



PR1: Baseline assessment

T1.3: Current Waste Management Practices Assessment

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Contents

List of Tables	5
List of figures	6
Abbreviations.....	7
Executive summary	8
1 Introduction	1
1.1 Brief project description.....	2
1.1.1 Projects results.....	4
2 EU and national policies on waste management	5
2.1 EU policies	5
2.2 National policies	8
2.2.1 Greece.....	8
2.2.2 Croatia.....	10
2.2.3 Serbia.....	12
2.2.4 Belgium	14
2.2.5 Cyprus.....	19
3 Waste production and composition in EU	21
3.1 Waste generation	21
3.2 Waste composition.....	25
4 Waste management practices in EU	28
5 Challenges and opportunities.....	35
6 Current waste management practices on enterprise level	36
6.1 Greece	36
6.1.1 Food waste behaviours of enterprises and consumers.....	36
6.1.2 Identifying crucial links	37
6.1.3 Qualitative analysis for separate collection of specific materials streams.....	38
6.1.4 Identifying specific challenges and opportunities	39
6.1.5 Challenges	39
6.1.6 Percentage/Level of waste reuse.....	41
6.1.7 Mandatory separation of waste streams.....	41
6.1.8 Best practices.....	42
6.2 Belgium.....	43
6.2.1 Food waste behaviours of enterprises and consumers.....	43
6.2.2 Identifying crucial links	46

6.2.3	Qualitative analysis for separate collection of materials streams.....	48
6.2.4	Identifying specific challenges and opportunities	49
6.2.5	Percentage/Level of waste reuse.....	50
6.2.6	Mandatory separation of waste streams.....	50
6.2.7	Best practices.....	51
7	Current waste management practices on municipal level	52
7.1	City of Zadar.....	52
7.1.1	Evaluation of regional and local policies and strategies on waste management.....	52
7.1.2	Collection systems.....	53
7.1.3	Waste production and composition.....	55
7.1.4	Waste management practices.....	55
7.2	City of Novi Sad	57
7.3	Evaluation of regional and local policies and strategies on waste management.....	57
7.4	Collection systems.....	57
7.5	Waste production and composition	59
7.6	Waste management practices	60
8	References.....	61

List of Tables

Table 1. Share of food waste at the different stages of the food supply chain (in %) according to different studies.....	2
Table 2: Project results leaders.....	5
Table 3. Total MSW generation in partner countries and the EU-29 over the last 5 years (in thousand tons).....	22
Table 4. MSW generation per capita in partner countries and the EU-29 over the last 5 years (in kg)	22
Table 5. Pollution taxes paid by households, in million Euros	25
Table 6. Waste composition – European regional averages and specific partner countries (%)	26
Table 7: Overview of food waste (food losses + inedible unavoidable residues in the Flemish agri-food chain, in tons, 2015	45
Table 8. Quantities of municipal waste in the Republic of Serbia in the period 2011-2020	59

List of figures

Figure 1. Green-house gasses (GHGs) emissions of 4 countries VS Food Wastage	2
Figure 2. The CE monitoring framework - Source: European Union, 2018.....	3
Figure 3. Municipal waste generation per capita in the EU-27 member states and Serbia between 2000 and 2020 (source of data: (Eurostat, 2022a)).....	21
Figure 4. MSW generation per capita to real GDP per capita (Eurostat, 2022a).....	23
Figure 5. Association between the generation of MSW and GDP per capita in the EU-27 and project countries (Eurostat, 2022a)	24
Figure 6. Composition of MSW in Europe (source: (Czajczyńska et al., 2017) based on based on OECD data for 1999)	25
Figure 7. MSW treated as a percentage of MSW generated in the EU-27 and Serbia (source of data: (Eurostat, 2022a)).....	28
Figure 8. Landfill of MSW per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a).....	29
Figure 9. Incineration of MSW per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a).....	29
Figure 10. Energy recovery from MSW) per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a).....	30
Figure 11. Recycling materials from MSW) per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a)	30
Figure 12. Composting and digestion of MSW per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a)	31
Figure 13. MSW management practices, based on 2018 data and onwards (Eurostat, 2022a)	31
Figure 14. Recycling materials per capita (in kg) in the EU-27 and project countries, 2010-2020 (Eurostat, 2022a).....	33
Figure 15. Composting and digestion per capita (in kg) in the EU-27 and project countries, 2010-2020 (Eurostat, 2022a).....	34
Figure 16. Energy recovery per capita (in kg) in the EU-27 and project countries, 2010-2020 (Eurostat, 2022a).....	34
Figure 17. Level of knowledge in Greece about food waste between consumers.....	36
Figure 18: Distribution of destinations of food waste in Flanders, in tons, 2015	45

Abbreviations

Abbreviation	Definition
APMS	Alternative Packaging Management System
CE	Circular Economy
EC	European Commission
EPA	Environmental policy agreement
EU	European Union
FLW	Food Loss and Waste
FW	Food Waste
GDP	Gross domestic product
HDPE	High-density polyethylene
HORECA	Hotel, restaurant, café accommodation and food service activities
IPCC	Intergovernmental Panel on Climate Change
MSW	Municipal solid waste
NSRF	National Strategic Reference Framework
NWMP	National Waste Management Plan
OER	Open Education Resource
OVAM	Public Waste Agency of Flanders
PET	Polyethylene terephthalate
PMD	Plastic, Metal cans & Drink cartons
PVC	Polyvinyl chloride
SDG	Sustainable Development Goals
SMEs	Small and medium enterprises
SRSS	Structural Reform Support Service
UN	United Nations
UNEP	United Nations Environment Programme
VET	Vocational Education and Training
WEEE	Waste Electrical and Electronic Equipment

Executive summary

Food loss and food waste have gained increasing public, academic and political attention, over the last decade. It has been estimated that about one third (1/3) of the food produced is lost and wasted, such a high scale of waste involves also significant resource, energy, environmental and socio-economic impacts. According to the UNEP Food Waste Index 2021, around 931 million tonnes of food waste were generated globally in 2019, of which 61% came from households, 26% from food service and 13% from retail. Food waste in the EU-28 was estimated to be around 88 million tonnes, with an associated cost of around 143 billion €.

