants. The municipality covers an area of approximately 19.3 square kilometers, forming the historic and administrative core of the city.

The urban area of Thessaloniki includes 7 more municipalities:

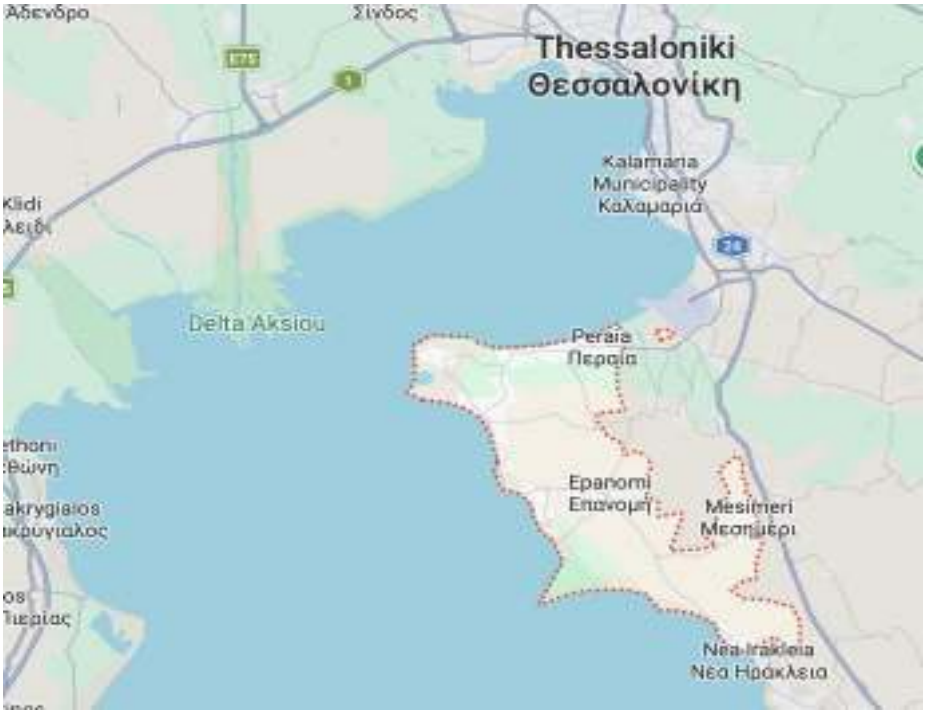


Map 7: The urban area of Thessaloniki
source: wikipedia

1.3 Municipality of Thermaikos



Map 8: Municipality of Thermaikos
source: wikipedia



Map 9: Municipality of Thermaikos

source: maps.google.com

The Municipality of Thermaikos, according to the official results of the 2021 population census by the Hellenic Statistical Authority (EL.STAT), has 45,561 permanent residents.

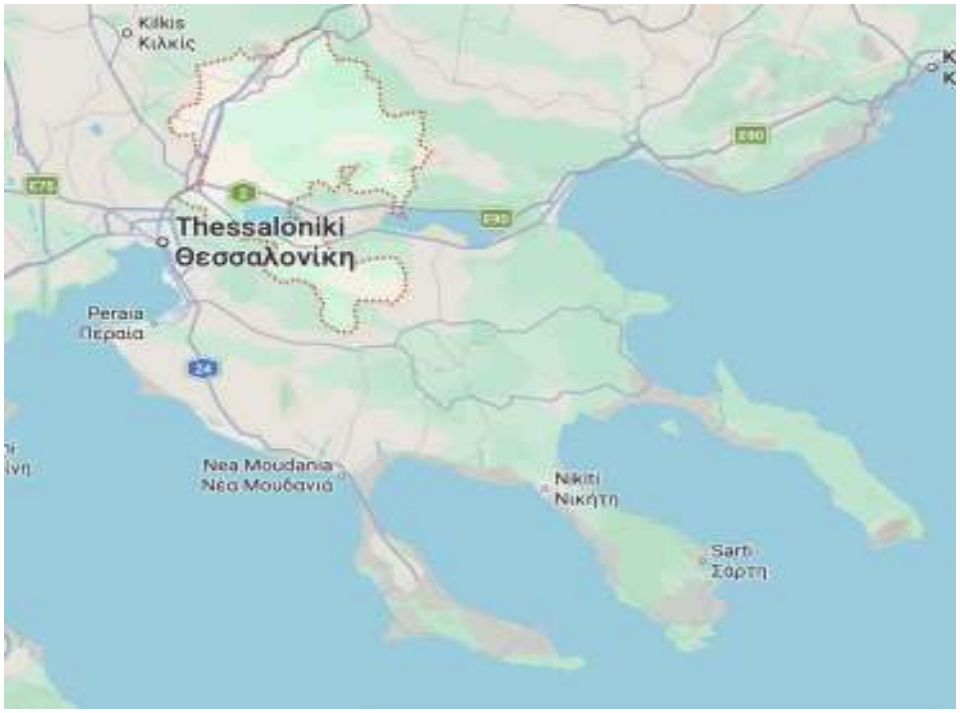
This number corresponds to a decrease compared to the previous census (2011), when the population exceeded 50,000 residents. The Municipality of Thermaikos is located east of the urban complex of Thessaloniki and includes areas such as Perea, Epanomi and Nea Michaniona.

1.4 Municipality of Lagadas



Map 10: Municipality of Lagadas

source: wikipedia



Map 11: Municipality of Lagadas

source: maps.google.com

The Municipality of Lagadas, according to the official results of the 2021 census by the Hellenic Statistical Authority (EL.STAT), has 37,022 permanent residents.

This number corresponds to a decrease of approximately 9.8% compared to the 2011 census, when the population was 41,103 residents.

The Municipality of Lagada is one of the largest municipalities in Greece, with an area of 1,220.3 sq km, and includes seven municipal units: Lagadas, Assiros, Vertiskos, Kalindoia, Lachanas, Koroneias and Sochos

2. Institutional framework

The waste management system in the target municipalities is governed by a multi-level regulatory structure, ranging from European Union Directives to specific local municipal ordinances.

2.1 European Union Legal Foundation

As Greece is an EU Member State, the institutional framework is strictly aligned with the **EU Waste Framework Directive (WFD)**:

- **Directive 2008/98/EC on Waste:** Established the 'Waste Hierarchy' (Prevention, Preparation for Re-use, Recycling, Recovery, Disposal) and the 'Polluter Pays Principle' (Directive 2008/98/EC, Art. 4 & 14).
- **Directive (EU) 2018/851 (Circular Economy Package):** Amending Directive 2008/98/EC, it sets higher recycling targets for municipal waste (55% by 2025) and mandates the separate collection of bio-waste by 2024 (Directive 2018/851, Art. 1).

2.2 National Legislative Framework (Greece)

National policy translates EU mandates into the Greek legal system through the following key instruments:

- **Law 4819/2021 (Government Gazette A' 129):** The primary national framework for waste management and circular economy. It regulates the obligations of municipalities for the 'Source Separation' of at least four streams (paper, metal, plastic, glass) and bio-waste (Law 4819/2021, Art. 25).
- **National Waste Management Plan - NWMP (ESDA 2020-2030):** Approved by the Cabinet (Act 49/2020), it sets the strategic roadmap for reducing landfilling to below 10% by 2030.
- **Landfill Tax (Circular Economy Levy):** Imposes a financial penalty on municipalities for every ton of waste sent to landfills to incentivize recycling (Law 4819/2021, Art. 38).

2.3 Local Governance and Regulatory Bodies

The operational management for the Municipalities of Thessaloniki, Thermaikos, and Lagadas is structured as follows:

- **Regional Association of Solid Waste Management Agencies (FODSA) of Central Macedonia:** Responsible for the final treatment and disposal of waste at the regional level (Law 4555/2021 – ‚KLEISTHENIS I' program).

- **Municipal Waste Management Ordinances (Local By-laws):** Each of the three municipalities operates under its own 'Cleanliness Regulation', which defines specific collection hours, citizen responsibilities, and administrative fines for illegal dumping or non-compliance.
- **Local Waste Management Plans (TSDA):** These are mandatory strategic documents drafted by the Municipalities of Thessaloniki, Thermaikos, and Lagada to harmonize local infrastructure with the Regional Waste Management Plan (PESDA) of Central Macedonia.

While the national and regional frameworks set the targets, the operational execution is decentralized. Each of the target municipalities has established specific administrative bodies to manage waste streams in accordance with their unique geographical and socio-economic characteristics:

Municipality of Thessaloniki: The municipality is directly responsible for waste and recycling services within its boundaries. The **Directorate of Recycling and Municipal Waste Management** oversees the collection and transport of municipal solid waste (MSW), the cleanliness of public spaces, and the management of recycling programs. A key feature of its institutional structure is the operation of **civic amenity sites** (e.g., the Enhanced Green Centre) and the execution of public awareness campaigns to promote source separation (Law 4819/2021 compliance).

Municipality of Thermaikos: Responsibility is held by the municipality in coordination with regional frameworks. Due to its coastal nature, the institutional framework here is expanded through collaborations with local stakeholders, such as the **Mussel Farm Association**. To address specialized waste streams (marine and mussel farming waste), the municipality partners with specialized organizations like **iSea and BlueCycle**. For general MSW, it operates under the guidance of **FODSA Central Macedonia**, ensuring that local collection aligns with regional infrastructure.

Municipality of Lagadas: The **Cleaning and Recycling Directorate** is the competent authority for the collection and transportation of both waste and recyclable materials, as well as fleet maintenance. A distinct administrative feature is the operation of **decentralized Cleaning and Recycling Offices** within individual municipal units, which allows for localized management across its diverse rural and suburban territory.

2.4 Compliance Status and Enforcement Challenges

In accordance with the WISE-WASTE methodology, the following institutional gaps are noted:

- **Monitoring Gaps: Monitoring Gaps:** A significant lack of verified, real-time data on separate collection rates, which complicates the assessment of municipal performance against national targets. This is further evidenced by the FODSA Central Macedonia 2024 Report, which shows that while total waste management reached 1,146,035.23 tonnes, the data remains aggregate and retrospective rather than real-time. Furthermore, as noted in the Thessaloniki Bay Floating Litter Report, the absence of systematic monitoring in sensitive areas like the Thessaloniki seafront necessitates the use of ad-hoc

innovative tools like drones to fill information gaps (Municipality of Thessaloniki & EKBY, 2020).

- **Enforcement Deficiencies:** Challenges in enforcing source-separation protocols in commercial sectors, particularly in the coastal zones of Thermaikos and the industrial areas of Lagadas. According to the Zero Waste Management Guide (Part A), the transition to a circular model in Greece is hindered by a lack of infrastructure and clear enforcement of separate collection for organic waste, which remains a primary challenge for municipal authorities (ZeroWasteBSB, 2020).
- **Contractual Limitations:** Existing contracts with waste operators often lack specific Key Performance Indicators (KPIs) regarding smart technology integration. The need for such digital reporting and eco-innovation is highlighted as a national priority in the EEA Greece Waste Prevention Factsheet (2025), which points out that while economic incentives exist, there is still a gap in integrating eco-innovation into governance and local waste management contracts.»

3. Technical infrastructure

Types of containers, waste collection vehicles, landfills, transfer stations, and recycling centers.

3.1 Types of Containers

- Household Waste Bins: Standard bins for general waste are provided to residents, often in different colors for mixed waste and recyclables.
- Recycling Bins: Blue bins are commonly used for paper, plastic, metal, and glass. These are placed at collection points throughout the municipality.
- Organic Waste Bins: Brown bins may be used for organic waste in areas where separate collection is implemented.
- Special Waste Containers: For hazardous waste (e.g., batteries, electronics, bulky items), special collection points or scheduled pickups are organized.

The municipality of Thessaloniki plans to replace old and damaged bins with 2,232 new green bins (general waste), which are expected to cover the needs of all neighborhoods for the next two years. In addition, 75 new underground bins are being installed in key points of the city. (Source from 3.2.2026)

3.2 Waste Collection Vehicles

- Compactor Trucks: Used for collecting mixed household waste.
- Split-body Trucks: For separate collection of recyclables and organic waste.
- Specialized Vehicles: For bulky waste, green waste, or hazardous materials.

According to recently published data, the Municipality of Thessaloniki operates 75 garbage truck routes daily to collect garbage, in order to meet the needs of the city. However, the total number of vehicles is not explicitly mentioned, but only the number of daily routes. In the municipality's announcements for the supply of new garbage trucks, it is stated that an effort is being made to strengthen the fleet, but there is no exact record of the total number of vehicles currently available to the municipality (23.10.2025, ertnews). It is therefore difficult to assess whether this proposed improvement to the fleet will be adequate to meet the city’s waste needs as there is no official specific number given.

There are no official figures available for the exact number of waste and recycling vehicles available to the Municipality of Thermaikos in 2026. However, for the neighboring Municipality of Thermi (which has a similar size and population), it is reported that in 2025 it has 123 vehicles for cleaning and waste collection services, including 28 garbage trucks.

3.3 Landfills

The municipalities in the Thessaloniki region, likely sends its non-recyclable waste to sanitary landfills managed by the Region of Central Macedonia or the FODSA (Solid

Waste Management Association of Central Macedonia). These landfills are designed to minimize environmental impact and comply with EU regulations.

3.4 Transfer Stations

Transfer stations are used to consolidate waste from collection vehicles before transport to landfills or processing facilities. This helps optimize logistics and reduce transportation costs.

3.5 Recycling Centers

- Material Recovery Facilities (MRFs): These centers sort and process recyclables collected from households and businesses.
- Civic Amenity Sites: Residents can drop off recyclables, bulky items, and hazardous waste at designated points.
- Composting Facilities: For organic waste, if a separate collection is in place.

3.6. Statistical Overview

Recycling Network Overview (Central Macedonia)
The three municipalities fall under the operational scope of the Central Macedonia Waste Management Association (-FODSA) and the packaging recycling system of the Hellenic Recovery Recycling Corporation (HERRCO). By the end of 2024, the Central Macedonia network included 32,570 active blue recycling bins, serving 1,793,923 residents, and recovered 46,028 tons of recyclable materials.

Municipality of Thessaloniki
Separate Collection Infrastructure

Infrastructure	Status	Data / Performance (2025)
Blue Bins (packaging)	Operational	~3,800 bins + ~450 glass bell containers · 30,330 tons (2025) · +3.9% vs 2024
Brown Bins (biowaste)	Operational	1,300 bins · 5,000+ tons/year · 3-year contract of €6.18 million for 8,500 tons/year (2026)
Green Spots	Under implementation	2 locations: 32 Gianni Angelou St. & 13 Katsimidi St. (LIFE-IP CEI-Greece, 2024+)
Clothing Recycling	Operational	345 EASTWEST bins · ~450 tons/year
Recycling Festival	Annual	10th Festival: March 2026 · TIF-HELEXPO

Chart 1: Recycling initiatives of the Municipality of Thessaloniki.
Sources: HERRCO (Hellenic Recovery Recycling Corporation) 2024, Municipality of Thessaloniki Annual Report 2025.

Municipality of Thermaikos

Infrastructure	Status	Details
Blue Bins	Operational	200 new HERRCO bins in **2025** · 2,412 tons sent to Thermi Waste Treatment Center (**2023**) · **53 kg/inhabitant**
Brown Bins	Not available	Not yet included in the FODSA Central Macedonia program (**December 2025**)
Green Spot	Not available	First licensed bulky waste site under construction (**2025**)
Cooking oil Recycling	New (**2026**)	Contract with EASTWEST signed **January 2026** - bins in all municipal districts
WEEE / Electronics	Operational	Collection by appointment
Clothing / Textiles	Operational	EASTWEST bins at municipal locations

Chart 2: Recycling initiatives of the Municipality of Thermaikos.
Sources: thermaikos.gr, HERRCO (Hellenic Recovery Recycling Corporation) 2024.

Municipality of Lagadas

Infrastructure	Status	Details
Blue Bins	Operational	Network in operation - quantitative data not publicly available
Brown Bins (commercial)	Partial	Full operation from November 2025 - commercial producers only (taverns, catering). Households not yet included.
Green Spot	Not available	Site selection study to be completed in 2025 · Budget: €40,000
Compost Return	Operational	The Municipality receives compost from BIOSOLIDS S.A. (Mavrovouni, Pella)

Chart 3: Recycling initiatives of the Municipality of Lagadas
Sources: lagadas.gr, Central Macedonia Waste Management Association (FODSA), Makedonia newspaper.

The study was undertaken utilizing the most up to date, publicly available data at the time. However, the report recognizes that each municipality, each organization and each focus of data collection is separate and not necessarily undertaken within the same timescales or with overarching unified guidelines. Therefore, although the research aims to use data from the last 3-5 years, some of the information available

was carried out during the period 2020-2024, while other municipalities have studies provided, with data from 2021-2026. It is therefore important to work with the assumption that the findings from the combined data should not be taken as 100% accurate facts, nor utilized as finalized statistics, but rather employed to generate a broad picture of the situation and use this to create practical actions for improvement. Moreover, in some cases, due to gaps in information available, researchers have had to utilize estimates or proxy data, when official statistics have not been found.

In addition to the field research and desk research on the statistics and waste flow data, a small survey on citizen readiness for engagement with smart technologies on waste management was undertaken. As with all social research, the results must be evaluated with caution, to not make assumptions about the population of a region as a whole, based on the sample of citizens who responded. Moreover, it is essential to delineate multiple-choice responses from open-question replies and give credence to not only the quantitative analysis, but equal emphasis to qualitative responses to open ended or long form questions. This approach to social research should not assume that the researcher has considered all of the potential responses of the public and should always allow for the respondent to include any other comments, ideas, questions and issues. If the aim of the research is to find ways to better engage the public in smart solutions for waste, then it is essential that at the research stage, their voices are not only heard within the framework that the researchers expect, but are also given free reign to express whatever else they would like with regard to the issue at hand.

4. Quantitative analysis

This chapter presents the available quantitative evidence on municipal solid waste generation and composition in the target area of Central Macedonia, with specific reference to the Municipalities of Thessaloniki, Thermaikos, and Lagadas. The analysis is based primarily on official regional and municipal sources, complemented where necessary by proxy indicators and reference values in cases where municipal-level data are incomplete or not publicly available.

The purpose of this chapter is to establish a practical statistical baseline for the comparative assessment of current waste management conditions. In line with the WISE-WASTE methodology, emphasis is placed on data that can support strategic planning, identification of gaps, and the design of feasible smart waste management interventions.

4.1 Central Macedonia

Before examining the three selected municipalities individually, it is useful to consider the broader regional picture in Central Macedonia. The official data published by the Central Macedonia Waste Management Association (FODSA)[1] provide the basis for understanding total municipal solid waste generation and management patterns at regional level.

The 2024 regional dataset shows the volume of municipal solid waste generated by regional units and municipality, as well as the overall management flows for the same year. These figures are particularly important because they provide the common statistical framework within which the three municipalities under study can be compared.

[1] FODSA is the first and only nationwide Regional Solid Waste Management Agency, is a guide for all the corresponding Agencies throughout the country, with remarkable results in the specialization and implementation of objectives and actions for the temporary storage, transshipment, processing, recovery and disposal of solid waste at the regional level. The Central Macedonia Waste Management Authority, aiming at the circular economy, is trying with various actions to act as a catalyst to support the green concept.

With this philosophy, it works in an organized manner, creating infrastructures that improve the entire process from the collection, disposal, sorting and of course the sanitary landfill of waste. The goal that Central Macedonia has set is to send less than half of the waste produced in mixed form to waste factories.



Map 12: Quantities (tn) of Municipal Solid Waste (MSW) Production by Regional Unit in Central Macedonia (2024) – Waste Generation Indicator (WGI) – kg/capita/day

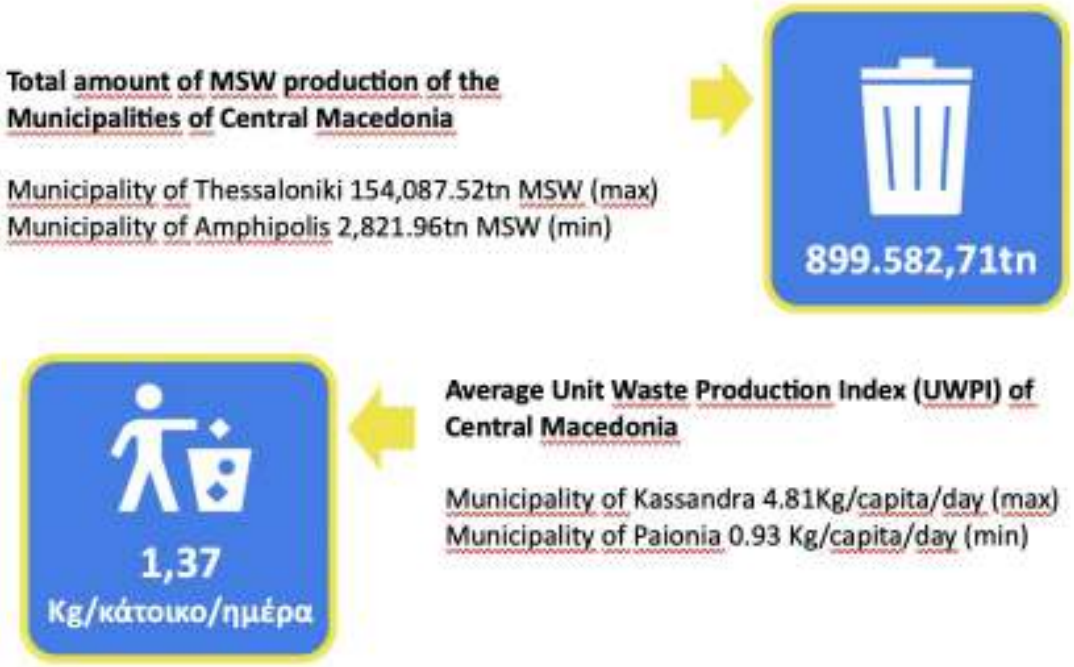


Chart 4: Total Quantities (Thousand tn) of Municipal Solid Waste (MSW) Production by Municipality for 2024



Chart 5: Unit Waste Production Index (UWPI) of the Municipalities of Central Macedonia for 2024 – kg/capita/day

The total amount of *Municipal Solid Waste (MSW):*



In addition to waste generation, regional data also provide an overview of the main waste management streams. This makes it possible to place municipal performance within the wider context of treatment, recovery, and disposal practices across Central Macedonia.

The different management services in a schematic presentation of the MSW management services and the quantities that correspond to them.
The total of management services constitutes the final managed quantity of Municipal Solid Waste (MSW) for the year 2024.