As a first step towards identifying real solutions to tackle with the food waste problem and the conditions to apply them, this report aims to provide an assessment of current waste management practices, focusing mostly on municipal and enterprise levels. In this direction, the EU and partner countries policies on waste management are examined, waste generation and composition are analysed, and waste management practices in EU, together with the main challenges and opportunities are explored. Focusing on the enterprise level, the report provides insights from Greece and Belgium regarding food waste behaviours, separate collection of specific waste streams, mandatory separation of waste streams, and best practices among other issues. On a municipal level, the report is based on the participating municipalities, i.e., the City of Zadar and the City of Novi Sad to evaluate regional and local policies and strategies, to analyse the characteristics of the collection systems, to evaluate waste production and composition, and, finally, to explore current waste management practices.

1 Introduction

Food loss and food waste have gained increasing public, academic and political attention, intensifying relevant research (Aschemann-Witzel et al., 2015; Gruber et al., 2016; H. Charles J. Godfray et al., n.d.). It has been estimated that about one third (1/3) of the food produced is lost and wasted, such a high scale of waste involves also significant resource, energy, environmental and socio-economic impacts (Eshel et al., 2014). Food waste occurs after preparation, cooking, or serving, as well as from not consuming before the expiration date as a result of over-shopping, which might be associated with poor planning and bulk purchasing. In addition to this, cosmetically perfect supply pressures the food system so that could maintain the quality before reaching the consumer, leading to increased waste. Recently, the food waste crisis has been further impacted by the world-wide pandemic. With a study on COVID-19 and the food system suggesting that adopting circular practices hold the potential for a win-win solution, promoting the sustainable production and consumption of food while reducing its waste (Giudice et al., 2020).

In the HoReCa (Hotel-Restaurant-Catering/Café) sector the food waste constitutes a significant challenge, as this sector generates disproportionately large amounts of waste (von Massow & McAdams, 2015). Thus, the quantity and causes of food wastage are to be comprehended in order to explore and establish innovative strategies, under governmental supervision and legislative guidance, which could lead to its reduction. The United Nations (UN) has set a target of halving per capita global food waste at the retail and consumer levels and reducing food losses along production and supply chains by 2030, in the Sustainable Development Goals (SDG) Target 12.3. The rise of Industry 4.0 offers a promising and safer approach in the food industry, providing solutions during each level of the food supply chain further supporting the reduction of food loss and waste.

Food waste in the EU-28 was estimated to be around 88 million tonnes (Stenmarck et al., 2016). This estimation was for 2012 and equated to 173 kg of FW per person, with household and processing sectors contributing the most. According to the UNEP Food Waste Index 2021, around 931 million tonnes of food waste were generated globally in 2019, of which 61% came from households, 26% from food service and 13% from retail. Similarly, in EU the households generate more than half of the total food wasted, almost 47 million tonnes in a year (Stenmarck et al., 2016), highlighting the fact that an opportunity to feed the growing world population is missed. Yet, wasting food is not only an ethical issue but an economic also. Specifically, the cost associated with the food waste for EU-28 was estimated at around 143 billion €. Along with the negative economic impact of the FLW there are also environmental and social impacts (Chen et al., 2020; Corrado & Sala, 2018; De Laurentiis et al., 2020; Esposito et al., 2020; Lopez Barrera & Hertel, 2021; Priestley, 2016). Specifically, if FW was a country, it would be the 3rd largest country globally contributing to the greenhouse gasses emission (Figure 1) (Food and Agriculture Organization of the United Nations, n.d.).



Figure 1. Green-house gasses (GHGs) emissions of 4 countries VS Food Wastage

Data on food waste varies significantly according to the source. Evidently, one of the reasons for this is the different interpretation of what constitutes food waste (i.e., the lack of an agreed definition) and the different methodologies used for measuring it. Different studies present divergent data for each of the sectors of the food supply chain (Jenny Gustavsson et al., 2011; Stenmarck et al., 2016; University of Applied Sciences & iSuN - Institute of Sustainable Nutrition, n.d.). Table 1 presents the results of a selection of those studies and shows that food waste occurs along the entire food chain, though care should be taken when comparing the results as the methodology and definition of food waste used are not homogeneous. The high variability of the results highlights the need of additional and join efforts to enhance the availability, reliability and level of detail in data provided on FW generation.

Table 1. Share of food waste at the different stages of the food supply chain (in %) according to different studies

	FAO (Europe)	Foodspill (Finland)	FH Münster (Germany)	Bio Intelligence Service (EU)	Fusions (EU)
Production sector	23	19-23	22	34.2	11
Processing sector	17	17-20	36	19.5	19
Retail sector	9	30-32	3	5.1	17
Consumers	52	28-31	40	41.2	53

1.1 Brief project description

In view of the above challenges, the project aims to create a strategic educational, training and awareness alliance, aiming to achieve the ambitious target regarding food waste, between Municipalities and Small and Medium Enterprises so that both parties can implement smoothly and effectively the shift towards Circular Economy practices (including EU Directives targets, national laws and regulations) contributing to the protection of public health and the environment, the creation of environmental opportunities and the improvement of EU citizens' quality of life.

ADVANCE project will develop a Roadmap and develop a step-by-step methodology to implement the EU Circular Economy Action Plan in order the major players in managing food

waste (Municipalities and HORECA SMEs) to be able to adopt a circular transition strategy contributing to environmental protection and fight against climate change. To this direction, one of the main ADVANCE's ambition is to analyse and present digital appliances from IND 4.0 that could be utilized to boost the effectiveness, the speed and the cost-saving of Municipal and SMEs Circular Economy transition. ADVANCE project results and outcomes will be built around the needs of the main target population. Increased flexibility can be more effective for individuals who are less likely to be admitted and complete a standard VET track. To this extent, in order the Project to cover the needs of certain groups such as municipal workers, HO.RE.CA. low skilled workers and digital illiterate individuals who might have different background and starting point and therefore meet challenges in completing the training, all Project results will be tested against criteria like comprehensibility, effectiveness, terms understanding, plain language, to produce a tailor made and adapted VET program.

The main aim of the ADVANCE project is to (Figure 2):

- Assess the current food waste management practices in selected municipalities and SMEs in the HORECA sector
- Compare the assessment results above with the best practices in the relevant fields
- Develop a concrete set of Circularity Indicators that will be used to describe both the current and the future description – monitoring of food waste management
- Assess the gap between the baseline assessment and the requirements posed by the EU Circular Economy Action Plan using the Circularity Indicators
- Develop a Roadmap and develop a step-by-step methodology to implement the EU Circular Economy Action Plan requirements regarding food waste
- Present all the above as training/educational materials and implement training courses in selected municipalities and SMEs in the HORECA sector.
- Develop an Open Education Resource online platform which will host and include all the above

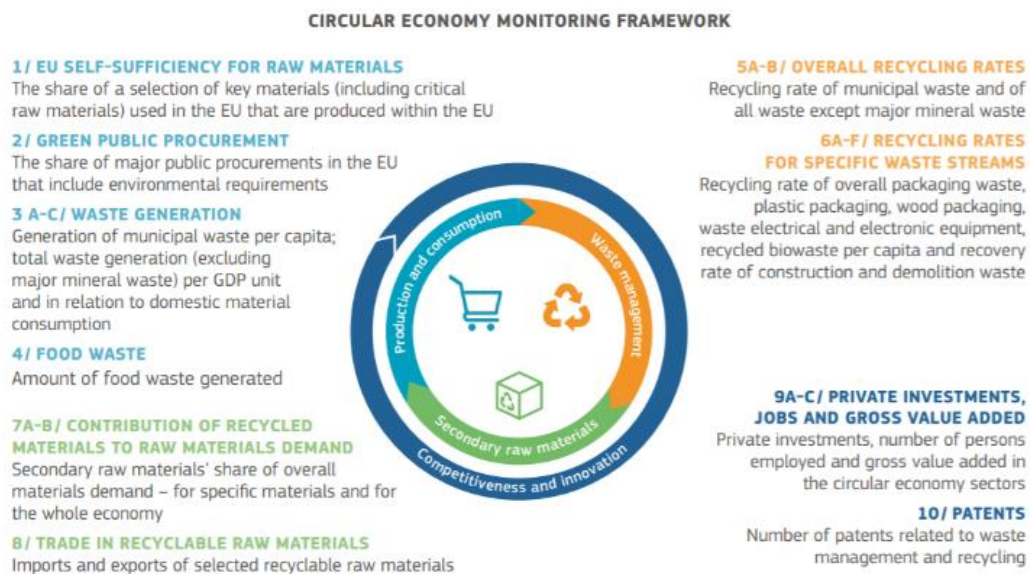


Figure 2. The CE monitoring framework - Source: European Union, 2018

1.1.1 Projects results

The project results are as follows:

- Baseline assessment (PR1) of the current waste food waste management practices in Municipalities and HORECA SMEs – the baseline assessment will also include benchmarking to existing best practices in EU
- Gap Analysis methodology and tool (PR2) between current and required, according to the EU targets, waste management practices relevant to food waste. The main outcome of the Gap Analysis will be the Circularity Gap Indicators that could be used in other cases too. These indicators concern both the municipalities involved and the HORECA SMEs that will participate in the program.
- Development of a Roadmap (PR3) – Design and development of a step-by-step methodological framework for implementing the food waste targets. The Roadmaps will be developed in two different types, one for Municipalities and one for HORECA SMEs. A special part of the Roadmaps will be to demonstrate how Industry 4.0 can help municipalities and SMEs to achieve better food waste management and advance food waste prevention. The Roadmap will be established on the outcomes of PR1 and PR2 and it will use the Circularity Gap Indicators as its main tool to guide the required steps.
- ADVANCE Course (PR4) – Creation of a training material broken down into certain learning modules for waste management adopted to the needs of target groups
- Open Education Resource (OER) – An Online Platform (PR5), which will include and host interactively all the above.

The above-mentioned results are expected to:

- Contribute, on a European level, to the development of indicators that can be used in other countries too, for the adaptation of municipalities and SMEs from the HORECA sector in the new context of circular economy.
- Contribute, on a European level, to the development of tools and training packages that can be used in other countries too for the adaptation of municipalities and SMEs from the HORECA sector in the new context of circular economy.
- Help Municipalities to develop and use tools that will allow them to identify the changes required to achieve the targets regarding food waste
- Help HORECA SMEs to develop and use tools that will allow them to identify the changes required to achieve the targets regarding food waste
- Prepare a core set of people, from municipalities and the HORECA sector, that can act as trainers for other people, thus stimulating the project's results dissemination and multiply its impacts
- Prepare a basis for the development of more advanced and in-depth training programs that will cover the current gap in skills and know-how regarding circularities in the food supply chain

The ADVANCE consortium consists of 7 partners from 5 EU countries (Greece, Cyprus, Belgium, Serbia and Croatia). The project team was established with these specific project partners considering their contribution to the completion of the project's results and the development



of high-quality products. They are all selected for their experience regarding the topic of the project, their background, their expertise in the fields of education, the perspective of dissemination and sustainability, their ability to access the target groups and other relevant local, national and European networks and the diversity of the organisations' types.

A leader to each Project Result of the ADVANCE Project is assigned, as follows (Table 2):

Table 2: Project results leaders

Project result (PR)	PR Leader
PR1. Baseline Assessment on Waste Management	D-WASTE
PR2. Gap Analysis Methodology and Tool	SIGMA
PR3. Development of ADVANCE Roadmap	D-WASTE
PR4. ADVANCE Course	NTUA
PR5. ADVANCE Online Platform	EUGENE

2 EU and national policies on waste management

2.1 EU policies

In 2014, the European Commission (EC) published a report entitled “Towards a circular economy: A zero waste programme for Europe”, and one year later a revised document was published by the EC entitled “Circular Economy closing the Loop – An EU Action Plan for the Circular Economy”. On March 11, 2020, building on the work done since 2015, the EC adopted a new Circular Economy Action Plan, which includes measures covering the whole cycle, from production and consumption to waste management and the market for secondary raw materials.