Total Managed Quantity of Municipal Solid Waste 2024:



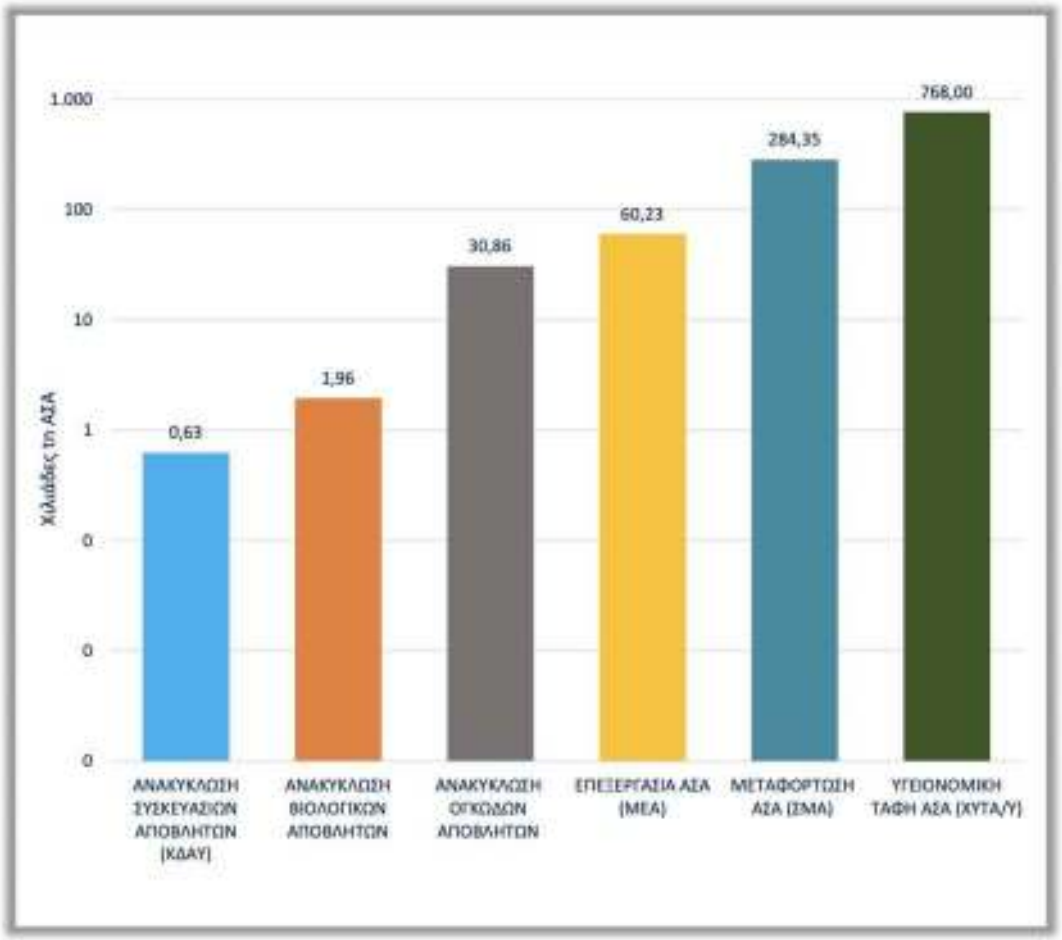


Chart 6: Quantities (thousands of tn) of MSW management in Central Macedonia

From left to the right:

waste, packaging, recycling (ΚΔΑΥ)[2] : 0,63 thousands of tons
biological waste recycling: 1,96
recycling of large waste: 30,86
MSW processing (MEA)[3]: 60,23
SMA Mechanical Recycling Systems[4]: 284,35
landfilling XYTA / XYTA/Y[5]: 768

According to the regional management data for 2024, the principal waste management streams include packaging recycling, biowaste recycling, bulky waste recycling, waste treatment, transfer operations, and landfilling. The overall distribution confirms that landfill disposal continues to account for the largest share of final waste management, underlining the importance of strengthening prevention, source separation, and material recovery across the region.

4.2 Thessaloniki

The Municipality of Thessaloniki represents the largest urban waste generator among the three municipalities examined in this report. Its quantitative profile reflects both the scale of the urban population and the concentration of commercial, institutional, and service activities within the city.

Available information indicates that Thessaloniki has a relatively developed waste transfer and collection system compared with the other municipalities in the study. The Waste Transfer Station plays a central operational role in the city's system, supporting the rapid unloading, compaction, and onward transfer of waste collected from municipal routes.

Municipal information also indicates that the city collects approximately 600 tons of waste per day, of which around 570 tons are reported as organic or mixed municipal waste, while an additional 30 tons per day consist of bulky items, rubble, branches, and related materials. These figures illustrate both the scale of the urban waste stream and the continuing dominance of mixed waste collection.

At the same time, the available quantitative evidence for Thessaloniki remains uneven across categories. While there are public references to route numbers, transfer capacity, and selected infrastructure upgrades, the report did not identify a fully consolidated and publicly accessible dataset covering the total number of containers,

[2] **ΚΔΑΥ** : Κεντρικός Διάδρομος Απορριμμάτων Υπολειμμάτων - "'**Central Residual Waste Corridor**'". It refers to infrastructure and systems used to transport and manage residuals

[3] Μονάδα Επεξεργασίας Απορριμμάτων (ΜΕΑ): "'Waste Treatment Plant'". These are facilities where municipal solid waste (MSW) is processed, such as recycling, composting, or energy production from garbage.

[4] ΣΜΑ Συστήματα Μηχανικής Ανακύκλωσης –– ,"Mechanical Recycling Systems'". These systems are used to automatically separate and process recyclable materials (e.g. plastic, paper, metal, glass) from municipal solid waste.

[5] Χώροι Υποδοχής Τελικής Απόθεσης / Χώροι Υγειονομικής Ταφής Απορριμμάτων - "'Final Disposal Reception Sites" / "Sanitary Landfill Sites".

the complete vehicle fleet, collection frequencies, and disaggregated flow data by waste stream for the same reporting period.
This does not prevent analysis, but it does limit precision. For this reason, the Thessaloniki case should be interpreted as statistically informative but only partially verified at operational level, particularly in relation to fleet composition, infrastructure inventory, and stream-specific collection performance.
A further quantitative indicator relevant to Thessaloniki is the marine litter composition data from Thessaloniki Bay. Although these data do not represent the municipality's entire municipal solid waste stream, they are useful for illustrating the composition of waste reaching the coastal environment. The available figures indicate a predominance of synthetic polymer materials, followed by textiles and paper, with smaller shares of straws, cotton buds, diapers, and filters.

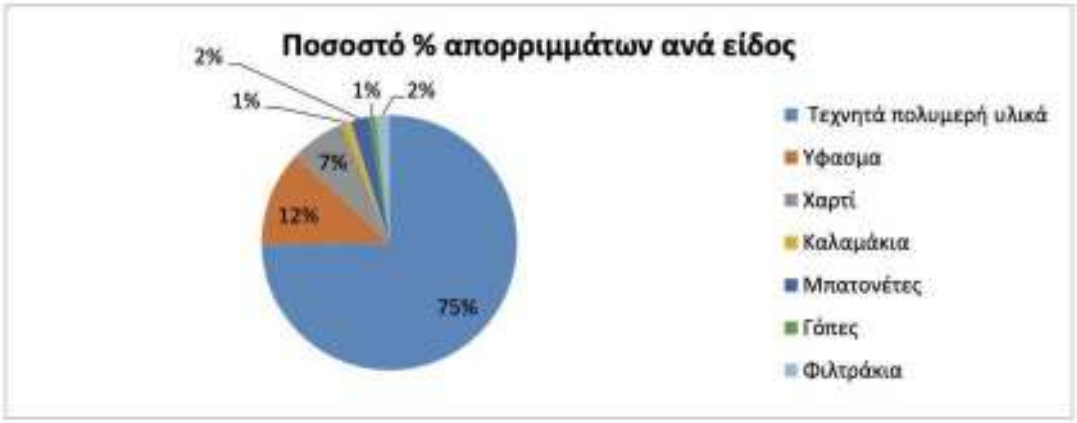


Chart 7: Percentage (%) of waste by type

Taken together, the quantitative evidence suggests that Thessaloniki's main challenge is not the absence of infrastructure, but the need for more systematic data consolidation and stronger source separation performance. The city has a large and active waste management system, yet the available data point to the continued predominance of mixed waste and to important gaps in real-time operational visibility.

4.3 Thermaikos

The Municipality of Thermaikos presents a different quantitative profile, shaped by its coastal location, seasonal pressures, and tourism-related activity. Compared with Thessaloniki, the municipality operates at a smaller scale, but its waste generation pattern appears to fluctuate more significantly due to seasonal demand and local service pressures.
The available municipal data indicate measurable progress in selected waste and cleaning services. During the first four months of 2024, the municipality reported a 7.6 percent increase in recycling compared with the corresponding period in 2023, with recyclable material rising from 727,480 kilograms to 782,660 kilograms.
Additional published municipal information for 2025 points to a strengthening of basic service capacity, including the installation of 200 additional blue recycling bins, the replacement of 228 green waste bins, the introduction of cooking oil recycling infrastructure, improvements in bulky waste collection, and the removal of

abandoned vehicles. These figures do not in themselves provide a full annual waste balance, but they do indicate an active period of operational improvement.
A further useful element in the Thermaikos case is the municipality's own reporting on service demand categories. The published "top ten" waste-related service issues for 2023 and 2025 suggest increased pressure in areas such as bulky waste, green waste, general cleaning operations, and bin replacement. These patterns are relevant because they reflect the operational burden placed on municipal services, even where full tonnage data are not available.



Chart 8: Sanitation in numbers

For the years 2023 and 2025 the municipality published the "top 10" of waste:

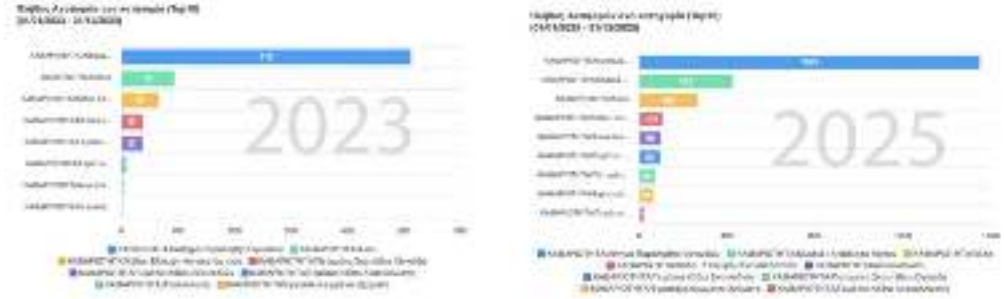


Chart 9: Top ten of waste

2023	*2025*
Large waste: 512	Large waste: 1551
General cleaning operations (various): 93	Branches, garden waste: 423
Bins shortage, replacement: 65	General cleaning operations (various): 264
Litter (dumped waste): 37	Bins shortage, replacement: 104
Full trash bins: 37	Recycling: 96
Full recycling bins: 7	Full trash bins: 93
Recycling operations: 2	Litter (dumped waste): 69
Abandoned vehicles removed: 2	Abandoned vehicles: 63
	Full recycling bins: 1

Despite these improvements, a key limitation remains: no complete, consolidated, and publicly available dataset was identified for the total annual quantities of all waste streams generated in Thermaikos over the full 2020–2025 period. As a result, the quantitative assessment of the municipality depends on a combination of official point-in-time service data, regional waste registry figures, and selected municipal updates.

Even with that limitation, the available evidence indicates that Thermaikos is under stronger seasonal and service-related pressure than the other municipalities in the study. This interpretation is also consistent with the later multi-year statistical overview, where the municipality records the sharpest increase in municipal solid waste generation over the 2020–2024 period.

4.4 Lagadas

The Municipality of Lagadas differs substantially from both Thessaloniki and Thermaikos due to its large geographical area, dispersed settlement pattern, and more rural operational profile. These characteristics affect both waste collection logistics and the availability of consolidated municipal data.

For the period under review, no comprehensive municipal dataset was identified that would allow a full independent assessment of annual waste quantities, recycling performance, and stream-specific trends based solely on published local sources. Official municipal information provides useful descriptions of services, facilities, and operational measures, but it does not offer a sufficiently detailed public statistical series for all key indicators.

For this reason, the quantitative assessment of Lagadas relies more heavily on regional registry data and secondary reference points than in the cases of Thessaloniki and Thermaikos. This approach is methodologically acceptable within the present report, provided that the limits of comparability are clearly acknowledged and the findings are interpreted as indicative rather than exhaustive.

The available evidence nevertheless supports a clear conclusion: Lagadas is not primarily characterized by high overall waste volumes, but by the complexity and cost of collection over a large and spatially dispersed territory. This operational reality should be considered central to the interpretation of its quantitative profile.

4.5 Statistical Overview, 2020–2024

To enable direct comparison between the three municipalities, this section presents the available multi-year statistical overview of municipal solid waste generation for the period 2020–2024. The data are drawn from the annual reports of the Electronic Waste Registry of the Central Macedonia Waste Management Association (FODSA).

Municipal Solid Waste (MSW) Production in Tons/Year

Year	Municipality of Thessaloniki	Municipality of Thermaikos	Municipality of Lagadas	Total for Central Macedonia
2020	128,663	18,747	15,069	722,397
2021	129,850	21,113	17,036	746,342
2022	133,448	20,539	16,684	766,007
2023	150,866	34,197	17,691	880,832
2024	154,088	36,030	18,740	899,583
Change 2020→2024	**+19.8%**	**+92.2%**	**+24.4%**	**+24.5%**

Chart 10: MSW production (tons/year) by municipality, 2020–2024

The data show that Thessaloniki remains by far the largest waste producer in absolute terms, which is expected given its population size and metropolitan role. At the same time, the most significant growth rate is recorded in Thermaikos, where municipal solid waste generation increased by 92.2 percent between 2020 and 2024, substantially above the regional average of 24.5 percent.

This pattern strongly suggests the influence of seasonal population movements, tourism-related activity, and the expansion of commercial services in the coastal zone. By contrast, Lagadas records lower total quantities but a growth rate close to the regional average, while Thessaloniki shows a moderate but substantial increase in line with its scale and functional importance.

Per Capita Production (kg/inhabitant/year)

Year	Municipality of Thessaloniki	Municipality of Thermaikos	Municipality of Lagadas	Total for Central Macedonia
2020	408 kg	409 kg	287 kg	~500 kg*
2021	412 kg	460 kg	325 kg	No data
2022	423 kg	448 kg	318 kg	No data
2023	475 kg	752 kg	478 kg	~500 kg
2024	482 kg	792 kg	508 kg	~502 kg

Chart 11: Per capita MSW production (kg/inhabitant/year)

*MS average based on total tonnes/population 1,793,923. According to EEA data (2025), the national average for Greece is 519 kg/capita/year, a value similar to the EU-27 average (513 kg/capita). The values of the municipalities of Thessaloniki and Lagadas fluctuate within the national range, while Thermaikos significantly exceeds the average due to specific factors.

Per capita data reinforce the same conclusion. Thessaloniki and Lagadas remain within a range that is broadly comparable to national and regional reference values, whereas Thermaikos rises well above them in 2023 and 2024. This divergence should be interpreted in relation to the municipality's seasonal tourism profile and the likely concentration of hospitality and service-sector waste generation during peak periods.
Morphological Composition of Municipal Solid Waste (MSW)
In the absence of recent municipal-level waste characterization studies for all three municipalities, this report uses the official reference composition provided by the Regional Waste Management Plan of Central Macedonia. This is the most appropriate common benchmark currently available for comparative planning purposes.

Fraction	Percentage (% w/w)	EWC Code (indicative)
Biowaste (food + garden)	44.3%	20 01 08 / 20 02 01
Paper - Cardboard	22.2%	20 01 01
Plastics	13.9%	20 01 39
Wood	4.6%	20 01 37* / 20 01 38
Glass	4.3%	20 01 02
Metals	3.9%	20 01 40
Other	6.8%	20 03 01
Total	**100.0%**	—

Chart 12: Morphological composition of municipal solid waste (MSW)
according to the Regional Waste Management Plan of Central Macedonia (RWMP) / National Waste Management Plan (NSWF) 2020–2030.

The regional composition indicates that biowaste is the dominant fraction, followed by paper/cardboard and plastics. From a management perspective, this is particularly important because it confirms that improved separate collection of organics and recyclables would offer the greatest potential for reducing mixed waste disposal and increasing recovery performance.
The use of regional morphology as a proxy is justified by the lack of recent local characterization studies and by the role of the Regional Waste Management Plan as the main planning reference for Central Macedonia. Nevertheless, this approach has limitations, since local variations related to urban density, commercial activity, tourism, and agricultural practices may not be fully reflected in a regional average.
The quantitative findings presented above should be read together with the introductory section on Data Quality and Limitations. Although the available data are sufficient to support comparative assessment and practical conclusions, some indicators are based on non-uniform municipal reporting, different reference years, and, where necessary, proxy values. For this reason, the analysis is intended as an operational baseline for identifying needs, gaps, and opportunities for smart waste management improvements rather than as a fully harmonized statistical dataset.

4.6 Methodological Remarks on Quantitative Data

The statistical analysis presented in this chapter should be interpreted in light of several methodological constraints. First, the available data do not always cover the

same years, reporting units, or waste streams across the three municipalities. Second, municipal public reporting remains uneven in terms of completeness, detail, and update frequency.

Third, some of the indicators used in this chapter are based on proxy values or regional references where municipality-specific measurements were not available. This applies in particular to the morphological composition data and to certain operational estimates relating to infrastructure and collection performance.

Despite these constraints, the data are sufficient to support several robust planning conclusions. Thessaloniki is the dominant waste generator in absolute volume, Thermaikos displays the strongest growth and highest seasonal pressure, and Lagadas faces the greatest logistical complexity in relation to territory and service coverage. These differences are central to the design of the strategic proposals developed in the following chapters.

The quantitative findings are affected by uneven municipal reporting, different reference years, and the use of proxy values where direct data were unavailable. For this reason, the chapter is intended as a practical baseline for comparison rather than a fully harmonized statistical dataset.

5. Smart technologies

This chapter examines the current and potential use of smart technologies in municipal waste management across the three selected municipalities. In line with the WISE-WASTE methodology, the analysis focuses on the availability of digital tools, the degree of operational readiness, and the opportunities for improving efficiency, monitoring, and citizen interaction through practical technological solutions.

Smart technologies in waste management may include fill-level sensors, vehicle tracking systems, route optimization tools, digital registries, mobile applications for citizens, and data platforms that support monitoring and performance evaluation. Their relevance in the present study lies not only in their technical function, but also in their capacity to improve transparency, reduce operational inefficiencies, and support more adaptive service delivery.

5.1 Thessaloniki

Among the three municipalities, Thessaloniki demonstrates the strongest existing operational base for the future deployment of smart waste management systems. The municipality already manages a large-scale urban waste service, supported by a Waste Transfer Station, a broad network of containers, and significant recent investment in new bins and collection infrastructure.

At the same time, the analysis indicates that the municipality's main technological need is not the creation of an entirely new system, but the digital consolidation of the existing one. The absence of a fully integrated and publicly accessible inventory of bins, routes, vehicles, collection frequencies, and stream-specific operational data limits the municipality's ability to use its infrastructure in a fully data-driven manner.

This creates a clear case for the introduction of core smart management tools. Priority technologies for Thessaloniki include GPS-based fleet tracking, digital asset registration for containers and collection points, and fill-level sensors for underground or high-pressure bins. These tools would allow the municipality to move from schedule-based service delivery toward more responsive and evidence-based collection practices.

Citizen-facing digital tools are also relevant in the Thessaloniki context. Given the municipality's size and urban density, applications that support service notifications, reporting of missed collections, location of recycling points, and public communication on source separation could significantly improve interaction between residents and municipal services.

Overall, Thessaloniki appears to be the municipality with the greatest immediate potential for the operational scaling of smart waste technologies. The basic infrastructure already exists; the strategic need is to improve visibility, coordination, and performance management through digital systems.

5.2 Thermaikos

The Municipality of Thermaikos presents a different type of smart technology challenge, shaped by seasonality, coastal pressures, and demand fluctuations linked

to tourism and service activity. In this setting, the value of smart tools lies primarily in their ability to improve flexibility, anticipate overload conditions, and support timely interventions in high-pressure periods.

The municipality has already shown signs of operational adaptation through service improvements, expansion of recycling infrastructure, and partnerships that address specific local waste streams. However, the available evidence does not indicate the presence of a fully developed smart waste management system based on integrated sensor data, digital dashboards, or systematic route optimization.

For Thermaikos, the most appropriate technological pathway is targeted and seasonal deployment. Fill-level sensors on bins in coastal or tourism-intensive areas, digital service request systems for bulky waste, and route coordination tools for cleaning operations would likely yield immediate practical benefits. These technologies are particularly relevant in an environment where waste generation and public space pressures vary significantly over time.

Thermaikos also offers opportunities for combining smart technologies with stakeholder engagement. Because the municipality already interacts with actors linked to tourism, marine activity, and environmental management, digital tools could be used not only for collection logistics but also for reporting local problems, supporting awareness, and improving service responsiveness during peak periods.

In strategic terms, Thermaikos would benefit most from smart technologies that improve adaptability rather than scale alone. The central goal is to reduce the effects of seasonality, avoid local overflows, and improve coordination between municipal services and local users.

5.3 Lagadas

The Municipality of Lagadas presents a predominantly rural and spatially dispersed case, where the main technological challenge is logistical rather than volumetric. The large territorial extent of the municipality increases collection distances, operational costs, and the difficulty of maintaining consistent service efficiency across multiple settlements.

In this context, smart technologies should be understood primarily as tools for territorial coordination and route rationalization. Digital mapping of collection points, GIS-based waste service registries, and route optimization systems would provide the municipality with a stronger basis for planning collection in a geographically extensive area.

The potential value of smart systems in Lagadas is therefore especially high, even if the municipality's current technological base appears more limited than that of Thessaloniki. Sensor deployment in remote collection points, combined with route planning tools, could reduce unnecessary trips, improve fuel efficiency, and support more targeted service provision in rural and semi-rural zones.

Lagadas may also require more specialized digital approaches linked to local economic activity. Given the municipality's rural and agricultural character, future smart waste management solutions could include adapted collection points for agricultural plastics, packaging, and other non-household streams that are not always addressed adequately through conventional municipal systems.

From a strategic perspective, Lagadas is the municipality where smart technologies could have the strongest effect on service efficiency and territorial coverage. The priority is to use digital tools to support smarter logistics, rather than simply to replicate urban technology models.

5.4 Comparative Assessment

The three municipalities share a common need for better data, more systematic monitoring, and stronger integration between operational management and digital tools. However, the appropriate smart technology pathway differs across cases.
For Thessaloniki, the priority is digital control of an already large and active system. For Thermaikos, the priority is flexible and seasonal responsiveness. For Lagadas, the priority is territorial optimization and cost-efficient service delivery across a dispersed area.
These differences are important because they show that smart waste management should not be approached as a uniform technological package. Instead, technologies should be selected according to local operational conditions, service pressures, and institutional capacity.

5.5 Citizen readiness for smart tools

The limited citizen feedback gathered during the study suggests that public readiness for digital waste services exists, but participation depends on simple design, clear instructions, and visible municipal response. This finding supports the inclusion of user-friendly reporting tools and targeted communication in future pilots.

5.6 User uptake and implementation conditions

The comparative assessment indicates that the successful deployment of smart waste technologies will depend not only on technical readiness, but also on user uptake, institutional responsiveness, and the clarity of municipal communication. Feedback collected through the study process suggests that digital tools are more likely to be effective when they are simple to use, linked to visible service improvement, and supported by clear guidance for residents and local stakeholders.

6. SWOT Analysis

6.1 Executive Summary and Context

The waste management systems in the Regional Unit of Thessaloniki are currently undergoing a significant transition. This report focuses on three distinct municipal profiles: **Thessaloniki** (Urban), **Thermaikos** (Coastal/Tourist), and **Lagada** (Rural/Agro).

In 2024, the Region of Central Macedonia produced approximately **899,582 tons** of Municipal Solid Waste (MSW), with the Municipality of Thessaloniki being the largest contributor (**154,087 tons**). While the institutional framework is strictly aligned with **EU Directive 2018/851** and the **Greek National Waste Plan (ESDA 2020-2030)**, operational challenges remain. Research indicates a significant data gap regarding real-time monitoring of fleets and containers, especially in the expansive rural areas of Lagada and the seasonally pressured coastal zones of Thermaikos.

The integration of " Smart Solutions‘- such as fill-level sensors, GPS telematics, and citizen-facing mobile applications - is identified as the primary lever for reducing the **1.37 kg/capita/day** waste generation index and avoiding the increasing financial burden of the national landfill tax.

6.2 SWOT Analysis matrix

STRENGTHS	WEAKNESSES
Advanced Logistics (Urban): Thessaloniki’s Waste Transfer Station (WTS) handles up to 1,200 t/day, reducing vehicle wear and fuel costs.	**Verified Data Deficit:** Difficulty in accessing real-time operational figures from municipal departments (fleet age, exact bin locations).
Existing Digital Foundation: The "anakyklosi anThess" app provides a ready-to-use platform for citizen engagement.	**Low Source Separation:** High volumes of organic waste (570 t/day in Thessaloniki) are still predominantly managed as mixed waste.
Specialized Adaptation: Thermaikos’ partnerships for marine waste management demonstrate high local responsiveness.	**Operational High Costs:** Lagada’s vast 1,220 sq km territory creates extreme logistics costs for traditional collection methods.

OPPORTUNITIES	THREATS
Funding for Digital Shift: EU and National funding (ESPA) is available for "Smart City" waste infrastructure and Green Points.	**Landfill Tax (Law 4819/2021):** Immediate financial risk to municipal budgets if recycling rates do not increase rapidly.
Infrastructure Upgrades: The planned installation of 75 underground bins and 2,232 new units offers a perfect pilot for sensors.	**Seasonal Peak Volatility:** Rapid surges in bulky and general waste during summer (Thermaikos) threaten to overwhelm services.
Agro-Waste Innovation: Potential to reduce mileage in rural zones (Lagada) by up to 20% through sensor-based collection.	**Environmental Impact:** Marine plastic pollution (75% of waste in the bay) directly threatens the local blue economy.

6.3 Strategic Proposals

The strategic proposals presented below are based on the comparative findings of this report and are intended to support practical, phased improvement in municipal waste management across the three selected municipalities. In accordance with the WISE-WASTE methodology, the emphasis is placed on realistic interventions that strengthen operational efficiency, improve data quality, and support the gradual integration of smart technologies into local waste management systems.

The proposals are structured around three complementary priorities: improving data and transparency, increasing efficiency through technological tools, and strengthening governance and citizen engagement. Although the three municipalities differ significantly in scale, geography, and operational conditions, these strategic directions provide a common framework within which each municipality can pursue tailored actions.

a. Addressing the Data and Transparency Gap

- ***Thessaloniki:*** *Digital audit of the 2,232 new containers and the implementation of* ***GPS Telematics*** *for the 75 active collection routes. This will provide the necessary baseline data that is currently missing from municipal records.*
- ***Thermaikos:*** *Manage the rising volume of service calls, we suggest transitioning to a* ***Digital Ticketing Platform*** *for bulky waste. This will replace manual scheduling and allow for better coordination of specialized vehicles.*

- ***Lagada:*** *Creation of a* ***GIS-based Registry*** *for all collection points. This is essential for mapping the vast 1,220 sq. km territory and identifying "blind spots" in the rural waste collection network.*

One of the most consistent findings of the report is the uneven availability, quality, and comparability of waste management data across the three municipalities. In several cases, the absence of consolidated and up-to-date information on waste flows, collection assets, route coverage, or separate collection performance limits the ability of local authorities to assess needs accurately and to plan targeted interventions.

For this reason, the first strategic priority should be the strengthening of data governance. Municipalities should work toward standardized recording of waste quantities, collection frequencies, infrastructure inventories, and stream-specific performance indicators. This is particularly important not only for local planning, but also for the preparation of comparable outputs within the wider Black Sea basin project framework.

A practical first step would be the development of common municipal templates for the recording of annual waste generation, per capita production, separate collection quantities, infrastructure assets, and service coverage. The use of harmonized formats would reduce uncertainty, improve transparency, and support more reliable comparison between municipalities and across reporting periods.

In Thessaloniki, this priority relates primarily to the consolidation of data on bins, routes, vehicles, and stream-specific collection performance. In Thermaikos, it concerns the systematic recording of seasonal variation and service demand. In Lagadas, it is especially relevant to the mapping of collection points, service distances, and territorial coverage patterns.

A stronger data framework would also improve accountability. When municipalities and service operators work with clearer and more consistent information, it becomes easier to define responsibilities, monitor outcomes, and evaluate whether public resources are being used efficiently.

b. Enhancing Efficiency through Technological Solutions

- ***Thessaloniki****: Installing* ***ultrasound fill-level sensors*** *in the 75 new underground bins. This would allow the city to move away from rigid collection schedules and respond only when bins are actually full.*
- ***Thermaikos****: Use, during peak tourist months of sensored* ***Seasonal Bins*** *in coastal areas. These sensors can provide real-time alerts to prevent bin overflows during high-traffic periods.*
- ***Lagada (Agro-Waste Management)****: Establishment of* ***Smart Agricultural Waste Collection Points****. These points would use sensors to monitor the disposal of specific agro-waste (e.g., fertilizer packaging, pesticide containers, and greenhouse plastics). Combined with sensors in remote villages, this*

technology can signal when these specialized containers need emptying, preventing hazardous agricultural waste from being dumped in fields or streams.

The second strategic priority is the use of technology to improve operational efficiency and service responsiveness. The report does not suggest that technology should replace existing municipal systems; rather, it should strengthen them by making collection, monitoring, and planning more adaptive and evidence-based.

The most suitable technologies for the municipalities examined in this study include GPS vehicle tracking, route optimization tools, digital asset registries, fill-level sensors for selected containers, and integrated dashboards for service monitoring. These solutions are relevant because they can reduce unnecessary collection trips, improve route planning, support faster response to local problems, and generate better operational records for future planning.

For Thessaloniki, the recommended technological emphasis is on digital control of a large and already active urban waste system. GPS telematics, smart monitoring of high-demand collection points, and a centralized operational dashboard would support more efficient management of routes and municipal assets. Given the city's scale, even modest improvements in route efficiency or bin servicing could result in meaningful operational benefits.

For Thermaikos, technological solutions should be designed primarily around seasonal pressure and flexible service adaptation. Fill-level sensors in coastal and tourism-intensive areas, digital request systems for bulky waste collection, and route management tools for peak periods would improve the municipality's ability to respond to fluctuating service demand.

For Lagadas, the strongest efficiency gains are likely to come from technologies that support territorial management. GIS-based planning tools, route optimization systems, and targeted monitoring of remote collection points could significantly improve service efficiency across a dispersed and geographically extensive area.

In all three cases, technology should be introduced in a phased and practical manner. Pilot actions are preferable to large-scale investments at the initial stage, because they allow municipalities to test functionality, assess costs, build internal capacity, and adapt solutions to real local conditions before wider deployment.

c. Optimizing Governance and Citizen Engagement

- **Thessaloniki & Thermaikos:** Upgrading citizen-facing tools (like the *anakyklosi anThess* app) to include a **"Report-to-Route" feature**. This would allow citizens to report issues directly to the waste management dashboard for quicker action.
- **Lagada:** Adoption of **Dynamic Route Optimization**. By analyzing sensor data from both residential and agricultural collection points,

the municipality can redesign truck routes daily, saving fuel and drastically reducing the carbon footprint of rural collection.

- **Policy Suggestion:** Smart Technology Indicators **(KPIs)** be included in future service agreements with waste operators, ensuring that data-driven management becomes a standard, sustainable practice for the entire region.

The third strategic priority concerns the institutional and social conditions required for long-term improvement. Waste management performance does not depend only on infrastructure and technology; it also depends on governance quality, inter-institutional coordination, clarity of responsibilities, and the active participation of citizens and local stakeholders.

At institutional level, municipalities would benefit from stronger coordination between technical departments, waste operators, regional authorities, and other relevant stakeholders. Clearer contractual requirements, including reporting obligations and measurable key performance indicators, would help ensure that service delivery is linked to verifiable outcomes and not only to routine operational practice.

Governance improvement should also include attention to implementation continuity. Smart waste management initiatives often require sustained monitoring, staff training, and medium-term investment. For this reason, municipalities should avoid treating technology adoption as a stand-alone procurement exercise and should instead integrate it into broader planning, budgeting, and performance review processes.

Citizen engagement is equally important. The findings of the report, together with the methodological guidance of the project, indicate that public participation should be treated as a structural component of smart waste management rather than as a secondary communication issue. This includes informing residents about available systems, making participation simple and accessible, and ensuring that digital tools are designed around real user needs.

Effective engagement requires more than one-time awareness campaigns. Municipalities should combine clear communication, practical education, and user-friendly service design in order to support continued participation over time. In practical terms, this may include simple instructions on source separation, visible information on recycling points, school-based awareness activities, targeted local campaigns, and digital reporting tools that provide residents with a direct and meaningful interface with municipal services.

Long-term use of smart systems also depends on trust and usability. If citizens are encouraged to use digital applications or reporting platforms, these tools should be easy to navigate, clearly relevant to daily needs, and visibly connected to actual municipal response. Otherwise, adoption may be limited or short-lived, regardless of the technical quality of the system itself.

Different municipalities may apply this principle in different ways. In Thessaloniki, engagement can support urban participation at scale through reporting tools and better recycling information. In Thermaikos, it can be linked to seasonal visitors, local businesses, and coastal users. In Lagadas, it may depend more on local community networks and practical communication adapted to dispersed settlements.

Overall, governance reform and citizen engagement are essential to the success of the other strategic priorities. Better data and smarter tools can improve performance, but lasting results depend on whether municipalities are institutionally prepared to use them effectively and whether citizens are willing and able to participate in the systems being developed.

The strategic priorities should be treated as phased actions rather than fixed projects. The short-term focus is data standardization and small pilots, the medium-term focus is operational digitalization, and the long-term focus is governance, continuity, and citizen participation.

Implementation orientation

Taken together, the three strategic priorities suggest a phased implementation pathway. In the short term, municipalities should improve data recording and identify a limited number of practical pilot actions. In the medium term, they should expand the use of digital monitoring and route management tools. In the longer term, the focus should shift toward institutional consolidation, stronger contractual frameworks, and more mature forms of public participation and inter-municipal learning.

This phased approach is particularly suitable for the three municipalities examined in this study because it allows each of them to proceed according to its own operational context while still contributing to the common objectives of the WISE-WASTE project. In this way, the strategic proposals support both local relevance and cross-project comparability.

Closing

This report examined waste management practices in three municipalities of Central Macedonia - Thessaloniki, Thermaikos, and Lagadas—within the framework of the WISE-WASTE project. Drawing on available official data, municipal information, regional statistics, and qualitative assessment, the report identified common structural challenges as well as municipality-specific operational needs.

A central finding of the analysis is that all three municipalities face constraints in data consistency, reporting completeness, and real-time operational visibility. Although the quantity and quality of available data vary by municipality, the overall evidence is sufficient to support a clear comparative assessment and to identify practical directions for improvement.

The findings also confirm that the three municipalities differ significantly in their waste management profiles. Thessaloniki is characterized by high waste volumes and relatively developed infrastructure, Thermaikos by strong seasonal variation and coastal service pressure, and Lagadas by territorial scale and logistical complexity. These differences imply that future interventions should be tailored to local conditions rather than designed as uniform measures across all cases.

At the same time, several cross-cutting needs emerge clearly from the report. These include improved source separation, stronger monitoring of waste flows, better integration of digital tools into daily operations, and more structured forms of citizen and stakeholder engagement. In this respect, the study supports the broader WISE-WASTE objective of linking technological modernization with practical and locally grounded management improvements.

The first and most immediate priority is to strengthen data governance through standardized recording of waste quantities, collection frequencies, infrastructure inventories, and stream-specific performance indicators, so that municipal reporting becomes more comparable and more useful for planning.

The overall conclusion of the report is that the three municipalities are starting from different operational realities, but all have a clear need to move toward more data-informed, adaptive, and technology-supported waste management systems. The recommended actions are intended to be practical, scalable, and compatible with both local priorities and the broader objectives of the WISE-WASTE project.

The report therefore supports a differentiated strategy: digital consolidation for Thessaloniki, seasonal responsiveness for Thermaikos, and territorial optimization for Lagadas. Taken together, these priorities provide a realistic basis for future pilot actions, improved governance, and stronger regional comparability in the next stages of project implementation.

Public resistance to waste separation, seasonal fluctuations in waste generation, and the use of targeted tools such as fill-level sensors and fleet telematics highlight the need for solutions that are both technical and behavioral in nature. Public engagement through awareness campaigns and incentives for recycling participation, together with collaboration among regional stakeholders, will be essential for long-term uptake.

Overall, the report establishes a useful baseline for the next stages of the WISE WASTE project and supports the identification of realistic priorities for more efficient, data-informed, and locally adapted waste management systems. This approach is consistent with the methodology's practical orientation and with the broader objective of strengthening municipal waste management capacity across the project area.

Sources

1. **Official Reports & Statistical Data**

Fo.D.S.A. Central Macedonia (2025). Annual Report on Municipal Solid Waste (MSW) Generation Quantities for 2024. Regional Association of Solid Waste Management Agencies for Central Macedonia. [Online] Available at: https://fodsakm.gr/wp-content/uploads/2025/08/2025.06.24_ANA_%CE%95%CF%84%CE%AE%CF%83%CE%B9%CE%B1-%CE%91%CE%BD%CE%B1%CF%86%CE%BF%CF%81%CE%AC-%CE%A0%CE%BF%CF%83%CE%BF%CF%84%CE%AE%CF%84%CF%89%CE%BD-%CE%A0%CE%B1%CF%81%CE%B1%CE%B3%CF%89%CE%B3%CE%AE%CF%82-%CE%91%CE%A3%CE%91-2024-1.pdf [Accessed: 17.03.2026].

Fo.D.S.A. Central Macedonia (2025). Total Quantities of MSW Management - 2024 Analysis. [Online] Available at: https://fodsakm.gr/wp-content/uploads/2025/08/2025.06.02_ANA_Report-%CE%A3%CF%85%CE%BD%CE%BF%CE%BB%CE%B9%CE%BA%CE%AD%CF%82-%CE%A0%CE%BF%CF%83%CF%8C%CF%84%CE%B7%CF%84%CE%B5%CF%82-%CE%94%CE%B9%CE%B1%CF%87%CE%B5%CE%AF%CF%81%CE%B9%CF%83%CE%B7%CF%82-%CE%91%CE%A3%CE%91-2024.pdf [Accessed: 17.03.2026].

Hellenic Statistical Authority (ELSTAT) (2021). Permanent Population Census Results for the Municipalities of Thessaloniki, Thermaikos, and Lagadas. Athens: ELSTAT.
Municipality of Thessaloniki (2020). Sea quality monitoring and surveying in Thessaloniki Bay: Marine Litter Report. [Online] Available at: https://opendata.thessaloniki.gr/sites/default/files/REPORT_2020_trash.pdf [Accessed: 17.03.2026].

Google Maps (2026). Geospatial Data and Map Extracts for Central Macedonia, Thessaloniki Regional Unit, and target Municipalities. [Accessed: 23.03.2026].

Kaza, S., Bhada-Tata, P., et al. (2026). What a Waste 3.0: A Global Snapshot of Solid Waste Management toward Circularity until 2050. Washington, DC: World Bank Group. [Online] Available at: https://hdl.handle.net/10986/44141 [Accessed: 17.03.2026].

ANTIGONE (2021). Zero Waste Strategy: Methods and Implementation in Black Sea Basin (ZeroWasteBSB) – Waste Characterization Research in Target Areas (Part A & B). Joint Operational Programme Black Sea Basin 2014-2020. [Online] Available at: https://www.antigone.gr/wp-content/uploads/Projects/ZeroWaste/gr/DT-1.1.1-ZW-MANAGEMENT-GUIDE-PART-A-GR.pdf and https://www.antigone.gr/wp-content/uploads/Projects/ZeroWaste/gr/D-T-1.1.1-ZW-MANAGEMENT-GUIDE-PART-B-GR.pdf [Accessed: 17.03.2026].

HERRCO (2024). Annual Report 2023: 22 Years of Contribution to Sustainability and Circular Economy. Athens: Hellenic Recovery Recycling Corporation. [Online] Available at: https://www.herrco.gr/ [Accessed: 17.03.2026].

HERRCO (2025). Annual Report 2024: Results and Actions of the Blue Bin and Blue Glass Bell Systems. Athens: Hellenic Recovery Recycling Corporation. [Online] Available at: https://www.herrco.gr/ [Accessed: 17.03.2026].

European Environment Agency (EEA) (2025). Waste Prevention Country Profile: Greece. Copenhagen: EEA. [Online] Available at: https://www.eea.europa.eu/en/topics/in-depth/waste-and-recycling/country-profiles-on-waste-prevention-2025/gr-waste-prevention-factsheet-final.pdf/@@download/file [Accessed: 17.03.2026].

Regional Association of Solid Waste Management Agencies of Central Macedonia (2021). Regional Waste Management Plan (PESDA) Guide for the Region of Central Macedonia: Directions for Medium-to-Long-term Planning 2020-2030. Thessaloniki: Ministry of Environment and Energy / General Secretariat for Waste Management Coordination. [Online] Available at: https://diktiofodsa.gr/wp-content/uploads/2021/12/%CE%9F%CE%B4%CE%B7%CE%B3%CF%8C%CF%82-%CE%A0%CE%95%CE%A3%CE%94%CE%91-%CE%A0%CE%B5%CF%81%CE%B9%CF%86%CE%AD%CF%81%CE%B5%CE%B9%CE%B1%CF%82-%CE%9A%CE%B5%CE%BD%CF%84%CF%81%CE%B9%CE%BA%CE%AE%CF%82-%CE%9C%CE%B1%CE%BA%CE%B5%CE%B4%CE%BF%CE%BD%CE%AF%CE%B1%CF%82.pdf [Accessed: 17.03.2026].

2. Regulatory References

Circular Greece (n.d.). Institutional Profile and Circular Economy Compliance: Municipality of Thessaloniki. [Online] Available at: https://circulargreece.gr/ [Accessed: 17.03.2026].

Cabinet Act 39/31.08.2020 (Government Gazette A' 185/29.09.2020). Approval of the National Waste Management Plan (NWMP/ESDA) 2020-2030. Athens: Hellenic Republic, Cabinet of Ministers. [Online] Available at: https://ypen.gov.gr/wp-content/uploads/2021/02/%CE%B5%CE%B3%CE%BA%CF%81%CE%B9%CF%83%CE%B7-%CE%95%CE%A3%CE%94%CE%91.pdf [Accessed: 17.03.2026].

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Waste Framework Directive - Consolidated version 2024).

Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste.

Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (Single-Use Plastics Directive).

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste.

Regulation (EU) 2024/1157 of the European Parliament and of the Council of 11 April 2024 on shipments of waste.

Regulation (EU) 2025/40 of the European Parliament and of the Council of 19 December 2024 on packaging and packaging waste.

Law 4819/2021 (Government Gazette A' 129). Integrated framework for waste management – Transposition of Directives 2018/851 and 2018/852.

European Commission (2024). EU Construction & Demolition Waste Management Protocol: Including Guidelines for Pre-demolition and Pre-renovation Audits of Construction Works (Updated Edition). Brussels: Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs.

European Commission (2016). EU Construction and Demolition Waste Management Protocol (Greek Edition: Πρωτόκολλο της ΕΕ για τη διαχείριση των αποβλήτων κατασκευών και κατεδαφίσεων).

3. Municipal Authorities & Infrastructure

Municipality of Thessaloniki (n.d.). Department of Cleaning and Mechanical Equipment: Official Portal for Infrastructure and Waste Collection Fleet. [Online] Available at: https://thessaloniki.gr/%CE%B8%CE%AD%CE%BB%CF%89-%CE%B1%CF%80%CF%8C-%CE%B1%CF%80%CE%BF%CF%84%CE%BF%CE%BD-%CE%B4%CE%AE%CE%BC%CE%BF/%CE%BF-%CE%94%CE%AE%CE%BC%CE%BF%CF%82/%CE%B3%CE%B5%CE%BD%CE%B9%CE%BA%CE%AE-%CE%B4%CE%B9%CE%B5%CF%8D%CE%B8%CF%85%CE%BD%CF%83%CE%B7/diefthinsi-kathariotitas-kai-mixanikon-meson/ [Accessed: 22.03.2026].

Municipality of Thessaloniki (n.d.). Municipal Cartography Service: GIS Mapping of Waste Infrastructure. [Online] Available at: https://maps.thessaloniki.gr/public/ [Accessed: 22.03.2026].

Municipality of Thermaikos (2025). The Cleaning Service in Numbers for 2025: Municipal Performance Report. [Online] Available at: https://www.thermaikos.gr/i-ypiresia-kathariotitas-tou-dimou-thermaikou-se-arithmous-gia-to-2025/ [Accessed: 22.03.2026].