Regarding waste management, the focus is on avoiding waste altogether and transforming it into a high-quality and well-functioning market for secondary raw materials. The Action Plan will set an EU-wide, harmonised model for the separate collection of waste and labelling and will put forward actions to minimise EU exports of waste and tackle illegal shipments.

More specifically, the Action plan foresees new strategies, regulatory frameworks and mandatory requirements for:

- enhancing the sustainability and boosting the circular potential of batteries;
- promoting the reduction of (over)packaging;
- reducing plastics and microplastics and promoting bio-based and biodegradable plastics;
- strengthening textile reuse;
- having longer product lifetimes for electronics and ICT, and improving the collection and treatment of electronic and electrical waste;
- establishing a Sustainable Built Environment promoting circularity principles for buildings, and finally
- reducing food waste.

In this direction, the Action Plan introduced new waste management targets regarding reuse, recycling and landfilling, strengthens provisions on waste prevention and extended producer responsibility, and streamlines definitions, reporting obligations and calculation methods for targets, by proposing changes on the following legislations:

- Directive 2008/98/EC on waste
- Directive 1999/31/EC on the landfill of waste
- Directive 94/62/EC on packaging and packaging waste
- Directives 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, 2012/19/EU on waste electrical and electronic equipment (WEEE)

Given the focus of ADVANCE project on food waste, the analysis is limited to municipal waste, part of which is food waste. According to Directive 2018/851, the term “municipal waste” refers to:

(a) mixed waste and separately collected waste from households, including paper and cardboard, glass, metals, plastics, bio-waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, and bulky waste, including mattresses and furniture;

(b) mixed waste and separately collected waste from other sources, where such waste is similar in nature and composition to waste from households.

Following the above-mentioned definition, municipal waste originates from households, commerce and trade, small businesses, office buildings and institutions. Municipal waste, however, does not include waste from production, agriculture, forestry, fishing, septic tanks and sewage network and treatment, including sewage sludge, end-of-life vehicles or construction and demolition waste.

Nowadays, the most important pieces of legislation relating to municipal waste are, as follows (Municipal Waste Europe, 2020):

- Directive 2018/851 of the European Parliament and the Council on amending Directive 2008/98/EC on waste - Waste Framework Directive. It sets the basic concepts and definitions related to waste management, introduces the waste hierarchy, the Polluter Pays principle and the Extended Producer Responsibility and sets out separate collection targets.
- Directive 2018/850 of the European Parliament and of the Council amending Directive 1999/31/EC on the landfill of waste - Landfill Directive. It applies to all landfills, defines the different categories of waste, classifies the types of landfills and obliges Member States to minimise biodegradable waste to landfills.
- Directive 2018/852/EC 2018/852 of the European Parliament and of the Council amending Directive 94/62/EC on packaging and packaging waste - Packaging and Packaging Waste Directive. It sets out measures and requirements for the prevention, re-use and recovery of packaging wastes in Member States and implies the Producer Responsibility principle.

- Directive 2019/904 of the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment - Single Use Plastic Directive. It aims to reduce the consumption of single use plastics, states that Extended Producer Responsibility is involved in the targets and calls the Member States to ensure separate collection.
- Directive 2015/720 of the European Parliament and of the Council 2015 amending Directive 94/62/EC as regards reducing the consumption of lightweight plastic carrier bags - Plastic Bags Directive. It amends the Packaging and Packaging Waste Directive (94/62/EC) to deal with the unsustainable consumption and use of lightweight plastic carrier bags.
- Directive 2018/849 of the European Parliament and of the Council amending Directives 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment - Batteries Directive. It establishes rules regarding the market of batteries and accumulators and their collection, treatment, recycling and disposal.
- Directive 2018/849 of the European Parliament and of the Council of 30 May 2018 amending Directives 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment) – WEEE Directive. It amends Directive 2012/19/EU and establishes an obligation to collect WEEE separately for sorting and recycling. It also sets the framework for Extended Producer Responsibility and aims to prevent the generation of WEEE and to promote reuse, recycling and other forms of recovery.

Based on the latest Directives and their amendments, the following targets have been set:

- Separate collection of bio-waste by 31/12/2023 and of textiles and hazardous waste from households by 1/1/2025
- Preparing for re-use and recycling of municipal waste to a minimum of 55% by weight by 2025, 60% by 2030 and 65% by 2035, respectively
- Recycling of packaging waste to at least 65% by 31 December 2025 and 70% by 31/12/2030
- Reducing landfill to a maximum of 10% of generated municipal waste by 2035 and ban on landfilling of waste suitable for recycling effective from 2030.
- Recycling rate per material by 2025:
 - Plastics: 50%
 - Wood: 25%
 - Ferrous metals: 70%
 - Aluminium: 50%
 - Glass: 70%
 - Paper and cardboard: 75%
- Recycling rate per material by 2030:

- Plastics: 55%
 - Wood: 30%
 - Ferrous metals: 80%
 - Aluminium: 60%
 - Glass: 75%
 - Paper and cardboard: 85%
- Separate collection of plastic bottles up to 3 lt, to achieve 90% recycling by 2029 with an interim target of 77% by 2025. These bottles should contain at least 25% recycled plastics as raw material by 2025 (for PET bottles), and 30% by 2030 (for all bottles).