Municipality of Thermaikos (n.d.). Announcements / Official Updates. [Online] Available at: https://www.thermaikos.gr/category/anakoinoseis/ [Accessed: 22.03.2026].

Municipality of Lagadas (n.d.). Official portal and waste/recycling information pages. [Use the local municipal URL you cited in the draft] [Accessed: 22.03.2026].

4. Smart Solutions & Technology Apps

Anakyklosi AnThess (n.d.). Mobile Application for Recycling Services in Eastern Thessaloniki & Thermaikos. [Online] Available at: https://www.anakyklosianthess.gr/ [Accessed: 17.03.2026].

SmartIsCity (n.d.). Smart City Applications and Waste Management Digital Tools for the Municipality of Thermaikos. [Online] Available at: https://www.smartiscity.gr/en/dimos-thermaikos/ [Accessed: 17.03.2026].

Blue Cycle (n.d.). Environmental Solutions: Mussel Farming Waste Management in the Thermaikos Gulf. [Online] Available at: https://bluecycle.com/en/ [Accessed: 17.03.2026].

5. Press & Media Reports

ERT News (2025). Thessaloniki: Record Collection of Bulky Items for the Municipality – Over 10,000 Tons Since the Start of 2025. [Online] Available at: https://www.ertnews.gr/ert3/thessaloniki-rekor-syllogis-ogkodon-gia-ton-dimo-thessalonikis-mazeytikan-pano-apo-10-000-tonoi-apo-tin-arxi-tou-2025/ [Accessed: 17.03.2026].

Intergeo (2022). Cleaning and Garbage Removal from the Seabed of Thermaikos Gulf. [Online] Available at: https://intergeo.gr/en/2022/03/31/cleaning-and-garbage-removal-from-the-seabed-of-thermaikos-gulf/ [Accessed: 17.03.2026].

BSB Zero Waste (2022). Thessaloniki: Thermaikos Hid 40 Tons of Tires. [Online] Available at: https://bsbzerowaste.eu/2022/04/11/thessaloniki-thermaikos-hid-40-tons-of-tires-the-cleaning-left-everyone-speechless/ [Accessed: 17.03.2026].

eThermaikos (2025). Pressroom / News Archive. [Online] Available at: https://ethermaikos.gr/author/pressroom/ [Accessed: 17.03.2026].

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WISE WASTE

Individual Report — Waste Management Comparative Analysis

Region: Burgas / Nessebar



Project: "Collaboration for smart solutions for waste management and pollution reduction in urban, rural, and coastal areas of the Black Sea basin -WISE-WASTE"

Study period: 2023–2025

Prepared by: Municipality of Nessebar/PP4

2026

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The report evaluates the municipal solid waste management system in Nessebar Municipality and the city of Burgas (2023–2025). Main findings: a mixed collection model with strong seasonal peaks, lack of local MRF/MBT (Material Recovery Facility / Mechanical Biological Treatment), limited digital monitoring, and a low rate of source-separated collection in tourist areas. Priorities: Priority A — sensor pilot and full-fleet GPS; Priority B — municipal mobile application and seasonal optimization; Priority C — regional partnership for MRF and digital procurement capacity.

Objective: To describe the current state, identify gaps, and propose priority measures for the introduction of smart technologies.

Scope: Nessebar Municipality + the city of Burgas, period 2023–2025.

Methodology: Analysis of public registries, operator reports, spot composition surveys, employee interviews, and regulatory framework review; SWOT focus on smart integration.

Regional Profile: Burgas & Nessebar (2023–2025)

Nessebar: Municipal Overview and Demographics

Nessebar Municipality serves as the primary engine for mass tourism on the Bulgarian Black Sea coast. The permanent population of the municipality stands at approximately **29,000 residents**, with the town of Nessebar proper hosting around **17,400 permanent inhabitants**. However, due to its status as Europe's densest resort hub, the influx of visitors causes the seasonal population to expand exponentially. During the peak summer window from **May to September**, the daily active population routinely scales past **250,000 individuals**, heavily concentrating waste generation inside tight coastal zones.

The region's unique waste footprint is anchored by two contrasting realities:

- **The Historic Peninsula (Old Town)**: A compact UNESCO World Heritage site characterized by ancient 3,000-year-old cobblestone streets, museum-churches, and high-density pedestrian traffic. Space limitations here strictly prevent the deployment of standard, large-scale waste infrastructure.
- **The Modern Resort Infrastructure**: Expansive modern holiday networks stretching across the mainland, prominently featuring **Sunny Beach**, Ravda, and Sveti Vlas. This layout requires extensive, high-volume seasonal collection logistics to manage commercial packaging and organic fractions.

Burgas: Urban Center and Year-Round Functionality

In contrast to the highly seasonal dynamics of Nessebar, the **City of Burgas** operates as a major administrative, industrial, and economic core with a stable, year-round population of over **200,000 citizens**. While Burgas functions as a steady baseload zone for municipal solid waste throughout the winter months, it experiences its own significant **summer tourism spikes**.

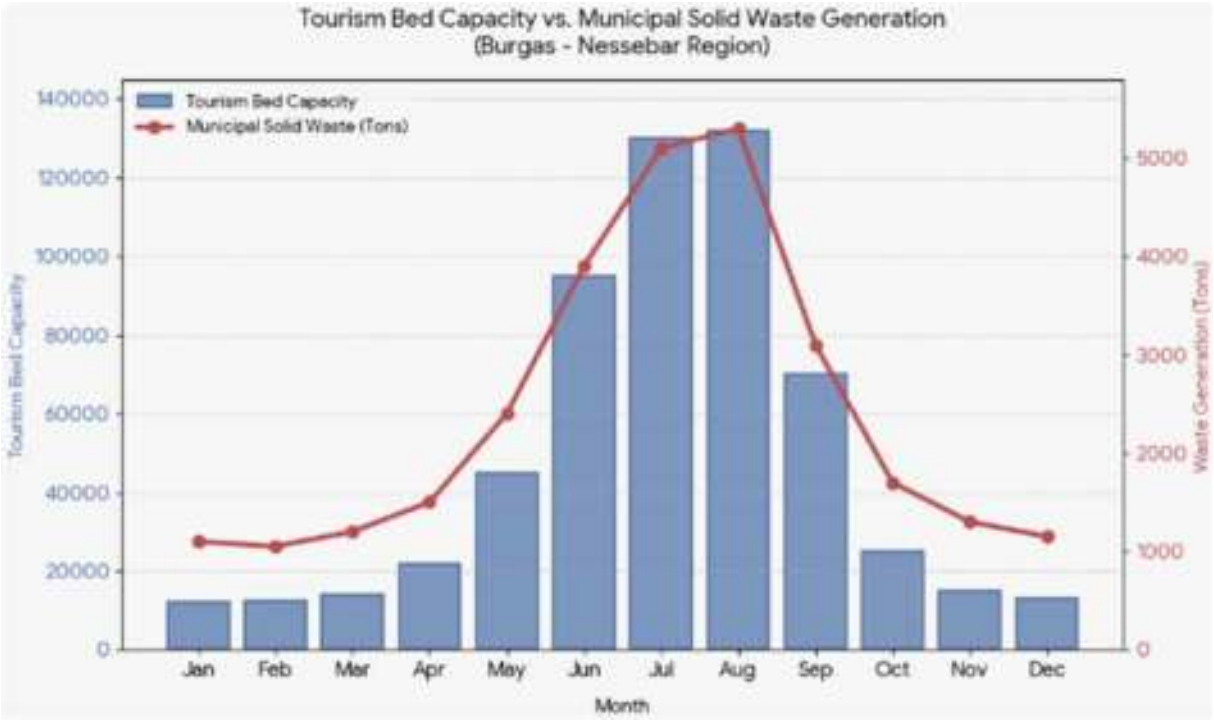
Between June and August, visitor traffic surges via Burgas International Airport (BOJ) and local cruise networks. This seasonal influx expands the city's waste generation profile, specifically concentrated around major urban landmarks:

- **The Sea Garden (Morska Gradina)**: A sprawling coastal park spanning several kilometers along the urban beach line, drawing tens of thousands of daily visitors during summer.
- **Central Commercial Pedestrian Zones**: High-traffic areas (Aleko Bogoridi and Aleksandrovska streets) hosting dense concentrations of retail, hospitality, and dining venues.

Figure: Tourism Capacity Profile (Bed-Places by Month)

The table below represents the sharp variance in regional operational capacity. Total available beds within registered commercial infrastructure and shared-economy platforms scale up rapidly to meet summer demand, driving the corresponding peak waste generation curves.

Indicator / Metric	Off-Season Baseline (Oct–Apr)	Shoulder Season (May & Sept)	Peak Summer Window (Jun–Aug)
Nessebar Municipality Bed Capacity	~15,000 beds	~95,000 beds	**~250,000+ beds**
Burgas Municipality Bed Capacity	~4,500 beds	~6,500 beds	**~12,000+ beds**
Estimated Waste Generation Impact	Stable urban baseload	Gradual ramp-up	**3x to 5x surge vs winter**
Primary Waste Composition Drivers	Domestic organics / ashes	Commercial packaging	**Single-use plastics / food waste**



Institutional and Regulatory Framework

The governance of municipal solid waste (MSW) in the Burgas and Nessebar regions operates within a multi-tiered legal framework, strictly aligned with European Union directives and Bulgarian national legislation. This section outlines the regulatory boundaries, key stakeholders, and the specific contractual mechanisms driving waste operations.

Regulatory Alignment and Compliance

The foundational architecture of the regional waste management strategy is dictated by the **EU Waste Framework Directive (Directive 2008/98/EC)**, which enforces the waste hierarchy principles: prevention, reuse, recycling, recovery, and disposal. At the national level, operations are governed by the **Bulgarian Waste Management Act (ZUP)**.

Both municipalities operate under mandatory national targets for 2025–2030, which require:

- A minimum of **55% recycling rate** by weight for municipal waste.
- A strict **10% limit on landfilling** of total municipal waste by 2035.
- Mandatory separate collection of bio-waste and hazardous domestic waste streams.

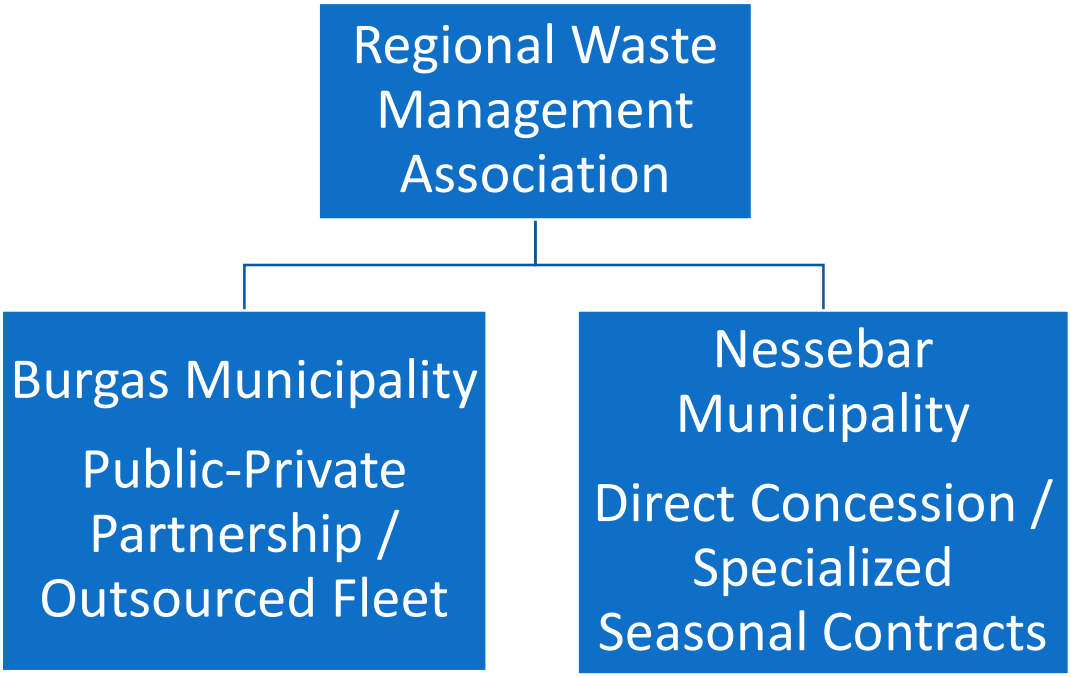
Key Stakeholders and Governance Roles

The institutional matrix requires seamless coordination between public authorities and private operators:

- **Ministry of Environment and Water (MoEW) & RIEW-Burgas**: The Regional Inspectorate of Environment and Water (RIEW) acts as the regional regulatory enforcement body. It monitors compliance, issues operational permits, and audits landfill volumes and eco-tax indices.
- **Burgas Regional Waste Management Association (BSRE)**: A critical regional institutional vehicle. Since Nessebar and Burgas share regional infrastructure, the association coordinates inter-municipal logistics, sets regional disposal quotas, and manages joint EU-funded infrastructure applications.
- **Municipal Administrations (Burgas & Nessebar)**: The Mayors and Municipal Councils hold ultimate legal responsibility for organizing local collection, transport, and treatment. They draft local ordinances, set the local "Waste Tax" (*Такса битови отпадъци*), and manage public procurement procedures for waste services.

Current Service Delivery and Procurement Models

The operational models of the two municipalities present contrasting institutional approaches to service delivery:



- **Burgas Municipality**: Utilizes a mixed-service model. Collection and transportation are largely outsourced to private concessionaires via long-term, performance-based public procurement contracts. The municipality maintains an internal control unit to audit service level agreements (SLAs).
- **Nessebar Municipality**: Operates through a dedicated framework tailored for extreme seasonal variance. Due to the rapid scaling of commercial waste from hotels and resorts, procurement contracts include highly flexible clauses. These allow for a **3x to 5x escalation** in collection frequency and personnel deployment during the peak summer months (May–September).

Current Analysis of the Waste Management System

3.1 Collection Model

The region operates a **mixed collection model,** presenting stark operational contrasts between standard urban baseloads and high-density tourist areas.

- **Nessebar Municipality**: The collection matrix relies heavily on a dual-stream approach (commingled residual waste vs. limited packaging source-separation). In tourist areas, the system faces severe logistical pressure during the summer peak. The presence of international hotel complexes and heavy restaurant density shifts the waste composition toward high moisture levels (organic food waste) and high volume-to-weight ratios (packaging). Source separation in hotels remains critically low due to rapid staff turnover and inadequate space for multi-bin storage.
- **Burgas Municipality**: Features a highly integrated urban collection model, utilizing specialized containers in residential quarters alongside a structured network for household hazardous waste and bulky items. While year-round residential zones show steady, predictable generation curves, the coastal strip (Sea Garden and tourist-heavy pedestrian zones) requires rapid service adjustment during summer.

3.2 Infrastructure and Fleet

The technical infrastructure across both territories is diverse, featuring modern sub-surface systems alongside standard collection assets.

- **Container Infrastructure**: The bin inventory is categorized into three distinct operational tiers:
    - **Standard Containers**: Widespread deployment of traditional 1.1 m³ plastic and galvanized steel bins (standard "Bobber" and "Hook" types).
    - **Underground Containers**: Strategically implemented in the central urban zones of Burgas and the historic/dense parts of Nessebar. This represents a **key best practice** for the region; these systems successfully prevent waste scattering caused by high winds and seagulls, while drastically reducing odor pollution during the hot summer months.
    - **Individual Household Bins**: Smaller 120-liter and 240-liter individual bins allocated strictly to low-rise residential areas and suburban quarters.
- **Logistical Fleet**: The logistics network utilizes specialized waste collection vehicles (rear-loaders and automated side-loaders). While vehicles are technically robust, route efficiency is heavily compromised. In Nessebar, severe summer traffic congestion and restricted access in

historic pedestrian zones significantly prolong cycle times, increasing fuel consumption and carbon footprint per collected ton.



3.3 Transfer, Treatment, and Recycling

The regional treatment architecture relies on centralized infrastructure to mitigate the high costs of long-distance waste logistics.

- **Nessebar Transfer Station**: To optimize the long-distance transport loop, Nessebar operates a dedicated municipal transfer station. This facility **compresses the collected residual waste** prior to long-haul transport. This operational step significantly lowers municipal transport expenditures and curtails overall greenhouse gas emissions.



Figure 3.3a: Nessebar Transfer Station

- **Centralized Treatment at "Bratovo - West" Regional Landfill**: All compressed and bulk regional waste is hauled to the modern "Bratovo - West" Regional Landfill facility. This centralized infrastructure serves the entire region and is equipped with:
    - **Engineered Landfill Cells**: Designed for safe, compliant final disposal of non-recyclable fractions.



Figure 3.3b: Bratovo - West Regional Landfill

- **Sorting Installation (Separation Plant)**: An automated and manual recovery line tasked with extracting valuable recyclable materials from the incoming mixed waste stream.
- **Composting Facility**: A specialized open-air or semi-enclosed infrastructure dedicated to processing source-separated green and biodegradable waste into organic compost.



Figure 3.3c: Modern anaerobic digestion facility in Burgas for biodegradable waste treatment

3.4 Operational Practices and Digital Tools

The digital maturity of the waste management ecosystem is currently in its early stages, characterized by passive tracking rather than active, data-driven optimization.

- **Fleet Tracking**: The collection fleet across both municipalities is fully equipped with basic GPS tracking devices. However, this data is used exclusively for retroactive auditing (e.g., verifying if a truck completed its route or checking total mileage) rather than dynamic, real-time dispatching.
- **Lack of Smart Integration**: There is a total absence of Internet of Things (IoT) ultrasonic fill-level sensors inside the containers. Route planning remains entirely static, relying on historic seasonal estimations rather than automated, demand-responsive scheduling.

3.5 Data Quality

The analytical value of current operational data is low, creating a weak foundation for long-term strategic investments.

- **Data Fragmentation**: Waste generation metrics are heavily siloed. Data points from weighbridges at the landfill or transfer stations are collected independently from fleet GPS logs, making it impossible to perform automated, cross-variable analysis (such as calculating the exact waste weight collected per kilometer for specific routes).
- **Reporting Lags**: Operational dashboards do not exist. Data regarding container fill-rates, seasonal composition variations, and operator performance indexes are compiled manually with significant time lags. This lack of clear data prevents municipal leadership from making immediate, proactive interventions during the critical summer weeks.

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4. Quantitative Analysis (2023–2025)

This section provides a data-driven evaluation of waste generation metrics, seasonal variance multipliers, and infrastructure utilization rates across the Burgas-Nessebar regional ecosystem.

4.1 Municipal Solid Waste (MSW) Generation Baselines

The total consolidated municipal solid waste volume within the managed asset perimeter displays a steady structural urban baseline that undergoes extreme distortion driven by the international tourism sector along the coastal strip.

- **Consolidated Annual Mass**: The combined annual waste generation generated within both municipal borders averages between **115,000 and 120,000 tons**.

- **Structural Distribution Breakdown**:
    - **Burgas Municipality** operates as a stable, year-round macroeconomic baseline. It generates approximately **75,000 to 80,000 tons per annum** of municipal waste, anchored by its large permanent urban population.
    - **Nessebar Municipality** contributes a highly volatile annual volume of approximately **38,000 to 42,000 tons**. However, this total volume is uniquely compressed into an intensive, high-velocity operational window of less than five calendar months.

4.2 The Seasonal Variance Multiplier (The "Summer Spike")

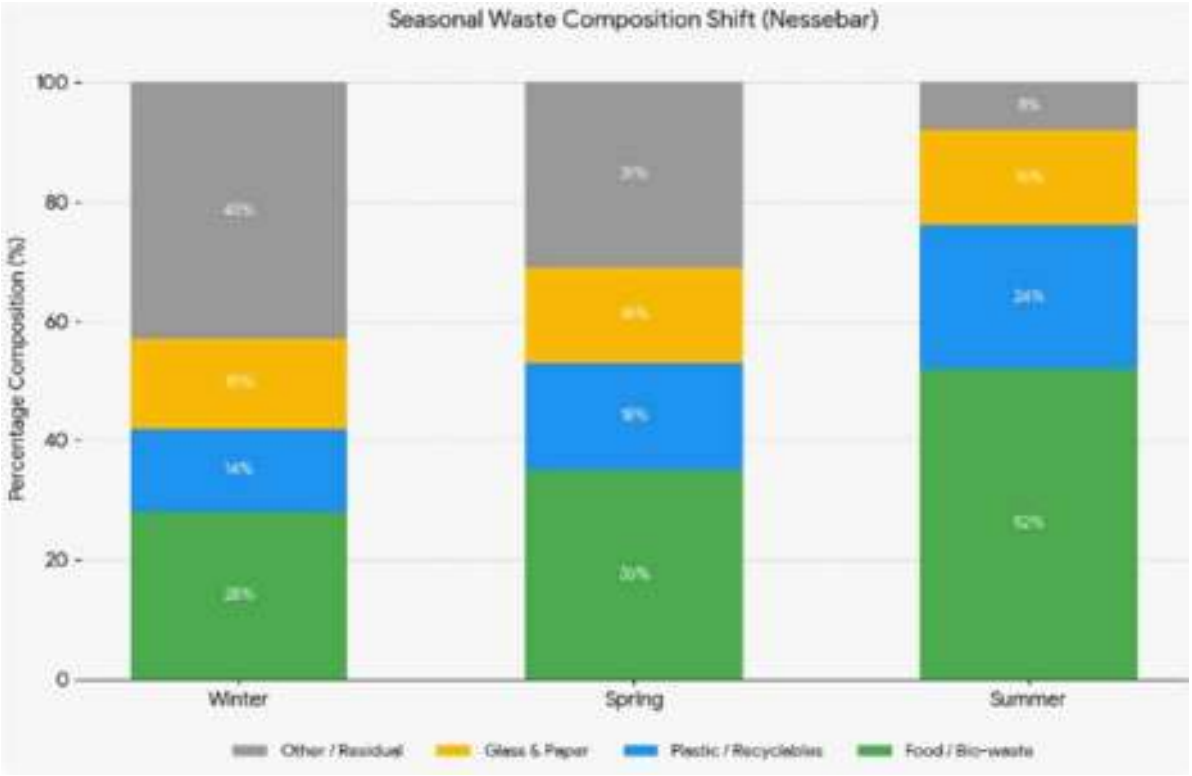
Quantifying the mathematical variance between the winter baseline and peak summer waste patterns highlights the core operational bottleneck of the regional logistics fleet.