2.2 National policies

2.2.1 Greece

The legal framework that designates the direction of waste management in Greece follows closely the development of European waste management and the corresponding Directives. The most important laws, ministerial decrees and related EU Directives are the following:

- Ministerial Decision 39 (Gazette 185 A/2020) - Approval of the National Waste Management Plan, Official Gazette 185/A/29-09-2020
- Law 4685/2020 (Gazette 92 A/2020) - Modernisation of the Environmental Legislation, incorporation of Directives 2018/844 and 2019/692 of the European Parliament and the Council into Greek legislation and other provisions
- Greek National Circular Economy Strategy and Action Plan (2018)
- Law 4496/2017 (Gazette 170 A/2017) - Packaging and alternative management of packages and other products. Establishment of the National Organization for Alternative Management of Packaging and Other Products
- Law 4042/2012 (Gazette 24 A/2012) - Protection of the environment through criminal law in compliance with the Directive 2008/99/EC – Waste Production and Management Framework, in compliance with the Directive 2008/98/EC
- Ministerial Decree 41624/2057/E103 (Gazette 1625 B/2010) - Measurements, terms and program for alternative management of waste, electrical batteries and accumulators in conformity with the provision of the Directives 2006/66/EC and 2008/103/EC of the European Parliament and Council
- Ministerial Decree 9268/469/2007 (Gazette 287 B/2007) – Modification of the quantitative objectives for the recuperation and recycling of waste packaging according to article 10 (paragraph A1, last section) of law 2939/2001 (A' 179), as well as other provisions of this law, in conformity with provisions of the Directive 2004/12/EC

The timeline set for the different MSW management targets is practically the same as the one set by the EU Directives and CE strategy except for the separate collection of bio-waste

(Greece's target has been set for 31/12/2022 instead of 31/12/2023) and of textiles and hazardous waste from households (Greece's target has been set for 2023 and 2022, respectively, instead of 2025).

In addition to this, the National Waste Management Plan (NWMP) of Greece is a strategic and political planning for its waste management. Specifically, the development of the NWMP is an obligation for all the EU members and follows the article 28 of Directive 2008/98 / EC for waste (L312).

The main points of the strategy of the NWMP are presented below:

- Reduction of the municipal solid waste which is disposed in landfill. (<10% of the produced MSW could be deposited in the landfills)
- Introduction of waste prevention measures, reinforcement of recycling, promotion of secondary material market, raising public awareness, developing networks, supporting separate collection of recyclables and biodegradables and development of new waste management facilities.
- Improving separated recycling (separating materials by type at the point of discard so they can be recycled), enforcing this by the end of 2022.
- Setting recycling targets, based on the obligations which result from the EU legislation and particularly from the Waste Directives 2018/851 and 2018/852 (L 150), as well as the Disposable Plastics Directive 2019/904 (EU, L 155).
- Implementing the extended producer responsibility (EPR), so that the manufacturers of the products are responsible for the entire life cycle of the products and especially for the take – back system, recycling and final disposal of these products.
- Enabling and encouraging municipalities to create partnerships and cooperate with private sector to improve the waste management process.
- Constructing the necessary infrastructures (such as municipal solid waste treatment plans).
- Providing a specific plan for the development of new and improvement of existing collection network for recyclable materials and biodegradables.
- Following good European practices in terms of circular economy (e.g. utilization of alternative (to fossil) fuels).
- Taking into account tourism and specifically the waste generation that produces. (It is estimated that in Greece about 3.3 % of the produced MSW resulted from tourists arrived in the country (2018), with this number expected to rise and reach 5.4 % in 2025 and 7.5 % in 2030).

2.2.2 Croatia

Waste management in Republic of Croatia is governed by the Waste Management Act (Official Gazette 84/21) as an umbrella act. The Act is harmonized with EU directives in the field of waste management and it prescribes:

- measures to protect the environment and human health by planning or reducing the generation of waste, reducing the overall effects of the use of raw materials and improving the efficiency of the use of raw materials and increasing the recycling and reuse of recycled materials, which is necessary for the transition to a circular economy and ensuring the long-term competitiveness of the Republic of Croatia and the European Union;
- priority order of waste management, principles, goals and methods of waste management, planning documents, responsibilities and obligations in waste management; locations and facilities for waste management, cross-border transport of waste; information system, administrative and inspection control;
- conditions for the operation of the landfill and the requirements for the waste that is allowed to be disposed;
- measures for preventing and reducing the impact of certain plastic products on the environment, especially the aquatic environment;
- transition to a circular economy with innovative and sustainable business models, products and materials;
- measures to prevent the production of packaging waste and encourages the reuse of packaging, recycling and other forms of recovery of packaging waste and the reduction of the amount of final disposal;
- measures for achieving the goals of the European Green Plan.

Waste Management Plan of the Republic of Croatia 2017.-2022. (Official Gazette 3/17, 1/22) is an umbrella plan and it defines the measures that need to be implemented in order to achieve the goals in waste management as well as financial resources. This Plan also analyses the existing management systems for certain types of waste in Croatia, state of existing waste management facilities and providers of municipal waste collection. An integral part of this document is the Waste Prevention Plan, which analyses the current state of waste prevention and defines waste prevention measures.

Besides, a number of by-laws were adopted on national level, as follows:

- Rulebook on criteria, procedure and method of determining the amount of compensation to real estate owners and local self-government units (OG 59/06, 109/12)
- Rulebook on waste oil management (OG 124/06, 121/08, 31/09, 156/09, 91/11, 45/12, 86/13)

- Rulebook on the management of sludge from wastewater treatment plants when the sludge is used in agriculture (OG 38/08)
- Rulebook on management of waste electrical and electronic equipment (OG 42/14, 48/14, 107/14, 139/14, 11/2019, 7/20)
- Rulebook on management of polychlorinated biphenyls and polychlorinated terphenyls (OG 103/14)
- Rulebook on waste management from titanium dioxide production (OG 117/14)
- Ordinance on by-products and abolition of waste status (OG 117/14)
- Ordinance on medical waste management (OG 50/15, 56/19)
- Instruction on bulky waste (OG 79/15)
- Ordinance on packaging and waste packaging (OG 88/15, 78/16, 116/17, 14/20, 144/20)
- Rulebook on waste catalogue (OG 90/15)
- Rulebook on the management of waste textiles and waste footwear (OG 99/15)
- Ordinance on waste batteries and accumulators (OG 111/15)
- Ordinance on waste disposal methods and conditions, categories and operating conditions for waste disposal sites (OG 114/15, 103/18, 56/19)
- Rulebook on waste vehicle management (OG 125/15, 90/16, 60/18, 72/18, 81/20)
- Ordinance on construction waste and asbestos waste (OG 69/16)
- Rulebook on thermal treatment of waste (OG 75/16)
- Rulebook on waste tires management (OG 113/16)
- Rulebook on waste management (OG 106/22)
- Rulebook on waste management from the mining industry (OG 22/19).