❄ WINTER BASELINE INDEX (Predictable Low Season)	🔥 SUMMER PEAK INDEX (Extreme High Season)
• **Daily Generation:** ~170 Tons / Day • **Fleet Workload:** Underutilized capacity (38%–44% vehicle optimization). • **Route Dynamics:** Stable, long cycles with calendar-based scheduling.	• **Daily Generation:** ~750 Tons / Day • **Fleet Workload:** Overloaded capacity (32% container overflows). • **Route Dynamics:** Severe traffic delays and intensive high-frequency routing.
System Status: Stable urban baseload	**Volumetric Shock: 4.4x Volumetric Surge**

- **The Regional Volumetric Surge**: During the off-season winter baseline period (November to March), the combined daily waste collection across both administrative territories ranges from **160 to 180 tons per day**. During the peak summer tourism window (July and August), this daily metric surges to a massive **720 to 780 tons per day**, requiring continuous fleet deployment.
- **The Nessebar Local Tourism Multiplier**: In Nessebar proper, the variance is even more extreme. The off-season winter baseline drops to a minimal **35 tons per day**. In July and August, the sudden arrival of over 250,000 concurrent temporary residents and tourists causes daily waste volumes to skyrocket past **240 tons per day**. This represents a severe **6.8x seasonal multiplier** that overwhelms static, traditional container collection networks.

4.3 Seasonal Waste Composition and Morphological Characterization

Based on the field data compiled from **Seasonal Spot Composition Surveys in Nessebar Municipality (2023–2025)**, the physical profile and material properties of the waste stream undergo radical changes between the off-season and peak-season windows:



A. Winter Baseline Profile (Off-Season Analytics)

During the winter calendar months, the physical waste matrix reflects standard domestic residential habits:

- **Organic Fraction (Food and Yard Waste)**: Stabilizes at approximately **26% to 28%** of the total mass.
- **Recyclable Packaging Fractions**: Combined plastics, commercial paper, cardboard, and glass account for an estimated **29%** of the waste stream.
- **Inert and Residual Mass**: Displays high volume-to-weight metrics due to the persistent presence of heating ash, fine inert particles, and general mixed residential municipal waste, which comprises the remaining **43%** of the total winter collection volume.

B. Shoulder Season Profile (Spring Transition Analytics)

The spring transition survey captures a clear upward shift in commercial packaging fractions, mirroring the opening of beachfront hospitality venues:

- **Organic Fraction**: Increases moderately to **34%–36%,** driven by the initial restart of commercial kitchen operations.
- **Packaging and Recyclables**: Paper, cardboard, and composite packaging materials surge to **16%**, while the plastic fraction climbs to **18%** of total mass, signaling a clear shift toward consumer packaging waste.

C. Summer Peak Profile (High-Season Commercial Analytics)

During the high-season summer window (June–August), the structural composition of the waste stream changes completely, driven entirely by hotel chains, restaurant clusters, and institutional tourist behavior:

- **Organic Bio-waste Surge**: The biodegradable food waste fraction increases dramatically to a dominant **52% to 55%** of the total generated mass. This organic surge creates high-moisture conditions within collection bins, accelerating fermentation and producing severe odor issues during the hot summer months.
- **Plastic Fraction Escalation**: Driven by single-use beverage bottles, commercial films, and hospitality packaging, plastics experience a major structural surge, rising to **24% of the total waste volume**.
- **The Commercial Packaging Deficit**: Combined recyclables (Plastics, Glass, Paper, and Cardboard) make up nearly **40% of the total summer waste volume**. Because source-separation rates in hotels remain critically low, these valuable materials end up mixed with heavy food waste, making mechanical separation difficult and causing severe contamination.

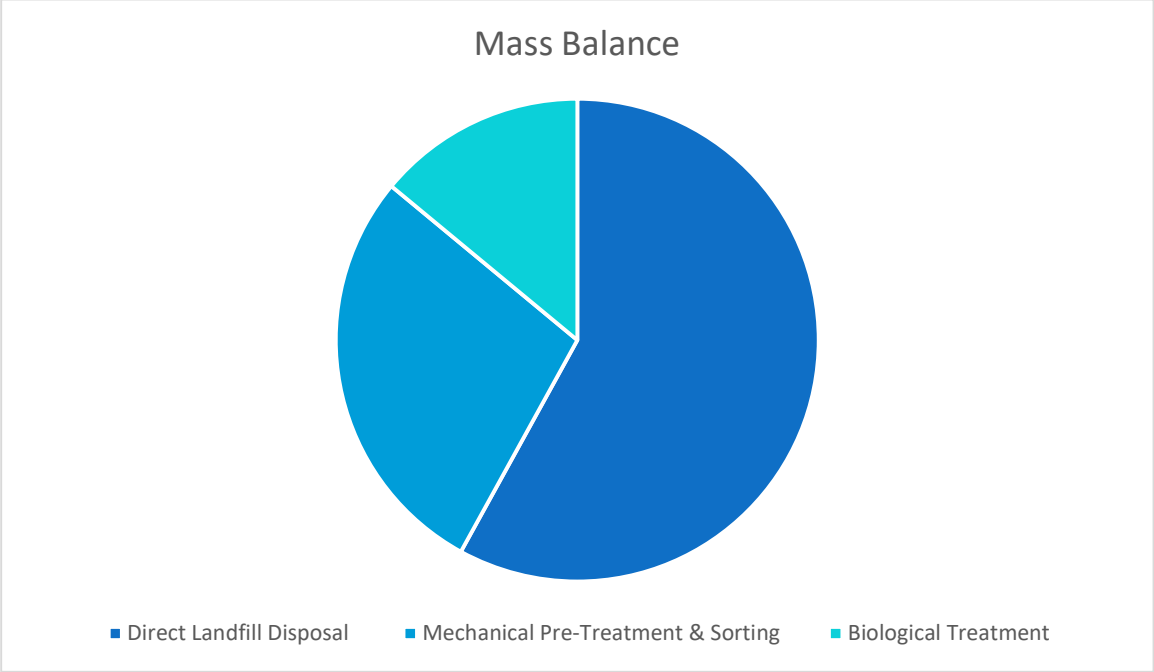
4.4 Logistical Fleet and Infrastructure Utilization Rates

Analyzing this quantitative data highlights significant operational inefficiencies and structural strains under the current fixed waste collection model.

- **Off-Season Capacity Underutilization**: Tracking logs show that during the winter baseline months, the rear-loader vehicle fleet operates at an average **capacity utilization of just 38% to 44%** per route. Running heavy collection vehicles for half-empty containers leads to high fuel costs and unnecessary carbon emissions per collected ton.
- **Peak-Season Container Overflow Metrics**: Conversely, during the July-August surge, static 1.1 m^3 bins in the tourist zones reach **100% volumetric capacity within 4 to 6 hours** of being emptied. Because fixed route scheduling cannot adapt to this speed, container overflows occur on **32% of all coastal routes** before the next scheduled truck arrives, creating noticeable public space littering.

4.5 Consolidated Mass Balance and Final Destination Split

The table below maps the structural mass flow of municipal solid waste through the regional collection and processing infrastructure, highlighting the wide gap between current recycling rates and upcoming EU regulatory targets.



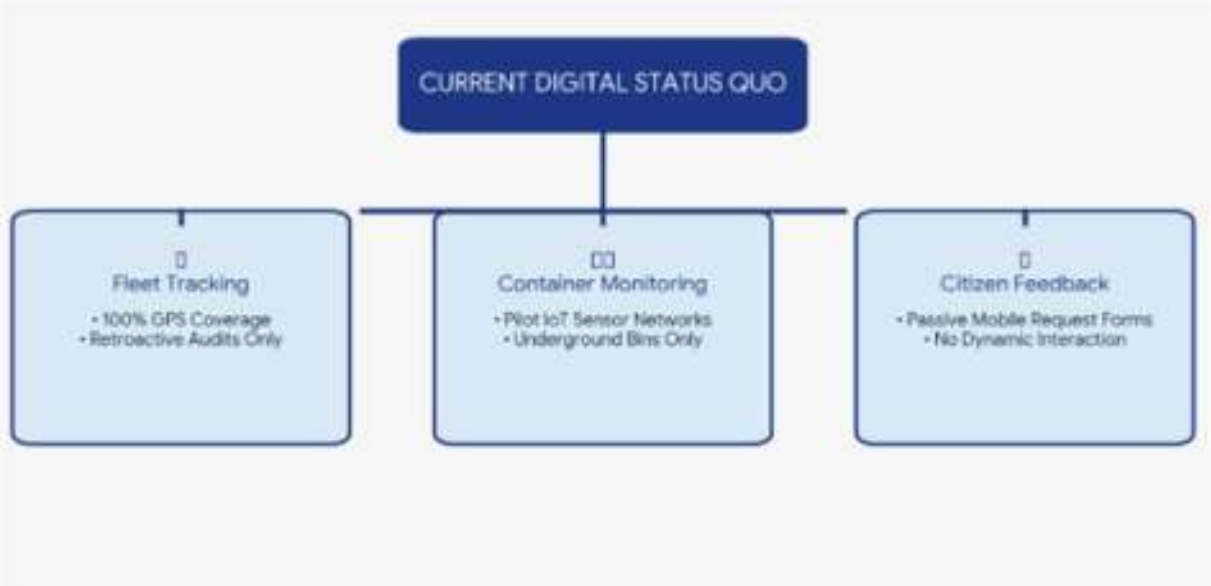
Waste Processing and Treatment Stream	Annual Mass Volume (Tons)	Percentage Component Share (%)	Current Operational Status vs. Statutory EU 2025 Targets
Direct Landfill Disposal (Bratovo-West Engineered Cells)	~68,000 tons	**58.0%**	Exceptionally high baseline. Requires immediate digital sorting and separation interventions to prevent landfill tax penalties.
Mechanical Pre-Treatment & Sorting (Central Sorting Plant)	~33,000 tons	**28.0%**	Processes mixed packaging waste. Suffers from high contamination rates due to the heavy influx of organic food waste.
Biological Treatment (Burgas Anaerobic & Composting Plants)	~16,500 tons	**14.0%**	Successfully processes clean green waste, but currently captures less than 15% of the organic food waste generated by hotel chains.
Total Consolidated Waste Stream	**117,500 tons**	**100.0%**	**Current Real Recovery Rate: ~23%**. Significant investment and smart tracking are needed to reach the **55% EU target**.

5. Smart Technologies: Status Quo and Technological Gaps

This section outlines the digital matrix of the waste management system in the Burgas-Nessebar region. While both municipalities have taken initial steps toward digitalization, the transition from passive tracking to active, data-driven optimization remains incomplete. Significant **technological gaps** still separate current operations from a fully integrated, smart circular economy.

5.1 Asset Inventory and Digital Status Quo

The existing deployment of digital tools focuses primarily on retroactive monitoring, asset security, and basic citizen communication rather than real-time operational adjustments.



A. Fleet Logistics and GPS Tracking (100% Fleet Coverage) 🚛

- **Operational Status**: All specialized waste collection vehicles (rear-loaders, side-loaders, and container haulers) operated by municipal concessionaires are fully equipped with functional Global Positioning System (GPS) tracking hardware.
- **Functional Limits**: This infrastructure is used strictly for **retroactive auditing and compliance control**. Fleet managers use GPS logs to verify if a truck completed its predetermined route or to check total daily mileage. The data remains siloed and is not integrated into any predictive routing software.

B. Bin Fill-Level Infrastructure (Pilot Container Sensor Networks) 📶

- **Operational Status**: Internet of Things (IoT) ultrasonic fill-level sensors are currently used in less than **5% of the total regional container inventory**. This setup is strictly limited to

isolated pilot projects in selected underground and semi-underground container networks in central Burgas and key high-visibility zones in Nessebar.

- **Functional Limits**: While these sensors successfully transmit volume metrics via cellular networks, they function as standalone monitoring tools. They provide data for internal municipal reports but do not trigger automated dispatch alerts or dynamic route changes. Widespread above-ground container networks (1.1 m³ bins) remain completely unmonitored.

C. Mobile Citizen Engagement Platforms (Passive Signaling Systems)

- **Operational Status**: Citizens can use generic municipal web portals and mobile request forms to report illegal dumpsites or overflowing containers.
- **Functional Limits**: These channels act as **passive complaint registers**. They lack interactive, waste-specific interfaces, real-time localized mapping, and modern behavioral nudges like gamification. This absence of advanced digital engagement keeps civic source-separation rates low, particularly in highly volatile tourist and commercial areas.

5.2 Critical Technological Gaps

The primary operational challenge is not a complete lack of hardware, but the total absence of real-time operational data processing and automation.

Identified Technological Gap	Current Operational Effect	Institutional and Financial Consequence
Static Route Scheduling *(No Dynamic Routing Optimization)*	Trucks follow rigid, calendar-based route schedules regardless of actual container volumes.	Leads to heavy "dead-haul" mileage for empty bins in winter, and severe container overflows in summer.
Isolated Data Silos *(Lack of Systems Integration)*	GPS truck data, landfill weighbridge logs, and pilot container sensor data are processed separately.	Municipal managers cannot calculate real-time efficiency metrics, such as weight collected per route kilometer.
No Automated Forecasting *(Lack of Predictive Analytics)*	Fleet managers rely on historical assumptions to adjust truck numbers for the summer tourism spike.	Logistics systems cannot predict sudden surges in food and packaging waste, causing delays in high-season service adjustments.

6. SWOT Analysis for Smart Waste Integration

This section provides a strategic evaluation of the internal and external factors influencing the deployment and scaling of smart waste management technologies within the Burgas-Nessebar regional ecosystem.

STRENGTHS (Internal)	WEAKNESSES (Internal)
• **100% Fleet GPS Coverage:** No additional capital investment needed for basic vehicle hardware. • **Unified Regional Body (BSRE):** Shared governance framework for joint EU funding and cross-border logistics. • **Modern Processing Infrastructure:** Solid technical foundation at "Bratovo-West" sorting and composting installations.	• **Extreme Seasonal Volatility:** The 6.8x tourism waste multiplier completely disrupts static routing routines. • **Fragmented Data Silos:** Fleet data, weighbridge logs, and sensor pilots are completely disconnected. • **Low Hotel Source-Separation:** Heavy organic contamination of recyclables in commercial zones.
OPPORTUNITIES (External)	**THREATS (External)**
• **EU Green Deal Funding:** Grant opportunities under national Operational Programs and Resilience Plans. • **Mandatory PAYT Transition:** Legislative push for quantity-based waste taxes requires smart bin tracking. • **Smart City Ecosystem:** Strategic option to integrate waste data into the unified Burgas urban dashboard.	• **Macroeconomic Tourism Shocks:** Geopolitical risks can drop tourist numbers and cut municipal tax revenues. • **Proprietary Vendor Lock-in:** Closed source hardware risk leading to monopoly pricing and high software costs. • **Cybersecurity & Network Down-time:** Data breaches or network failures disabling dynamic routing dashboards.

6.1 Strengths (Internal Factors)

- **Established Fleet Tracking Baseline**: The 100% integration of GPS hardware inside the existing operational vehicle fleet provides a functional logistical foundation that requires zero additional capital expenditure for basic vehicle tracking.
- **Shared Regional Waste Infrastructure**: The **Burgas Regional Waste Management Association (BSRE)** provides a unified governance framework, allowing both municipalities to coordinate cross-border logistics and submit joint procurement applications.
- **Modern Centralized Assets**: The presence of the modern **"Bratovo - West" Regional Landfill,** along with the advanced automated sorting plant and anaerobic composting facilities in Burgas, provides a solid infrastructure baseline capable of processing refined waste streams.

6.2 Weaknesses (Internal Factors)

- **Extreme Seasonal Volatility**: The **6.8x tourism-driven waste multiplier** in Nessebar completely disrupts static collection routines, making it difficult to balance vehicle capacity between the quiet winter baseline and the intense summer surge.
- **Fragmented Data Architecture**: GPS fleet coordinates, landfill weighbridge logs, and pilot underground sensor data operate in **isolated data silos**, preventing real-time, data-driven optimization and cross-variable analysis.
- **Low Source-Separation Compliance**: Inadequate separation infrastructure and minimal digital engagement within the commercial hospitality sector (hotels and restaurants) result in heavy organic contamination of recyclable streams during peak months.

6.3 Opportunities (External Factors)

- **EU Strategic Funding Alignment**: Widespread availability of targeted grants under the **EU Green Deal**, the Operational Program Environment, and the Recovery and Resilience Plan for Bulgaria provides massive co-financing opportunities for IoT sensor acquisition and dynamic software rollout.
- **Statutory Transition to PAYT Models**: Upcoming national mandates enforcing the **"Pay-As-You-Throw" (PAYT)** model (*Такса битови отпадъци според количеството*) serve as a major driver for implementing smart container identification and digital weighing mechanisms.
- **Smart City Ecosystem Synergies**: Burgas Municipality's established smart city dashboard infrastructure allows for the immediate integration of waste logistics into a unified urban management control platform.

6.4 Threats (External Factors)

- **Macroeconomic Shocks in Tourism**: Economic disruptions or geopolitical instability directly impacting Black Sea tourism can cause unpredictable drops in municipal waste tax revenues, threatening long-term software licensing and operational budgets.
- **Vendor Lock-in and Interoperability Risks**: Relying on closed, proprietary IoT hardware designs can trap municipalities with single-source suppliers, leading to high maintenance costs and software integration bottlenecks.
- **Cybersecurity and Data Privacy Risks**: Transitioning to automated sensor networks, data-driven routing dashboards, and digital citizen tracking tools exposes municipal databases to potential data breaches, operational manipulation, and network downtime.

7. Community and Institutional Actions: Review of Existing Initiatives

This section evaluates the current public campaigns, municipal programs, and institutional initiatives aimed at pollution reduction, environmental education, and recycling acceleration within the Burgas-Nessebar regional ecosystem.

7.1 Existing Pollution Reduction & Clean-Up Initiatives

Both municipalities actively support and host institutionalized public cleanup programs, though their operational scales vary significantly during the high tourism season.

- **"Let's Clean Bulgaria Together" (Да изчистим България заедно)**: Both Burgas and Nessebar participate annually in this national initiative. In Burgas, this involves large-scale volunteer coordination to clear marine litter from the Sea Garden coastal strip and Vaya Lake. In Nessebar, the campaign targets vulnerable natural dunes and peripheral resort zones before the official opening of the summer season.
- **The "Zero Waste" Educational Matrix (Бургас - Град с нулев отпадък)**: Burgas Municipality has established local institutional networks targeting schools and kindergartens. This includes providing localized source-separation bins coupled with specialized interactive ecology lessons, aiming to foster long-term behavioral changes in waste generation.
- **Marine Litter Reduction Campaigns**: Local NGOs, supported by the Burgas Regional Waste Management Association (BSRE), run specialized "Blue Flag" beach awareness campaigns and voluntary diving cleanups around the Old Town Nessebar harbor to intercept single-use plastics before they degrade into microplastics.

7.2 Existing Recycling & Source-Separation Infrastructure

Beyond standard container networks, specialized separation infrastructure has been introduced to intercept higher-value recyclable components.

🏛 SPECIALIZED RECYCLING INTERCEPTION	(Current Operational Mechanisms)
❤ Initiative: "Plastic Caps for Future"	🚌 Infrastructure: Reverse Vending Machines (RVM)
• **Target Material:** High-density Polyethylene (HDPE) bottle caps. • **Deployment:** Fixed public metal heart containers across Burgas and Nessebar. • **Impact:** Exceptionally high civic engagement and volunteer participation.	• **Target Material:** Clean PET packaging and aluminum beverage cans. • **Deployment:** Smart automated eco-automats placed in urban centers. • **Impact:** Incentive-driven sorting via public transit discount points.

- **"Plastic Caps for Future" (Капачки за Бъдеще)**: A highly successful community-driven campaign with designated public accumulation points (metal heart containers) across central Burgas and Nessebar. This initiative maintains exceptionally high civic engagement, collecting tons of high-density polyethylene (HDPE) plastic caps for charity recycling.
- **Reverse Vending Machine (RVM) Pilot Networks**: Burgas has introduced automated "Eco-Automats" (RVMs) in strategic urban locations. These machines incentivize citizens to return clean PET plastic beverage bottles and aluminum cans in exchange for reward points or public transit discounts. However, this high-utility smart infrastructure has not yet scaled to mass commercial deployments inside the high-generation tourist zones of Sunny Beach or Ravda.

7.3 Critical Gaps in Existing Community Initiatives

While community and institutional efforts show strong local engagement, they face significant limitations when dealing with massive seasonal tourism spikes.

Initiative Type / Focus	Current Operational Bottleneck	Missing Strategic Component
Voluntary Public Cleanups	Scheduled as single-day annual events; completely unable to manage continuous high-season tourist streams.	Requires continuous digital public alerts to dynamically deploy volunteers to overflowing coastal litter hotspots.
School Educational Programs	Strictly seasonal and focused on local resident children; completely misses temporary summer workers.	Needs targeted digital mobile outreach and micro-learning tailored for transient seasonal hospitality staff.
Incentive-Driven Smart RVMs	Located exclusively in the permanent urban residential quarters of the city of Burgas.	Needs immediate infrastructure deployment along high-traffic beach promenades to process single-use containers.

8. Strategic Development Needs and Action Plan

This final section outlines the strategic development roadmap to modernize the regional waste management framework. It leverages international best practices and targeted digital innovations to transition the Burgas-Nessebar ecosystem from a reactive, calendar-based model to a proactive, data-driven system.

PRIORITY A: FOUNDATION (Short-Term Deployment)	PRIORITY B: ENGAGEMENT (Medium-Term Deployment)	PRIORITY C: INTEGRATION (Long-Term Integration)
1. IoT Sensor Pilot Integration • Deploy ultrasonic sensors in 1.1 m^3 containers inside high-density tourist zones. • Real-time alerts to prevent container overflows.	**1. Unified Municipal Mobile App** • App featuring localization, scanning, and gamification elements. • Incentives for citizens & tourists (discounts, transit points).	**1. Regional MRF/MBT Development** • Joint Public-Private Partnership (PPP) under the BSRE association. • Mechanical separation to prevent recycling contamination.
2. Full-Fleet GPS Routing Optimization • Upgrade passive tracking to active, dynamic dispatch software. • Automated routes based on container fill-levels.	**2. Seasonal Optimization Framework** • Dynamic scaling of operational staff and vehicle assets. • Predictive data algorithms tied to hotel reservation metrics.	**2. Digital Procurement Capacity** • Transition to performance-based municipal tenders and smart contracts. • Contract clauses tied to verified digital recycling KPIs.

8.1 Priority A: Core Infrastructure and Real-Time Logistics (Short-Term Deployment)

The immediate focus centers on addressing the data vacuum and upgrading physical assets with intelligent communication capabilities.

- **Sensor Pilot Integration**: Deploy ultrasonic Internet of Things (IoT) fill-level sensors across high-volume container networks, focusing on the 1.1 m^3 containers in tourist-heavy zones. These sensors transmit real-time volumetric data via cellular networks to a centralized municipal operations center. This system triggers automated collection alerts before bins reach critical capacity, eliminating public space littering.
- **Full-Fleet GPS Routing Optimization**: Upgrade existing passive GPS tracking systems to active dispatch software. Instead of following static, calendar-based schedules, collection vehicles receive dynamic route navigation daily. Routes are automatically calculated based on real-time sensor data, reducing off-season "dead-haul" mileage, cutting fuel costs, and ensuring rapid response times during the summer surge.

8.2 Priority B: Citizen Engagement and Seasonal Optimization (Medium-Term Deployment)

This phase addresses institutional flexibility and public source-separation rates, which are critical to meeting upcoming European regulatory targets.

- **Unified Municipal Mobile Application**: Launch a waste-focused mobile application featuring localization and advanced gamification elements. Citizens and tourists can scan barcodes on single-use packaging to receive instant recycling instructions, view local container maps, and earn rewards (such as public transport credits or beach zone parking discounts). This platform also serves as an active reporting tool for localized overflow incidents.
- **Dynamic Seasonal Optimization Framework**: Modify public procurement structures to allow for flexible, demand-responsive scaling. Operational staff and vehicle assets are adjusted dynamically based on predictive data algorithms that combine hotel reservation metrics, airport passenger logs, and historical weather forecasts.

8.3 Priority C: Regional Infrastructure and Advanced Procurement (Long-Term Integration)

The final tier establishes regional infrastructure independence and upgrades institutional procurement systems.

- **Regional Partnership for MRF/MBT Development**: Establish a joint public-private partnership (PPP) under the Burgas Regional Waste Management Association (BSRE) to construct a localized, high-capacity Material Recovery Facility (MRF) and Mechanical Biological Treatment (MBT) plant near key generation zones. This facility will process mixed waste streams mechanically, protecting valuable recyclables from contamination and diverting organic fractions away from landfill cells.
- **Digital Procurement and Smart Contract Capacity**: Transition municipal tender frameworks into a modernized digital ecosystem. Future waste contracts will incorporate performance-based Smart Clauses tied to verifiable digital metrics (e.g., sensor fill-rates, recycling purity thresholds, and carbon reduction indexes), aligning municipal spending directly with circular economy results.

Strategic Implementation Matrix

The table below outlines the timeline, funding sources, and key performance indicators (KPIs) for the proposed strategic actions.

Priority Level	Strategic Action / Component	Target Deployment	Primary Funding Source	Key Performance Indicator (KPI)
Priority A	IoT Sensor Pilot & Full-Fleet GPS Dynamic Routing.	2026–2027	EU Recovery & Resilience Plan / Municipal Budgets.	• **35% reduction** in fuel consumption. • **Zero** tourist-zone container overflows.
Priority B	Municipal Recycling App & Seasonal Staff Scaling.	2027–2028	Operational Program Environment / Hospitality Taxes.	• **25% increase** in packaging source-separation. • **<2 hour** overflow response time.
Priority C	Regional MRF/MBT Facility & Digital Smart Contracts.	2028–2030	EU Green Deal / Public-Private Partnerships (PPP).	• **<10% total landfill** disposal rate. • **100% compliance** with EU 2030 targets.

References

- **Bulgarian Parliament.** (2012). *Waste Management Act* (Закон за управление на отпадъците). Promulgated in State Gazette No. 53/2012, with latest digital amendments.
- **Burgas Regional Waste Management Association (BSRE).** (2023). *Regional Waste Management Plan for the Burgas Region 2021–2028*. Internal institutional registry.
- **European Parliament and Council.** (2008). *Directive 2008/98/EC on waste (Waste Framework Directive)*. Official Journal of the European Union, L 312/3.
- **European Commission.** (2020). *A new Circular Economy Action Plan: For a cleaner and more competitive Europe*. COM/2020/98 final.
- **Municipality of Burgas.** (2021). *Municipal Waste Management Program 2021–2028*. Official Portal of Burgas Municipality.
- **Municipality of Nessebar.** (2023). *Seasonal Spot Composition Surveys & Morphological Waste Analysis Reports (Winter, Spring, Summer 2023–2025)*. Internal Data Registry, Ecology and Waste Management Department.
- **National Statistical Institute (NSI) of Bulgaria.** (2025). *Population and Housing Census Data & Regional Tourism Capacity Statistics for the Burgas District*. Sofia: NSI.
- **UNESCO World Heritage Centre.** (1983). *Ancient City of Nessebar – Cultural Property Evaluation and Protection Framework*. World Heritage List, Ref: 217.

Interreg NEXT Black Sea Basin

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WISE WASTE

INDIVIDUAL REPORT

Waste Management Comparative Analysis

KUTAISI, GEORGIA



Project: "Collaboration for smart solutions for waste management and pollution reduction in urban, rural, and coastal areas of the Black Sea basin -WISE-WASTE"

Prepared by: PP5 Imereti Scientists' Union "Spectri"

Study period: 2022-2026

2026

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Abbreviations

Abbreviation	Meaning
C&D	Construction and demolition waste
EPR	Extended Producer Responsibility
EU	European Union
GIS	Geographic Information System
GHG	Greenhouse gas
KPI	Key Performance Indicator
MRF	Materials Recovery Facility
MSW	Municipal solid waste
NGO	Non-governmental organization
SWMCG	Solid Waste Management Company of Georgia
WtE	Waste-to-Energy

Executive Summary

This report provides a structured assessment of municipal waste management in Kutaisi, Georgia, for integration into the WISE-WASTE comparative analysis across partner territories in the Black Sea Basin. It follows the project methodology, which requires a common framework, use of recent regional data, metric units, unified terminology adapted from the EU Waste Framework Directive, identification of technological gaps, and a SWOT analysis focused on opportunities for smart management. The report is therefore designed as a practical management and planning document rather than as a purely academic review.

Kutaisi has moved beyond a conventional collection-and-disposal model and now possesses several components of a more resource-oriented municipal system. Collection services cover the whole city; source-separated plastic collection has operated since 2015; cardboard is recovered and sold; a centralized green-waste composting facility has operated since 2021; and the 2025–2027 municipal plan refers to recycling sites equipped with fill-level sensors and to planned GIS use for waste-pollution monitoring and a notification system.

Recent publicly reported local data show that Kutaisi generated more than 50 thousand tons of municipal waste per year.

Waste composition indicates substantial potential for diversion from landfill. Historical Kutaisi characterization data identify food waste as the largest measured household fraction (43.7%), followed by plastics (13.5%), paper/cardboard (10.72%), glass (4.02%) and metals (approximately 3%) [2,8]. National data summarized by the National Waste Management Strategy similarly show organic waste at 54.7%, plastics at 13.8% and paper/cardboard at 10.6% [5,6]. These fractions point to two priority pathways: biological treatment of suitable biodegradable waste and expanded source separation of dry recyclables.

Separate collection is one of Kutaisi's strongest documented areas of experience. Plastic source separation has operated since 2015 and was introduced within the project “Introduction of Innovative Waste Management Practices in Selected Cities of Georgia, Moldova and Armenia,” implemented under the Black Sea Basin Programme during 2013–2015. The current Municipal Waste Management Plan of Kutaisi estimates that at least 7,000 t of plastic waste may be generated annually, while noting that the number of specialized containers remains insufficient [3]. Recent public reporting shows that 103 t of cardboard were sold for recycling in 2023, 118.2 t in 2024, and 192,6 t in 2025.

Biodegradable waste management is another comparative strength. The Kutaisi Composting Center began operation in 2021 and processes green waste such as branches, grass and leaves through aerobic windrow composting. The facility was established within the project “Waste Free Rivers for a Clean Black Sea,” implemented with support from the Black Sea Basin Programme during 2018–2021. The Municipal Waste Management Plan 2025–2027 reports that the resulting compost is certified as an organic fertilizer and sets a goal of increasing

green-waste composting by 50%, while also promoting home and school composting. However, the available sources contain differing figures for facility area and projected production capacity.

The current plan still identifies insufficient technical equipment, the need for additional containers and fleet renewal, illegal dumping, incomplete management of inert/construction waste, and the need to improve public participation. The earlier plan also identified gaps in regular waste-composition studies, local sorting and recycling capacity, and full cost recovery.

The recommended development pathway is therefore an integrated one: standardize municipal data; verify current asset inventories; expand sensor-equipped separation infrastructure; use GIS as a common spatial platform; introduce or expand vehicle telematics and route optimization where justified; increase recovery of paper, plastic and glass; maximize verified use of the composting facility; organize inert-waste management; strengthen EPR cooperation; and monitor all interventions using clear KPIs. In this way, Kutaisi can convert existing pilot and sectoral initiatives into a coherent smart municipal waste-management system with demonstrable environmental, operational and economic benefits.

Evidence base and source quality

The report combines municipal, official statistical, peer-reviewed, public web and current operational evidence.

Evidence category	Role in the assessment	Quality treatment
Municipal planning and official decisions [2,3,19]	Local responsibilities, infrastructure baseline, current targets and approved actions	Primary local evidence; current and historical periods kept distinct
Official statistics and public local reporting [20,21]	Population, recent waste quantities, cardboard recovery and smart-container evidence	Recent public evidence; partial-year values explicitly labelled
Peer-reviewed and technical literature [4,5,8,9,11,12]	Waste composition, composting, material flows and technical good practice	Scientific/technical evidence; older composition treated as historical baseline
National and EU legal/policy framework [6,7,10]	Regulatory obligations, terminology and policy direction	Authoritative framework
Regional/project and local operational evidence [13-18]	Zero Waste priorities, needs assessment, project experience and 2023-H1 2026 operational indicators	Recent contextual/operational evidence; regional results not treated as Kutaisi performance rates

1. Current Waste Management Analysis

1.1 Regional profile

Kutaisi is located in the central part of western Georgia and serves as the administrative centre of the Imereti Region. The city lies on both banks of the Rioni River, with lowland areas to the south and west and hillier terrain toward the north and north-east. The Municipal Waste Management Plan 2018-2022 of Kutaisi reported a municipal area of approximately 65 km2, of which around 55 km2 was urbanized, and described 12 administrative units. These characteristics influence waste logistics: dense central and multi-apartment areas are suited to container collection, while older or physically constrained neighbourhoods require different servicing patterns.

The city's road network, markets, commercial areas, schools, public institutions, parks and residential districts create a heterogeneous municipal waste stream. Historical municipal information also records extensive public green space, including parks and numerous squares, which is relevant to the generation of seasonal green waste and to the operation of the Kutaisi Composting Center.

According to the National Statistics Office of Georgia (Geostat), Kutaisi had 123.7 thousand residents at the beginning of 2025, compared with 147.6 thousand recorded for 2014 in the same city-level statistical series. The long-term decline in resident population strengthens the need to interpret waste-generation trends together with consumption patterns, commercial and service-sector activity, visitor flows and collection coverage rather than population change alone.

The relationship between population and waste generation is therefore not straightforward. Despite population decline, reported municipal waste quantities remain around the mid-50,000 t/year range. This suggests that consumption patterns, commercial and institutional activity, mobility, tourism, packaging intensity and service-sector waste may offset the effect of demographic contraction.

Indicator	Source-based description
Administrative role	Administrative center of Imereti Region
Municipal area	Approximately 65 km2
Urban structure	12 administrative units
Population	123.7 thousand (beginning of 2025, Geostat)
Main river	Rioni

Indicator	Source-based description
Collection coverage	Whole city territory covered according to 2025-2027 municipal plan
Collection modes	Container system and bell/door-to-door-type scheduled vehicle service
Key recovery assets	Plastic source separation, cardboard recovery, green-waste composting center, sensor-equipped recycling sites



Figure 1. Kutaisi municipal boundary and urban context.

1.2 System overview and collection model

The Kutaisi Municipal Waste management Plan 2025-2027 states that municipal waste collection services cover the entire territory of Kutaisi. The system continues to use both

containers and a bell system in which collection vehicles service areas at designated times. The bell system remains necessary in locations where street geometry or other physical conditions make conventional container-based service difficult.

Full geographic coverage should not be interpreted as full service optimization. The same current plan identifies insufficient technical equipment, the need to increase the number of 1.1 m^3 containers, the need to renew the waste-collection fleet and the need to increase collection frequency in certain neighbourhoods. These findings indicate that access is broadly established, but service quality and operational efficiency remain development priorities.

The Kutaisi Municipal Waste management Plan 2018-2022 provides the most detailed technical inventory available in the documented municipal baseline. At that time it recorded 1,475 mixed-waste containers of 1.1 m3, 380 decorative public litter bins, 106 dedicated 1.1 m3 plastic-separation containers and a vehicle fleet including 15 waste trucks with body capacities of approximately 6-22 m3 plus 6 smaller 3-4 m3 waste trucks [2]. The Plan also documented daily servicing of containers and multiple collection shifts in major streets and residential/service areas.

1.3 Operational practices and collection issues

Historical operational problems included unsuitable container placement in traffic-sensitive locations, overflow around markets and commercial centres, and inappropriate movement or use of containers. The earlier plan also noted that packaging materials such as cardboard and plastic were prominent in overfilled containers near commercial areas. These observations remain relevant to the design of targeted separation systems for high-volume commercial generators.

The current Kutaisi Municipal Waste Management Plan continues to focus on illegal or uncontrolled disposal, improved container placement, additional collection infrastructure and more effective street cleaning. Planned actions include control of waste-related environmental pollution, removal of waste from unauthorized dumping locations, placement of containers at problematic locations and the application of administrative sanctions where appropriate.

The earlier Municipal Waste Management Plan 2018-2022 described the Kutaisi landfill as the final disposal site for collected municipal waste and reported that it had entered operation in 1957, with a site area of approximately 15 ha and the nearest residential zone about 500 m away [2]. The same source identified the Solid Waste Management Company of Georgia as the landfill manager and referred to plans for regional sanitary landfill infrastructure.

The updated SWOT reproduced in the source material identifies delay in regional landfill construction as a continuing threat. This means that disposal infrastructure remains a strategic

vulnerability and reinforces the importance of diversion through recycling and composting. Nationally, more than 90% of municipal waste is still landfilled, leaving substantial secondary-resource potential unused.

The present operational model therefore combines broad service access with clear opportunities for optimization. The perspective is not simply to increase collection frequency, but to use local evidence to determine where service frequency, container location, dedicated recyclable rounds and smart monitoring can reduce overflow, unnecessary trips and illegal dumping.

1.4 Waste quantities and data quality

Kutaisi is one of the largest cities in Georgia, with a population of 125.6 thousand (as of 2024). The generation of waste increases annually, despite the fact that the population of Kutaisi has been generally declining (for comparison, in 2015, the population of Kutaisi was over 147 thousand). Despite a decrease in population, municipal waste generation in Kutaisi between 2020 and 2024 has shown a growing trend. In 2015, the city generated 47 thousand tons of municipal waste, which increased to approximately 55 thousand tons by 2024.

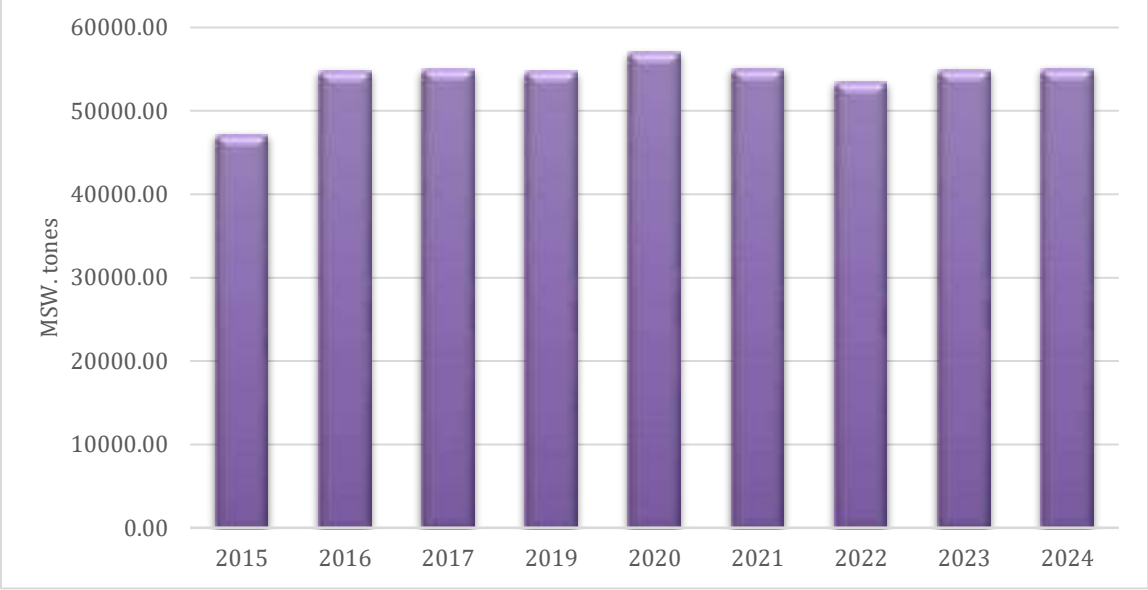


Figure 2. Municipal waste generation in Kutaisi, 2015-2024

1.5 Waste composition and seasonal effects

Regular, up-to-date municipal waste-composition monitoring is not documented in the available municipal planning evidence. The Kutaisi Municipal Waste Management Plan 018-2022 explicitly notes that continuous study and monitoring of waste composition had not been carried out. It therefore relied on project-specific studies conducted at different times.

The most frequently cited local characterization is the 2010-2011 study. Average household waste composition was reported as 43.7% food waste, 13.5% plastics, 10.72% paper, approximately 3% metals and 4.02% glass [2,8]. Another historical assessment summarized in the municipal plan reported approximately 47% organic waste, 14% plastic, 10% paper, 3% metal and 2% glass [2]. The consistency between these datasets supports the conclusion that organics, plastic and paper are the main recovery priorities, even though current percentages need fresh measurement.

Seasonality is also relevant. The 2010-2011 study reported the lowest per-capita monthly generation in February (15.4 kg/person) and the highest in August (21.7 kg/person), while the share of food waste was particularly influenced by summer months and holiday/fasting patterns [2,8]. For operational planning, a new composition study should therefore use repeated seasonal sampling rather than a single campaign.

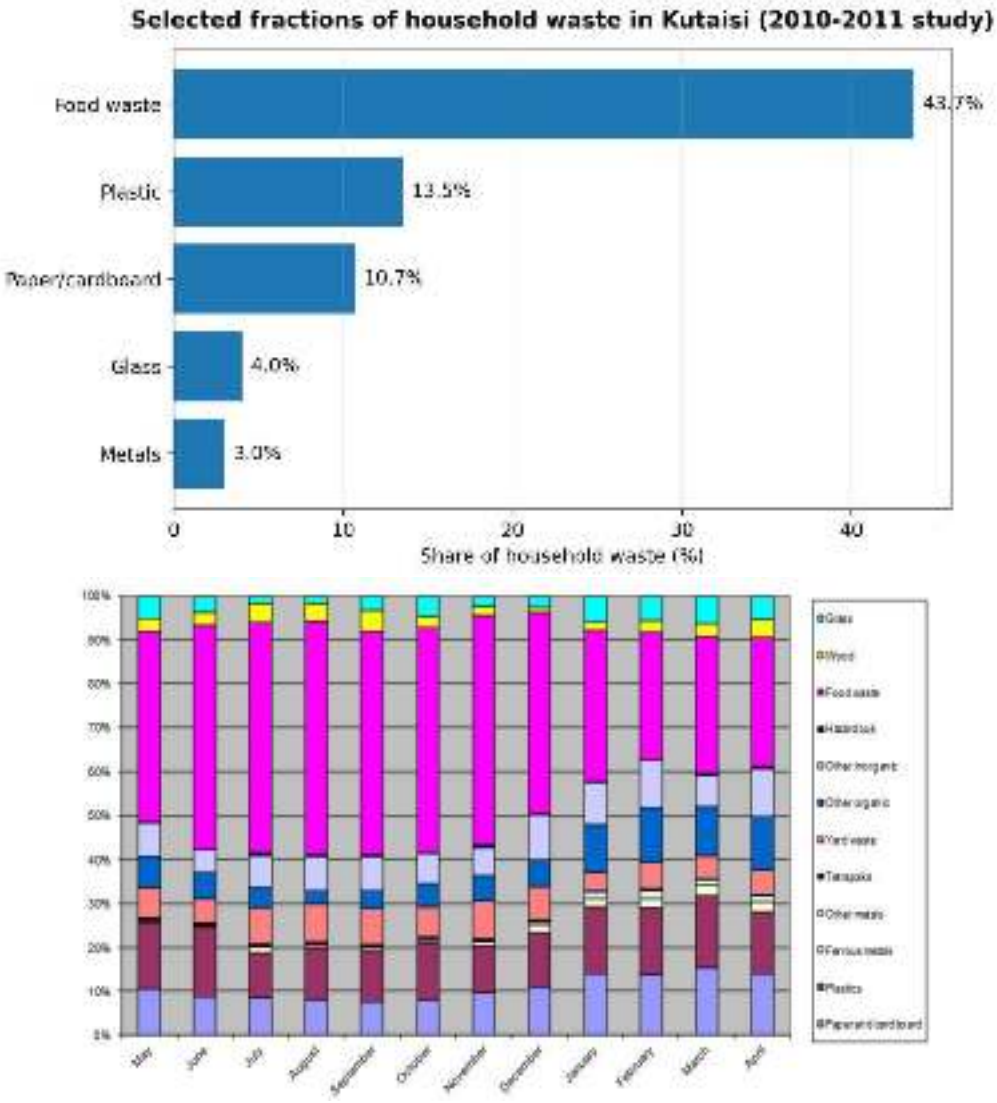


Figure 3. Selected fractions from the historical 2010-2011 Kutaisi household-waste characterization.

1.6 Separate collection and recycling

Kutaisi is one of the first cities in Georgia to introduce the separate collection of plastic and cardboard waste at the municipal level. To support this initiative, Kutaisi Municipality implemented two projects with financial assistance from the **Black Sea Basin Programme**. The system was introduced in 2015, initially with dedicated 1.1 m3 transparent containers. The 2018 plan reported more than 40 t of plastic collected during the first two years of implementation [2].

Kutaisi has also successfully implemented the separate collection of cardboard through the municipal enterprise LEPL “Special Services.” Cardboard recovery is a strong example of material recovery supported by recent public and operational evidence. During the period 2019–2025, a total of 756 tons of cardboard were collected and sold for recycling. In addition, within the framework of the **Eco-Smart City Project** under the **UNDP Mayors for Economic Growth (M4EG) Programme**, a network of waste separation points was established across Kutaisi. These collection points enable the separate collection of plastic, aluminum, and paper waste. The containers are installed within specially designed boxes and equipped with smart sensors that monitor fill levels, improving collection efficiency and optimizing waste collection routes.