Regarding to food waste, Ministry of agriculture has developed Program for the implementation of the Plan for prevention and reduction of food waste of the Republic of Croatia 2019 – 2022. Program has set up 6 measures for implementation (including activities and financing resources for each measure):

- Improvement of the food donation system in the Republic of Croatia
- Encouraging the reduction of food waste generation
- Promotion of social responsibility in the food sector
- Raising awareness and informing consumers about the prevention and reduction of food waste
- Determining the amount of food waste

- Investing in research work and innovative solutions that contribute to the prevention and reduction of food waste

2.2.3 Serbia

Waste management in the Republic of Serbia is based on a number of laws, bylaws and regulations (almost 30) which have to be harmonized with the EU legislation.

As part of the negotiations for accession to the EU, the Republic of Serbia, through Chapter 27, has begun the process of establishing a waste management system and adapting it to the EU goals.

The National Waste Management Strategy is an umbrella document that provides conditions for rational and sustainable waste management. Short-term and long-term goals are determined by the strategy.

Waste management in the Republic of Serbia is regulated by:

- Waste management strategy for the period from 2019 to 2024;
- Waste prevention program - WASTE MANAGEMENT PROGRAM OF THE REPUBLIC OF SERBIA FOR THE PERIOD 2022-2031;
- Law on Waste Management;
- Law on Packaging and Packaging Waste;
- Law on Fees for the Use of Public Goods,
- Law on Integrated Prevention and Control of Environmental Pollution,
- Regulation on Waste Disposal in Landfills;
- Decree on the plan for the reduction of packaging waste for 2025-2030
- Regulation on Construction and Demolition Waste Management;
- Regulation on minimum requirements for extended producer responsibility programs for certain specific waste streams;
- Regulation on Waste from Mercury and Mercury Compounds;
- Decree on Criteria for Selection of Waste Management Infrastructure Locations;
- Decree on the amount and conditions for the allocation of incentive funds
- Rulebook on categories, testing and classification of waste;
- Rulebook on the treatment of devices and waste containing (PCB);
- Rulebook on the list of electrical and electronic products, measures to prohibit and restrict the use of electrical and electronic equipment containing hazardous substances, methods and procedures for the disposal of waste from electrical and electronic equipment;
- Rulebook on the manner and procedures of managing used batteries and accumulators;

- Rulebook on the manner and procedure of waste vehicle management;
- Rulebook on the content of the request for entry in the Register of by-products and the Register of waste that has ceased to be waste;
- Rulebook on technical requirements and other special criteria for certain types of waste that cease to be waste;
- Rulebook on the manner and procedure of waste tire management;
- Rulebook on the manner and procedure of waste oil management;
- Rulebook on technical and other requirements for plastic bags with additives for oxidative degradation and biodegradation, on conformity assessment and conditions to be met by the notified body.
- Rulebook on technical and other requirements for plastic carrying bags and on conformity assessment;
- and other regulations arising from the obligation to comply with EU regulations.

The Waste Management Program in the Republic of Serbia for the period 2022 - 2031 (hereinafter: the Program) was preceded by the Waste Management Strategy for the period 2010-2019 ("Official Gazette of the RS", No. 29/10) (hereinafter: the Strategy), which set the conditions for the establishment and development of an integrated waste management system in the Republic of Serbia. During the previous period, the progress has been made in harmonizing waste management regulations with the EU regulations, in institutional strengthening and reaching regional agreements for the establishment of joint waste management, as well as in the construction of a number of sanitary landfills. The goals set by the Strategy have not been fully achieved, primarily in the scope of organized waste collection, the degree of primary waste separation and recycling, infrastructure construction and cessation of waste disposal at unsanitary landfills and dumps, application of economic instruments and establishment of sustainable waste management financing system. As the planned goals from the previous document were not fully achieved and as in the meantime new EU goals have been set in the field of waste management within the "green transition" for the transition to a circular economy in the EU, it is necessary to establish new goals in the field of waste management in the Republic of Serbia.

The program determines the strategic goals for the improvement of the waste management system and the basic principles that should guide all actors in waste management to achieve these goals in the Republic of Serbia for the period 2022 - 2031. The implementation of this program, in addition to reducing the harmful impact on the environment and climate change, should enable the realization of preconditions for the use of waste in the circular economy, for the development of which the goals and measures are determined in a special program. Also, special documents are being developed for the establishment of a waste sludge management system from wastewater treatment plants and for the treatment of animal by-products. Management of agricultural, mining and medical and pharmaceutical waste is planned through sectoral planning documents.

The waste prevention program is based on the principle of waste prevention and it is not a legal obligation.

The law on waste management does not regulate and define the basis for adoption Rulebook according to which biodegradable kitchen waste would be dealt with arises from the performance of the activity of preparing and serving food, as well as others activities, the performance of which constantly or occasionally produces food waste, that is, food that is unusable for the purpose for which it was originally intended. In accordance with the above, there is no primary separation of the above-mentioned waste and it cannot implement the EU thematic strategy on waste prevention and recycling whose goal is to use waste as a resource, primarily to obtain secondary raw materials and energy, which is one of the keys to the circular economy.