The current Kutaisi Municipal Waste Management Plan 2025-2027 states that the population remains willing to participate but that the number of special containers is insufficient to increase capture volumes. Using an average plastic share of around 14% in the municipal waste stream, the plan estimates that no less than approximately 7,000 t of plastic waste may be generated annually in the city and proposes increasing dedicated 1.1 m3 plastic containers to around 300.

This gap between estimated generation and separately collected quantities is a core management issue. It illustrates why future reporting should focus on capture rate, not only on the number of containers installed. A smart system should link container location, fill level, collected tonnage, contamination and final recycling destination.

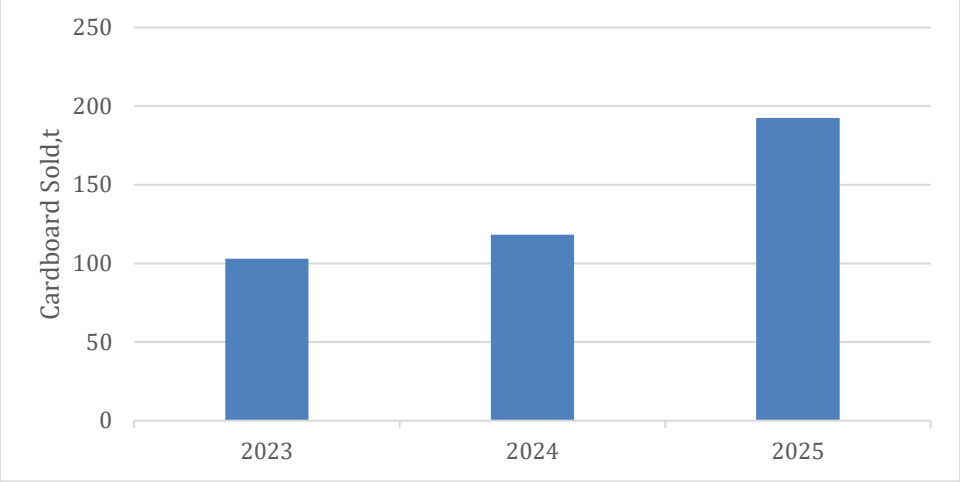


Figure 4. Cardboard sold for recycling in Kutaisi, 2023-2025.

The Kutaisi Municipal Waste Management Plan 2025-2027 identifies continued collection and sale of cardboard, particularly from commercial generators. UNDP also reports the use of a dedicated waste balling press machine supporting cardboard recycling in Kutaisi, complementing the city's material-recovery arrangements [20].

Historical municipal information also documented private reception points accepting plastics, paper/cardboard and metals, as well as a limited local recycling sector using plastic waste as secondary raw material. The current strategy proposes continued support for private waste reception and recycling businesses so that citizens can either use municipal separation containers or deliver materials to reception points.

The 2025-2027 plan gives attention to waste prevention and to implementation of the Extended Producer Responsibility principle. It proposes municipal cooperation with markets and large commercial centers for separate collection of streams including plastic, paper, glass and used batteries. This creates an opportunity to connect municipal collection infrastructure with producer-responsibility systems and to allocate responsibilities more efficiently.

Operational indicator	Reported value
Cardboard sold in 2023	103 t
Cardboard sold in 2024	118.2 t
Carboard sold in 2025	192.6 t



Figure 5A. Dedicated plastic-separation container in Kutaisi, 2015

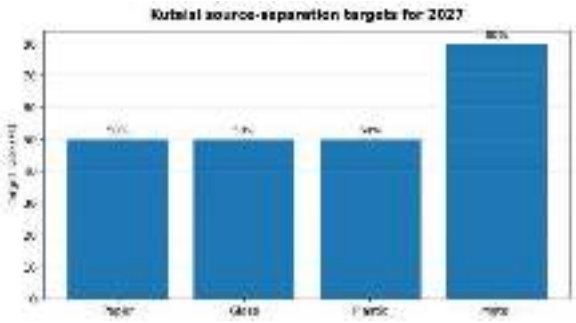


Figure 5B. Source-separation targets for 2027 in the current municipal plan.

1.7 Biodegradable waste and composting

Biodegradable waste is a priority local stream because historical Kutaisi composition studies identify food and other organic material as the dominant fraction, while the municipality also generates green waste from parks, streets and landscaped areas. Kutaisi is therefore one of the few Georgian municipalities in the documented local and regional evidence base with an established municipal-scale green-waste composting asset.

The Kutaisi Composting Center began operation in 2021 and is intended for green waste generated in the city. The composting area and auxiliary warehouses are located in a closed type building with an area of 3024 sq.m. The building parameters are: 84.00x36.00x10.76 meters. The building consists of the following areas: green waste reception - shredding area, compost storage area (including screening operation), composting area, and directly for the composting process, which includes aerobic composting in windrows. The facility processes tree branches, grass, leaves and similar green waste. The length of each windrow is 64 m, and the width is 3 m. The composting center is equipped with devices such as: shredder, turner (with tractor), a screen and so on. The projected production capacity of the Kutaisi composting center is 2000 tons of ready compost per year. The establishment of the Kutaisi composting center was made possible thanks to the support of the EU JOP Black Sea Basin within the framework of the “Waste Free Rivers for a Clean Black Sea” project.

The Kutaisi Composting Center is one of the first and large-scale composting enterprises in Georgia, where green waste (tree branches, grass, leaves) is processed/composted. As a result of the functioning of the Kutaisi Composting Centre, the amount of municipal waste disposed of at landfill decreased. In particular, in 2022, approximately 15 % less municipal waste was placed at landfill than in 2020, which is due to the commissioning of the composting center in 2021.

Kutaisi Composting Center produce the high level compost, laboratory analysis showed that the produced compost has high organic content (82.2%) and favorable chemical characteristics, including:

- pH (H_2O): 7.6
- Nitrogen: 3.9%
- Humus: 40%
- Calcium and magnesium in optimal ranges
- Low levels of toxic elements (Cd <0.01 ppm, Pb 0.65 ppm).

It should be noted that the compost produced by the Kutaisi Composting Center has been certified as an organic fertilizer by the National Food Agency . Therefore, it can be used for agricultural production, particularly for the cultivation of organic crops and the production of organic agricultural products. This gives the center value not only as a disposal-diversion facility but also as a municipal circular-economy asset producing a useful output.

Current operational monitoring reports finished organic fertilizer output of 2.5 t in 2023, 27.0 t in 2024, 41.7 t in 2025 and 14.1 t in the first six months of 2026. The cumulative reported output across these periods is 85.3 t. The 2026 result is partial-year and should not be annualized in comparative reporting.

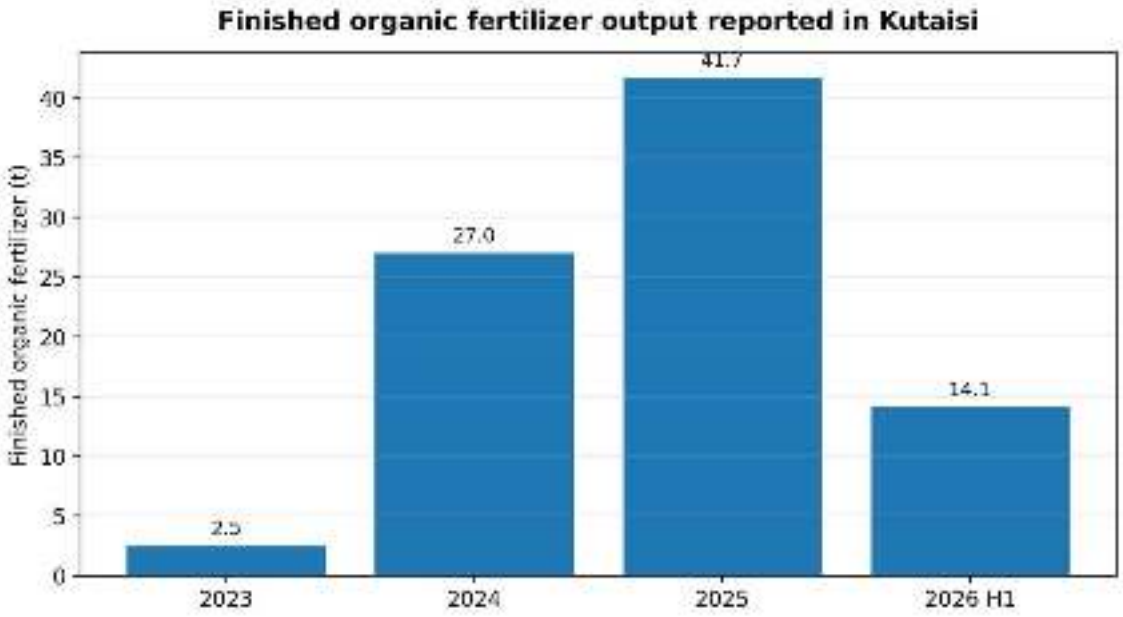


Figure 6. Finished organic fertilizer output reported from Kutaisi composting operations, 2023-H1 2026.

Parameter	Source value	Assessment
Start of operation	2021	Consistent across current sources
Main feedstock	Green waste: branches, grass, leaves	Current operational description
Process	Aerobic windrow composting	Scientific source
Reported area	3,024 m2	Requires verification
Projected finished-compost capacity	2,000 t/year	Requires verification
Recent finished organic fertilizer output	2.5 t (2023); 27.0 t (2024); 41.7 t (2025); 14.1 t (2026 H1) [13]	Current local monitoring; 2026 is partial-year
Municipal target	Increase green-waste composting by 50%	2025-2027 plan



Figure 7A. Windrow composting area at the Kutaisi Composting Center.



Figure 7B. Exterior of the Kutaisi Composting Center.

Source: Tskhakaia [5] and Interreg Black Sea Basin Programme [16].

1.8 Smart technologies and digital tools

In Kutaisi, sensor-equipped waste containers were introduced through the Eco-Smart City portfolio supported by the European Union and UNDP under the Mayors for Economic Growth (M4EG) programme. These containers notify the municipal cleaning service when they are nearly full, while the current municipal action plan also provides for GIS use in 2026 for waste-pollution monitoring and a notification system [3,20].

The earlier municipal plan also documented an automated system for cleaning-fee administration, including subscriber information, rates, billing, receipts and automated recording of payments [2]. Although this is not an operational route-optimization system, it demonstrates that the municipality has previous experience with structured digital administrative data.

Kutaisi should establish a single municipal waste data model with common definitions and reporting responsibility. At minimum, the database should record mixed waste collected, material separately collected by stream, material accepted for recycling, composting input and output, waste sent to landfill, rejected/contaminated material, container inventory and location, sensor status, vehicle and route information, illegal-dumping events, citizen complaints and relevant costs.

The database should preserve source and verification status for each value. This is particularly important when integrating data from the municipality, Special Services, the disposal operator,

EPR organizations, private recyclers and project partners. A clear data owner and annual validation procedure are as important as the software platform itself.

A practical phased architecture is recommended. Phase 1 should create a verified asset register and GIS map of containers, recycling sites, composting infrastructure, illegal-dumping hotspots and collection routes. Phase 2 should link fill-level sensor data and, if available or newly introduced, vehicle GPS/telematics. Phase 3 should develop operational dashboards and citizen-facing information such as recycling-point maps and service notifications.

The architecture should remain interoperable and avoid vendor lock-in. Data export, maintenance responsibility, device replacement, communications costs and cybersecurity should be specified during procurement. Smart equipment should be justified through measurable outcomes such as fewer overflow events, reduced unnecessary trips, lower fuel use, better capture of recyclables or improved response time.

Technology	Evidence in current sources	Status	WISE-WASTE implication
Fill-level sensors	Documented on recycling-site containers	Existing/introduced	Expand to high-use locations; connect to collection scheduling
GIS	Planned for waste-pollution control and notification system in 2026	Planned	Use as common spatial platform for containers, routes, hotspots and recycling points
Vehicle GPS/telematics	Not verified in current evidence base	Gap to verify	Assess current fleet coverage before procuring additional systems
Route optimization	Not verified	Development opportunity	Use only after reliable route, container and fill data are available
Citizen mobile app	Not verified	Development opportunity	Could support missed-collection reports, maps and notifications
Digital KPI dashboard	Not documented as integrated system	Development opportunity	Combine collection, landfill, recycling, composting and sensor data
Automated fee system	Documented historically	Administrative digital capacity	Update/integrate with service and cost data where appropriate



Figure 8. Proposed integrated smart-waste architecture for Kutaisi.

1.9 Current-system assessment

The current Kutaisi system can be characterized as a transitional municipal model: universal collection coverage is established, selected recyclable streams are separated, centralized green-waste composting is operational, and first smart-monitoring elements are present. However, the system is not yet fully integrated. The largest practical gaps are data standardization, verified current asset inventories, higher material capture, digital linkage between sensors and operations, full use of composting capacity, and organized management of inert/construction waste.

2. Regulatory Compliance and Obligations

2.1 Applicable framework

The current Kutaisi Municipal Waste Management Action Plan for 2025-2027 was formally approved by Kutaisi City Council on 31 July 2025 (Resolution No. 380), providing an official basis for current municipal targets and planned actions [19].

The applicable legal and policy framework is built around the Waste Management Code of Georgia [7], the National Waste Management Strategy 2016-2030 and current national action planning [6], relevant technical regulations, the Local Self-Government Code and EU-Georgia Association Agreement commitments. The Waste Management Code establishes the legal basis for prevention, collection, transport, recovery, recycling, composting and disposal.

The Waste Management Code of Georgia assigns municipalities important responsibilities in the municipal waste management system. In particular, municipalities shall provide:

a) municipal waste collection, establishment of a collection system for this purpose and

ensuring proper functioning of such a system;

b) the gradual introduction and operation of waste collection systems for separate collection of municipal waste."

The National Waste Management Strategy of Georgia 2016-2030, which was adopted in 2016 and updated in 2021, provides for the introduction of modern approaches to municipal waste management and the provision of waste prevention and recycling policies. Under the amendment, four new strategic objectives were added to nine already existing goals of the Strategy to address new challenges. And one of the new strategic objectives is the creation and implementation of biodegradable waste collection and treatment systems.

The National Waste Management Strategy 2016-2030 also seeks to ensure the best international experience in the process of developing a waste management system in Georgia - through gradual convergence with the aims of the European waste management policy.

Composting as a biodegradable waste processing technology is widely used in developed countries.

The policy hierarchy is consistent with European waste-management principles: prevention is preferred, followed by preparing for reuse, recycling, other recovery and disposal. A recent study on energy recovery emphasizes that energy recovery should complement rather than displace recycling and reuse, particularly because high-calorific fractions such as plastics and paper are also valuable recyclable materials.

Instrument	Relevance to Kutaisi report
Waste Management Code of Georgia	Defines municipal waste responsibilities, recovery concepts, separate collection and planning obligations.
National Waste Management Strategy 2016-2030	Sets the national direction toward prevention, recycling, source separation and improved management.
National Waste Management Action Plan 2022-2026	Provides the current national action context referenced in the municipal SWOT and scientific sources.
Local Self-Government Code	Assigns municipal responsibilities including collection and removal of household/municipal waste.
Technical Regulation on Municipal Waste Collection and Treatment	Referenced in the 2018 plan as Government Resolution No. 159 of 1 April 2016.

Instrument	Relevance to Kutaisi report
EU-Georgia Association Agreement	Drives approximation toward EU environmental and waste-management requirements.
Directive (EU) 2018/851	Used for terminology and comparison with EU definitions of municipal waste.
Landfill Directive 1999/31/EC	Relevant to biodegradable waste diversion and landfill-related policy context.

2.2 Municipal responsibilities and institutional structure

The Kutaisi Municipal Waste Management Plan 2018-2022 assigns responsibility for municipal waste generated within Kutaisi to the local self-government. It describes a structure involving the municipality's infrastructure/cleaning functions and the municipal non-commercial legal entity 'Special Services', which performs operational tasks such as street cleaning, waste collection and removal and related municipal services. The Solid Waste Management Company of Georgia is identified as responsible for final disposal infrastructure outside the municipal collection function.

The Kutaisi Municipal Waste Management Plan 2025-2027 continues to assign responsibility to Kutaisi Municipality and Special Services for collection assets, illegal-dumping control, separate collection, composting and awareness activities. This continuity is an institutional strength because smart-waste projects can be embedded in an existing operational organization rather than created as a parallel structure.

In practical terms, this division means that Kutaisi Municipality must organize collection, transport, source-separation and local recovery programmes, while final disposal infrastructure involves national-level institutions. For smart management, clear data exchange is therefore required between local collection functions, disposal operators, EPR organizations and private recyclers.

2.3 Current municipal targets

The current Municipal Waste Management Plan of Kutaisi frames its vision as ensuring a clean and healthy living environment through modern approaches focused on waste prevention and recycling. It identifies four principal priorities: improvement of collection and transport; improvement and expansion of separation; development of green-waste composting; and environmental awareness and citizen participation.

The Plan sets expected indicators including 100% municipal waste collection, source-separation targets for 2027 of 50% for paper, 50% for glass, 50% for plastic and 80% for metal, and a 50% increase in green-waste composting [3]. These are planning targets, not measured 2025 results, and should therefore be monitored using a clearly defined baseline, numerator and denominator.

2.4 Compliance assessment

Requirement / policy direction	Current local evidence	Assessment
Municipal collection coverage	Whole municipal territory covered	Substantially established; service-quality optimization remains necessary
Progressive source separation	Plastic separation operating; paper/cardboard recovery; multi-material sites planned/introduced	Partially implemented; capture must increase to meet targets
Waste prevention / recovery hierarchy	Municipal plan prioritizes separation, recycling and composting	Policy alignment is evident; measured diversion performance needs stronger data
Biodegradable-waste treatment	Kutaisi Composting Center operating since 2	Strong local asset; utilization and mass-balance reporting need improvement
Polluter-pays / cost recovery	Current plan continues emphasis on cleaning-fee collection	Implementation continues; full cost recovery should be monitored
Illegal-dumping control	Monitoring, removal, sanctions and GIS action included	Formal actions defined; performance indicators should be introduced
Inert / construction waste	Separate municipal system not yet fully organized	Clear compliance and infrastructure gap
Digital reporting / smart monitoring	Sensors documented; GIS planned	Emerging capacity; integrated digital reporting not yet demonstrated

3. Assessment of Local Challenges

Challenge	Evidence-based interpretation
Data quality	Approximate and inconsistent waste quantities; no current regular composition study.
Collection infrastructure	Need for additional containers, renewed collection vehicles and improved service frequency in specific areas.
Separate collection	Infrastructure and capture rates remain insufficient relative to estimated recyclable quantities.
Local processing capacity	Limited local sorting/recycling infrastructure; dependence on downstream markets and external facilities.
Biodegradable waste	Strong composting asset exists, but mass-balance data and capacity utilization need improvement.
Inert/C&D waste	Separate collection is not fully organized; uncontrolled disposal remains a concern.
Digital integration	Sensors and planned GIS are positive, but no fully integrated operational data platform is documented.
Citizen participation	Historical willingness exists, but participation depends on accessibility, communication and consistent service.
Financial sustainability	Historical documents report that cleaning-fee revenue did not fully cover waste-management costs.
Disposal dependency	Landfill remains structurally important; regional disposal infrastructure delays are identified as a threat.

3.1 Infrastructure deficiencies

The current Municipal Waste Management Plan identifies the need for additional collection containers and fleet renewal. The separate-collection network does not yet provide sufficient capture of high-volume recyclable streams, while local sorting and processing capacity remains limited. Inert and construction waste lack a fully organized collection and reception system. These issues require investment, but the sequence of investment should be driven by verified service data rather than by equipment procurement alone.

3.2 Social and behavioral barriers

A 2026 needs assessment, prepared within the Go2Recycling Project, covering stakeholders from all 12 Imereti municipalities provides useful regional context for Kutaisi. Fifty-six percent of respondents reported that separate collection was not implemented in their municipality, while 39% reported that it was implemented. The leading barriers were insufficient technical equipment (39.45%), insufficient funding (21.0%) and insufficient experience (18.43%). The most frequently requested forms of support were technical equipment (54.8%), training in integrated waste management (38.1%), access to best practices (31.0%) and professional staff training (23.8%) [15].