2.2.4 Belgium

As a consequence of the Belgian State reforms initiated in the 1980s, the three regions of the country (Flemish, Walloon and Brussels Capital) have become virtually exclusively competent for all environmental matters, including waste management. Specifically, as far as waste management is concerned, the most important pieces of legislation in the various regions are the following:

- Flanders:
 - Flemish Statutes (April 5th 1995) – General provisions in relation to environmental policy and its implementing decrees;
 - Materials decree (December 23rd 2011) – Decree on the sustainable management of material cycles and waste;
 - VLAREMA (February 27th 2012) – Decision of the Flemish Government establishing the Flemish regulation on the sustainable management of material cycles and waste;
 - EPA (June 15th 2018) – Environmental policy agreement on the take-back obligation for discarded portable and industrial batteries and accumulators;
- Wallonia:
 - Decree concerning waste products (June 27th 1996);
 - Order of the Walloon Government (September 23rd 2010);
 - Environmental Policy Agreement (December 5th 2013);
- Brussels Capital-Region:
 - Ordinance on waste materials (June 14th 2012);
 - Order of the Brussels Capital Regional Government (December 1st 2016);
 - Environmental Policy Agreement (June 14th 2019).

In every region, one or more specific regulatory authorities have been installed with a view to enforcing waste management legislation as well as general environmental legislation:

- in Flanders, the enforcement section of the Environmental Department and the Public Waste Agency (Openbare Vlaamse Afvalstoffenmaatschappij; OVAM) are the most important regulatory authorities;
- in Wallonia, the Department for Police and Controls (le Département de la Police et Contrôles; DPC) is the major regulatory authority;
- in the Brussels Capital-Region, the main regulatory authority is the Brussels Institute for Environmental Management (Leefmilieu Brussel).

Given that the regions are responsible for waste management, there is no national waste prevention program in Belgium. Nevertheless, as far as packaging waste is concerned, targets have been aligned at the federal level through a cooperation agreement. In the latter, the following recycling targets are set forth as of 2021 (all percentages refer to targeted recycling levels in terms of weight):

- 90% for glass, paper/cardboard, beverage cartons and ferrometals;
- 80% for wood;
- 75% for aluminium;
- 50% for plastics.

Furthermore, separate programs pertaining to waste prevention and management have been developed in each of the regions. Taking into account that the Belgian partner for this project (Horeca Partners) is located in Flanders, the remainder of this section focuses primarily on the Flemish region. Brief and general summaries are provided for the Walloon and Brussels Capital regions.

The Flemish Public Waste Agency (OVAM) generates plans for various waste and material streams, aimed at achieving EU and regional targets for reduction, reuse and recycling of waste. At the moment, policy plans are in place with respect to household waste and comparable company and/or commercial waste, plastics, biomass and food waste, sustainable building materials, asbestos, illegal dumping and littering:

- Flanders' main waste prevention policies are captured by the 'Implementation Plan for Household and Similar Industrial Waste'), replacing two previous documents, namely 'Environmentally responsible management of household waste for 2008-2015' and 'Separate collection of industrial waste from small businesses'. The new plan was originally adopted in 2016 and revised in May 2019. In principle, it is valid to the end of 2022, but it remains so as long as it is not replaced by another plan. Main priorities in the Flemish region's waste management are the prevention and reuse of waste. Thus, the principal objective is to reduce incineration and landfilling of household and industrial waste as much as possible, and the focus lies with waste prevention, reuse and material recycling. The plan covers various sectors, namely (1) agriculture, (2)

construction and infrastructure, (3) manufacturing, (4) wholesale, retail & transport, (5) households, (6) private service activities & hospitality, and (7) public services. It also targets the prevention of a wide range of waste types:

- food/organic;
 - construction and demolition waste;
 - hazardous waste;
 - household/municipal waste;
 - paper;
 - packaging;
 - waste electrical and electronic equipment (WEEE)/batteries;
 - manufacturing waste (similar to household waste);
 - other (e.g. textiles, plastics other than packaging, bulky waste);
- the purpose of the 'Plastics Implementation Plan (2020-2025)' and the 'Flemish Plan for Marine Litter' is to reduce the amount of plastic waste and stimulate the reuse of plastics;
 - the 'Packaging Plan (2018)' focuses on a number of issues: (1) fighting the problem of litter, (2) increasing separated collection and recycling, (3) giving more attention to the design and distribution methods with regard to packaging, and (4) increase local recycling;
 - the policy program 'Building Materials Sustainably in Cycles (2014-2020)' highlights the development of sustainable materials management as part of the transition to a circular economy;
 - the 'Asbestos Abatement Action Plan' seeks to achieve an asbestos-safe Flanders through the introduction of an asbestos inventory and the phased removal of high-risk asbestos applications;
 - the 'Circular Economy Roadmap' delineates how the region can organize its production and consumption systems for food, housing, mobility and comfort in a more circular manner;
 - the 'Soil Remediation of Polluted Sites – Objectives 2036' has as one of its main objectives to have started the remediation of all historical soil contamination by 2036;
 - the 'Action Plan for Circular Food Loss and Biomass (Residual) Flows 2021-2025' proposes policies to address food loss and food waste, as well as the circular use of biomass (residual) flows. The plan focuses on three cycles: (1) food loss and food waste streams from producer to consumer, (2) biomass (residual) flows from public space, nature, forestry and landscape management, and (3) wood (residual) flows from industry and households. Given that biomass and food (residual) flows are renewable,

versatile and biodegradable, they can play an important role in the circular economy. Therefore, within the materials policy, the emphasis is on separation at the source and separate collection of bio-waste from households and companies. The three policy objectives that are central to this action plan follow the materials hierarchy and the cascading principle. As such, they form the basis of the management of each cycle:

- more prevention, less loss;
- better sorting and collection;
- more high-quality valorisation.