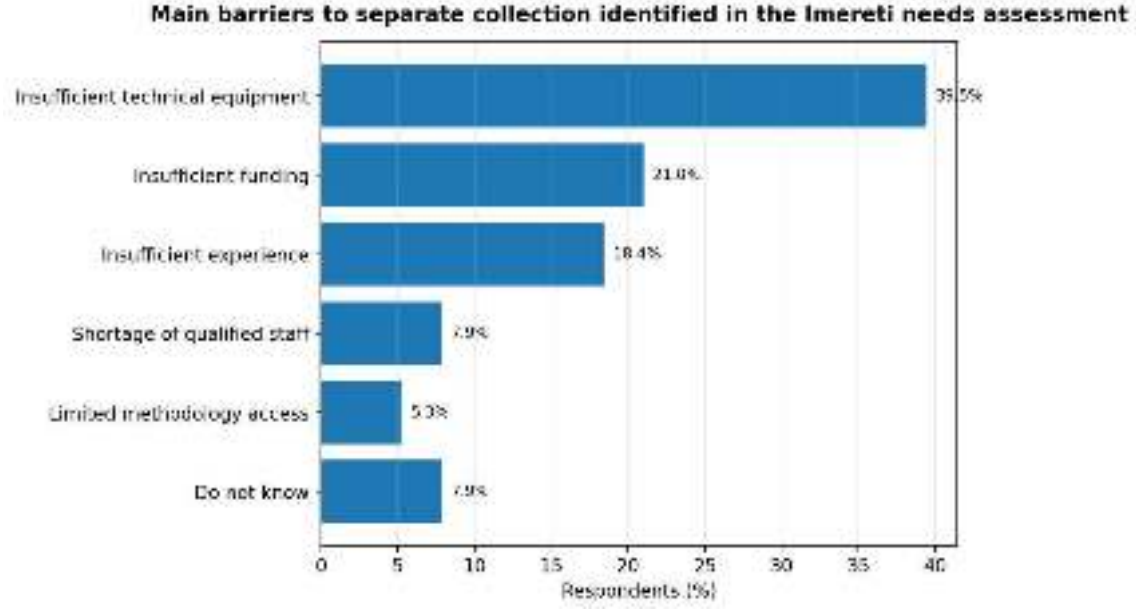
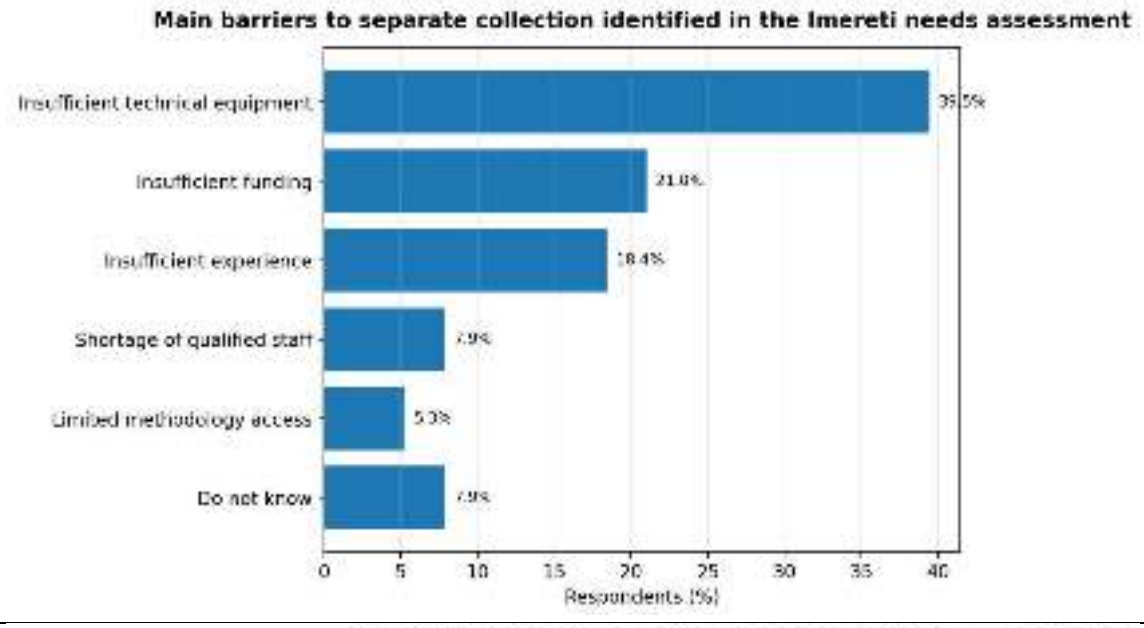


Figure 10A. Main barriers to separate collection identified by Imereti stakeholders.
Source: Imereti needs assessment [15].



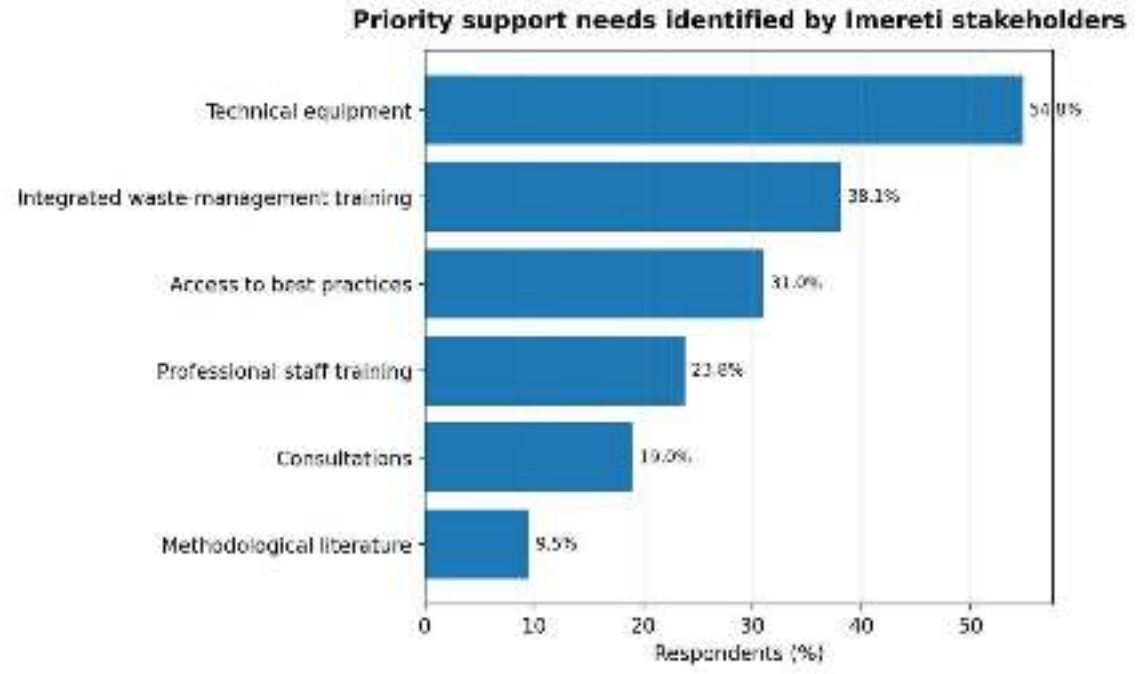


Figure 10B. Priority support needs identified by Imereti stakeholders.
Source: Imereti needs assessment [15].

Historical survey evidence demonstrates willingness to participate in plastic separation, but also showed that container proximity was a major limitation. This remains an important design principle: awareness campaigns cannot compensate for inconvenient infrastructure. Future programmes should therefore link communication, physical access, clear sorting rules and reliable collection service.

3.3 Financial and planning constraints

Kutaisi's 2025 municipal budget allocated GEL 9.35 million to programme 03 01, 'City Cleaning and Waste Removal' [17]. Following the May 2026 amendment, the corresponding 2026 allocation is GEL 10.15 million [17]. These are broad service-program allocations rather than recycling-only investment budgets, but they provide a current benchmark for municipal financing and reinforce the need to assess smart-technology investments against measurable operating savings, service-quality gains and landfill diversion.

Historical municipal planning records show that cleaning-fee revenues did not fully cover waste-management costs. Current planning continues to emphasize fee collection and polluter-pays principles. Future financial analysis should add the avoided costs and recovered value associated with recycling, cardboard sales, composting and optimized collection so that smart-waste investments can be assessed on whole-system economics.

3.5 Environmental risks

The main environmental risks are continued landfilling of recoverable material, illegal dumping, uncontrolled construction/inert waste disposal, and loss of biodegradable resources that could be composted. The local riverine and urban setting also makes rapid removal of illegal deposits and prevention of litter migration important for pollution reduction.

4. SWOT Analysis - Integration of Smart Technologies

The SWOT below is intentionally focused on smart-technology integration, as required by the methodology, rather than on the waste sector in general.

SWOT dimension	Assessment
Strengths	Citywide collection coverage; established municipal operator; plastic source separation since 2015; measurable cardboard recovery; operating green-waste composting center; recycling sites with fill-level sensors; planned GIS; experience with donor-supported projects; active NGO and educational partners; local technical/scientific expertise.
Weaknesses	Fragmented data; insufficient current asset inventory; need for fleet and container renewal; low capture relative to recyclable potential; limited local sorting/recycling capacity; no recent comprehensive composition study; incomplete inert-waste system; continued disposal dependency; limited evidence of integrated telematics/route optimization.
Opportunities	Scale sensor-equipped recycling sites; create GIS-based asset and hotspot map; integrate fleet telematics; route optimization; expand paper/plastic/glass collection; stronger EPR coordination; maximize composting capacity; home/community composting; citizen reporting tools; EU/Black Sea cooperation and funding; performance-based service contracts.
Threats	Delayed disposal infrastructure; equipment maintenance failure after pilot funding; low market prices for recyclables; contamination of separated streams; insufficient public convenience/adoption; uncontrolled C&D dumping; fragmented institutional data; procurement or vendor-lock-in risks; environmental impacts if recycling facilities are poorly managed.

4.1 Smart-technology priority matrix

Technology / tool	Local problem addressed	Readiness	Recommended priority
Fill-level sensors	Overflow and unnecessary servicing	Existing pilot/introduced infrastructure	High - expand selectively and evaluate performance

Technology / tool	Local problem addressed	Readiness	Recommended priority
GIS asset and hotspot mapping	Fragmented spatial information / illegal dumping	Planned for 2026	Very high - foundational platform
Vehicle GPS/telematics	Route verification, fuel and service performance	Current status not verified	High - verify baseline, then close gaps
Route optimization	Fixed routes may not reflect actual demand	Dependent on reliable data	High after sensor/GPS baseline
Digital KPI dashboard	Fragmented operational reporting	Not documented as integrated	High - once data model is standardized
Citizen app / reporting portal	Missed collections, recycling maps, illegal-dumping reports	Not verified	Medium - after municipal response workflow is defined
Smart compacting bins	High-use locations with space constraints	No local evidence yet	Selective / case-by-case
Composting process sensors	Process control and quality	Basic monitoring tools planned	Medium-high for facility performance

5. Community and Institutional Actions

Kutaisi has a comparatively strong history of municipal–NGO–education cooperation, but future actions should be tied more explicitly to measurable waste outcomes.

5.1 Existing public-awareness and education activity

Public participation has been a recurring element of Kutaisi's waste-management planning. The Kutaisi Municipal Waste Management Plan 2018-2022 describes a 21-member working group involving local government, NGOs, educational and medical institutions, business and media representatives, as well as public discussion of the municipal plan. It also links public participation to Georgia's obligations under the Aarhus Convention.

The same Plan describes awareness campaigns, clean-up actions, educational television and radio programmes and public information on plastic separation.

Both the historical and current Municipal Waste Management Plans emphasize the role of NGOs, schools, universities and media in environmental education. The MWM Plan 2025-2027 specifically identifies Imereti Scientists' Union “Spectri” as an organization with experience in environmental education and waste-management awareness, and calls for stronger NGO networks and educational involvement. “Spectri” has gained significant experience in combining environmental education with practical community engagement. Particular attention is given to promoting waste prevention, source separation, recycling and composting, encouraging behavioral change, and strengthening the participation of citizens and local communities in sustainable waste management.

The current Waste Management Plan of Kutaisi includes training seminars for target groups such as teachers and journalists, support for environmental education clubs in public schools, youth summer camps, eco-competitions, information materials on separation and recycling, clean-up activities, international environmental days and greening activities.

Awareness programmes should be evaluated by results rather than by the number of events alone. Recommended indicators include the number of households with convenient access to separation, participation rate, kilograms of material captured per participating household, contamination rate, number of schools actively separating waste, households participating in composting, repeat participation and changes in awareness before and after campaigns.

The municipality should also segment communication by generator type. Households need clear sorting rules and convenient access; markets and shops need collection schedules and storage requirements; schools need practical learning activities; and construction-sector actors need information on inert-waste rules and service options.

5.2 Private-sector and EPR engagement

Commercial actors are important both as waste generators and as potential partners in recovery. The municipal strategy highlights markets and large commercial centres for collection of paper/cardboard, plastic, glass and used batteries. Existing cardboard recovery from markets demonstrates that targeted commercial arrangements can produce measurable material and financial outcomes. Future EPR cooperation should define collection responsibilities, handover points, data reporting and final recovery destinations.

5.3 Effectiveness assessment

Action area	Existing evidence	Effectiveness issue / next step
Plastic awareness and separation	Long-standing public experience; historical survey showed willingness	Improve proximity/access and measure current participation
Cardboard collection	103 t sold in 2023 and 118.2 t in 2024; 192.6 t in 2025; revenues publicly reported	Expand to more commercial generators; report annual tonnage, contamination and revenue
School / youth education	Strong municipal and NGO planning role	Link education to actual separation/composting performance
Clean-up campaigns	Regular awareness value	Track material collected and recurrence of hotspots
Home/school composting	Planned/promoted in current strategy	Use pilots with training, follow-up and diversion estimates
Digital citizen engagement	GIS notification planned; dedicated app not verified	Build only when municipal response workflow and metrics are defined

5.5 Recommended community and institutional measures

- Formalize annual municipality–NGO–school cooperation around measurable separation and composting objectives.
- Prioritize commercial generators with high volumes of clean cardboard, paper, glass and plastic.
- Use simple incentive/recognition mechanisms for verified separation by businesses and institutions.
- Publish recycling-point maps and clear sorting rules through municipal digital channels.
- Use schools as demonstration sites for source separation and small-scale composting.
- Evaluate campaigns using participation, capture, contamination and repeat-engagement indicators.

6. Strategic Development Needs

6.1 Immediate / low-cost actions (0-6 months)

1. Validate and reconcile 2022-2025 annual waste quantities using weighbridge and operator records, and clearly document any partial-year values or residual discrepancies.
2. Create or update a GIS map of containers, recycling sites, waste reception points, composting infrastructure and illegal-dumping hotspots.
3. Prepare a standardized reporting form for cardboard, plastic, glass, metal and composting streams.

6.2 Short- to medium-term actions (6-18 months)

1. Expand multi-material recycling sites in locations selected using generation, accessibility and overflow data.
2. Extend fill-level sensors to high-use containers and integrate alerts with collection scheduling.
3. Implement the planned GIS waste-pollution monitoring and notification functions and link them to operational response workflows.
4. Pilot route optimization using verified container, sensor and vehicle data; measure kilometres, fuel and overflow events before and after the pilot.
5. Expand targeted cardboard and paper collection from markets, retailers and other high-volume commercial generators.
6. Increase separate plastic collection and monitor capture rate and contamination, not only container numbers.
7. Increase green-waste delivery to the composting center and weigh all inputs and outputs.
8. Pilot home and school composting with training, follow-up and simple performance indicators.
9. Conduct a new municipal waste-composition study with seasonal sampling and harmonized methodology.

6.3 Medium- to long-term actions (18-36 months)

1. Integrate GIS, sensor, fleet, recycling and composting data into a common municipal dashboard.
2. Expand GPS/telematics and route optimization if pilots demonstrate measurable operational savings.
3. Create a structured municipal/EPR data exchange for relevant product-waste streams.
4. Develop or formalize an organized system for inert and construction waste, including designated reception/disposal, service rules and enforcement.
5. Assess regional cooperation for sorting, recycling and residual treatment where single-municipality scale is insufficient.

6. Introduce performance-based service requirements, including digital reporting and measurable recycling/separation KPIs.
7. Develop citizen-facing digital tools such as recycling-point maps, missed-collection reporting and targeted service notifications.
8. Establish an annual public municipal waste-performance report

6.4 Best-practice adoption principles

The Imereti Zero Waste Strategy 2026-2030 reinforces the same direction at regional level. It prioritizes waste prevention, universal separate collection, expansion of composting, recycling and resource recovery, reuse and repair, elimination of illegal dumping, education and participation, and digitalization of waste management. Its digitalization goal calls for smart containers, real-time monitoring, mobile applications, regional databases and GIS, while the overall strategy sets 2030 ambitions for higher recycling, composting, separate-collection coverage and landfill diversion.

European and international practice should be adapted to Kutaisi rather than copied mechanically. Technologies should be selected for documented local problems, tested against a baseline and retained only when they generate measurable improvement. For example, fill-level sensors are most valuable at locations with variable demand or recurrent overflow; route optimization requires reliable route and fill data; and a citizen application is valuable only if reports trigger a defined municipal response.

Every proposed smart technology should be assessed against a small set of decision rules: Does it solve a documented local problem? Is there a baseline against which improvement can be measured? Can the municipality maintain the technology after external funding ends? Can data be exported and integrated? Is the procurement proportionate to expected savings or environmental benefit? For collection and organic-waste interventions, implementation should also draw on European Commission separate-collection guidance] and UNEP composting guidance.

For example, fill-level sensors are most useful on containers with variable demand or recurrent overflow, not necessarily on every container. GPS is most useful when route performance is actively analysed. A mobile application creates value only when reports are linked to municipal response processes. A dashboard is useful only when underlying data are accurate.

6.5 Measurement and evaluation

Kutaisi should report a concise core set annually, using consistent units and definitions.

Indicator	Unit	Preferred data source
Municipal waste collected	t/year	Verified annual weighbridge/operator data
Municipal waste generation per capita	kg/person/year	Annual waste quantity divided by same-year population
Waste sent to landfill	t/year and %	Disposal operator records
Paper/cardboard separately collected	t/year and capture %	Municipal + verified commercial/EPR data
Plastic separately collected	t/year and capture %	Municipal + verified downstream data
Glass separately collected	t/year and capture %	Municipal/EPR data
Metal separately collected	t/year and capture %	Municipal/EPR/private reception data
Green waste delivered to composting	t/year	Weighed input
Finished compost produced	t/year	Weighed output
Composting capacity utilization	%	Verified throughput/design operating capacity
Mixed-waste containers	number	Current GIS asset inventory
Recycling containers	number	Current GIS asset inventory
Sensor-equipped containers	number and %	Smart-asset register
Container overflow events	events/month	Sensor/complaint/inspection records
Illegal-dumping events	events/year	GIS/inspection data

Conclusions

Kutaisi has developed several of the building blocks required for a modern, circular and increasingly smart municipal waste-management system. Citywide collection coverage, long-standing plastic separation, measurable cardboard recovery, an operating green-waste composting center, multi-material recycling sites, fill-level sensors, planned GIS use and active

institutional/community partnerships provide a stronger starting position than a system based only on mixed collection and disposal.

At the same time, the transition remains incomplete. Large quantities of recyclable and biodegradable material continue to be associated with the mixed waste stream; technical equipment requires further investment; separate collection must be expanded substantially to approach municipal targets; inert and construction waste need a more organized system; and disposal infrastructure remains strategically important.

The most important cross-cutting issue is data quality.

The recommended development model is integration rather than isolated technology acquisition. Kutaisi should connect source separation, smart monitoring, GIS, optimized collection, recycling, composting, data validation, performance indicators and citizen participation into one management cycle. Technology should be selected because it solves a documented problem and produces measurable improvement, not because it is technologically advanced in isolation.

References

[1] WISE-WASTE. Methodology for the preparation of a comparative analysis and joint report on waste management. Project: Collaboration for smart solutions for waste management and pollution reduction in urban, rural, and coastal areas of the Black Sea basin.

[2] Kutaisi Municipality. Municipal Waste Management Plan 2018-2022. Municipal planning document prepared under the Waste Management Code of Georgia.

[3] Kutaisi City Council. Municipal Waste Management Action Plan 2025-2027. Approved 31 July 2025.

[4] Tskhakaia, K. Energy Recovery Potential of Municipal Solid Waste Generated in Georgia. Environmental and Climate Technologies, 2026.

[5] Tskhakaia, K. Biodegradable Waste Management in Georgia: Opportunities and Challenges. Environmental and Climate Technologies, 2024, 28.

[6] Ministry of Environmental Protection and Agriculture of Georgia. National Waste Management Strategy 2016-2030 and National Waste Management Action Plan 2022-2026.

[7] Parliament of Georgia. Waste Management Code of Georgia. Legislative Herald of Georgia (Matsne). https://matsne.gov.ge/en/document/view/2676416

[8] Denafas, G., Ruzgas, T., Martuzevicius, D., et al. Seasonal variation of municipal solid waste generation and composition in four East European cities. Resources, Conservation and Recycling 89 (2014), 22-30. https://doi.org/10.1016/j.resconrec.2014.06.001.

[9] Chachkhiani, M., Allesch, A., Reichenbach, J., Huber-Humer, M. Formal and informal solid waste management in Kutaisi, Georgia: A status quo report based on material flow analysis. Waste Management & Research 41(4) (2023), 848-859. https://doi.org/10.1177/0734242X221135261.

[10] Directive (EU) 2018/851 of the European Parliament and of the Council amending Directive 2008/98/EC on waste. Official Journal of the European Union L 150/109 (2018).

[11] Kawai, K., Liu, C., Gamaralalage, P.J.D. CCET Guideline Series on Intermediate Municipal Solid Waste Treatment Technologies: Composting. UNEP, 2020. https://wedocs.unep.org/20.500.11822/33737

[12] Dubois, M., Sims, E., Moerman, T., Watson, D., Bauer, B., Bel, J.-B., Mehlhart, G. Guidance for separate collection of municipal waste. Publications Office of the European Union, 2020. doi:10.2779/691513.

[13] Kutaisi local operational monitoring record. Prepared cardboard and plastic bundles and finished organic fertilizer production, 2023-H1 2026. Current monitoring data provided for the WISE-WASTE assessment in 2026; bundle counts are activity indicators and are not equivalent to tonnes.

[14] Imereti Scientists' Union "Spectri". Zero Waste Strategy for the Imereti Region 2026-2030. Go2Recycling (BSB00027), Interreg NEXT Black Sea Basin Programme, 2026.

[15] Imereti Scientists' Union "Spectri". Best Practices and Needs Assessment for Implementing Zero Waste Principles in the Imereti Region, Georgia. Go2Recycling (BSB00027), 2026.

[16] Interreg Black Sea Basin Programme. MWM-GMR (BSB457) - Green Waste Composting Center in Kutaisi. 28 May 2021; updated project information. https://www.blacksea-cbc.net/eni-cbc-bsb-2014-2020/projects/stories/stories-2021/mwm-gmr-bsb457-green-waste-composting-center-in-kutaisi

[17] Kutaisi Municipality / Legislative Herald of Georgia (Matsne). Kutaisi municipal budget acts: 2025 budget (programme 03 01: GEL 9.35 million) and 2026 budget as amended on 27 May 2026 (programme 03 01: GEL 10.15 million). https://matsne.gov.ge/ka/document/view/6335767 ; https://matsne.gov.ge/ka/document/view/6870507

[18] Imereti Scientists' Union "Spectri". Go2Recycling (BSB00027): Transnational Cooperation for Sustainable Waste Management and Recycling Practices in the Black Sea Basin. Project page, 2024-2026. https://spectri.org.ge/portfolio-view/transnational-cooperation-for-

sustainable-waste-management-and-recycling-practices-in-the-black-sea-basin-go2recycling-bsb00027/

[19] Kutaisi Municipality official documents portal. Resolution No. 380, Approval of the Municipal Waste Management Action Plan of Kutaisi Municipality for 2025-2027, 31 July 2025. https://kutaisi.gov.ge/documents?page=15

[20] United Nations Development Programme (UNDP). Kutaisi's Eco-Smart Journey, 22 January 2025. EU-UNDP Mayors for Economic Growth (M4EG) support; sensor-equipped waste containers; 2023 and Jan-Nov 2024 household-waste quantities; 2023-2024 cardboard-recycling results. https://www.undp.org/georgia/stories/kutaisi

[21] National Statistics Office of Georgia (Geostat). Statistical Yearbook of Georgia 2025, Table 2.17, Population in Cities and Boroughs (at the beginning of the year); Kutaisi: 123.7 thousand in 2025. https://www.geostat.ge/media/76143/Yearbook_2025.pdf