Since municipalities play a crucial role in terms of the local implementation of the plans, the Flemish Public Waste Agency works closely together with them in order to develop tailor-made solutions to local recycling and waste management challenges, as well as to facilitate the transition to a circular economy. The various aforementioned plans are updated regularly to respond to changing circumstances, and describe the current status, challenges, obligations, conditionalities, actions to be taken, ways of financing and funding, etc. The plans also provide some specific targets and objectives, such as for example:

- a 15% reduction in industrial waste by the end of 2022, in comparison with 2013;
- to reach a reuse target of 7 kg per inhabitant by the end of 2022;
- manufacturers of products that account for a significant share of litter waste should be responsible for the costs of collecting and processing such litter by 2023;
- a 75% reduction of the amount of litter entering the marine environment by 2025;
- a 25% reduction in residual waste incineration by 2030, by intensifying the separate collection of recyclable waste streams. This ought to correspond to a drop in the amount of residual household waste from 145 kg per person to 100 kg per person by 2030;
- an increase to 77.5% with regard to the separate collection of waste for recycling by 2030;
- all packaging will have to be reusable, recyclable, compostable or biodegradable by 2025;
- PET bottles must contain 50% of recycled content by 2025;
- a quadrupling of the sorting and recycling capacity for plastics in Flanders by 2030;
- 70% recycling of plastic packaging waste from households and 65% recycling of industrial plastic packaging waste;
- instalment of the obligation to obtain an asbestos attestation when selling one's house as of 2022;
- the removal of the riskiest asbestos applications (e.g. asbestos cement roofs and facades) from Flemish buildings and homes by 2034.

Specifically, as far as food loss and food waste flows from producer to consumer are concerned, the major targets can be summarized as follows:

- all food retail (specialized and non-specialized), all food wholesalers and all food distribution centres should contribute to food donations and/or some other form of redistribution of food products for human consumption;
- compulsory separate collection of organic bio-waste and organic waste from all companies and households by the end of 2023;
- 85% recycling of organic waste, household and commercial organic waste by 2025. It should be emphasized that this is not a target as such for all green waste. The aim lies on the recycling rate per treatment plant and is consequently concerned with the processing efficiency of those installations;
- a 30% reduction in food losses and waste through prevention, re-use and separate collection by the end of 2025, compared to 2015;
- a 20% decrease in residual waste from businesses (hotels, restaurants, catering, hospitality, retail) by the end of 2025, compared to 2019;
- optimum valorisation of food waste flows by the end of 2025. Where this is not yet happening although it is possible and legally permitted, the aim is to valorise them higher up the cascade, i.e. a higher cascade index in comparison to 2015;
- as Flanders contributes to the UN Sustainable Development Goals (SDG 12.3) with actions to reduce food loss and waste in primary production, horticultural cooperatives, the food industry, food retail and distribution, restaurants, catering and households, it subscribes SDG 12.3's aim to halve food waste per capita worldwide by 2030, at retail and consumer levels;
- Flanders also contributes to the European Waste Framework Directive's target to have at least 60% of municipal waste reused or recycled by 2030.

In Wallonia, the plan for waste and resources has been in place since 2018. While no specific end date is mentioned in the plan, the aim is to revise it every six years. The main objectives consist of reducing the overall environmental impact by optimizing the use and preservation of resources and materials, preventing the generation of waste by promoting qualitative waste prevention actions, promoting that products and goods be reused, and developing innovations with respect to the reuse and recycling of waste.

The waste prevention and management plan of the Brussels Capital-Region was renewed in 2018 and has the 2018-2023 period as a main time frame. The general objectives of the plan include promoting the overall shift towards more sustainable company and consumer practices, maximizing the conservation and valorisation of resources, and leading the region's economy to circular practices. Some of the targets set forth in the plan are an overall 5% reduction for household and non-household waste by 2023 and 20% by 2030.

2.2.5 Cyprus

As expected, the Cypriot policy on waste management is influenced by the relative EU legislation and, in this direction, it follows the EU waste hierarchy (reduction, reuse, recycling, recovery, and disposal). In the above context and following the Directives of the European Commission (EC) on waste, the application of environmentally rational management of waste generated in Cyprus is achieved through the implementation of the Waste Law of 2011 (L.185(I)/2011) and the Packaging and Packaging Waste Law of 2002 (L.32(I)/2002) and their amendments, as well as the Regulations and Decrees issued in accordance thereof (Republic of Cyprus - Department of Environment, n.d.).

In accordance with the article 28 of Directive 2008/98/EC, the Department of Environment developed the 2012 Management Plan for Household and Similar Type of Waste, which changed into the 2015–2021 Waste Management Plan for promoting the proper management of MSW (Angelis-Dimakis et al., 2022; Republic of Cyprus - Department of Environment, n.d.). The main axes of the strategy, upon which this plan is based, are: (i) compliance with the obligations arising from the European directives on waste management that fall under the municipal waste stream; (ii) full utilization of existing private and state waste management infrastructure; (iii) maintaining the waste management hierarchy, with emphasis on prevention and separate sorting of waste; and (iv) the adoption of best practices with the lowest cost (Angelis-Dimakis et al., 2022). Moreover, in accordance with Article 29 of Directive 2008/98/EC, the Department of Environment prepared an independent waste prevention Programme for the period 2015 – 2021, which: (a) establishes quality objectives towards changing consumption patterns associated with the generation of waste, limiting the generation of certain waste streams, the promotion of re-use, the reduction of organic waste for burial and reducing the generation of hazardous municipal waste, (b) sets out the waste prevention measures for organic waste streams, paper/cardboard, plastics, electrical and electronic equipment, hazardous municipal waste, apparel, bulky and excavation waste, construction and demolition waste and (c) sets out the areas in which measures are targeted and are the main generators of waste, i.e. the households, the public sector, agriculture, tourism, construction and the private sector/companies/organizations (Republic of Cyprus - Department of Environment, n.d.).

Today, the reduction of waste production and the management of waste are promoted through the Waste Prevention Programme 2015-2021 and the Municipal Waste Management Strategy 2015-2021 (Republic of Cyprus, 2021). The Waste Prevention Programme & Municipal Waste Management Strategy focusing on measures covering the three main policy pillars (Republic of Cyprus, 2021):

- Pillar I: Regulatory measures to implement the separate collection of waste.
- Pillar II: Measures to reduce waste in all sectors and provide incentives for the reduction and appropriate management of waste.
- Pillar III: Information and awareness raising measures to change production and consumption patterns.

Within the above context, qualitative and quantitative objectives have been set, which are summarised as follows:

- 50% separate collection on total MSW and 15% separate collection of the organic waste in MSW by 2021;
- 50% recycling of paper, plastic, metal, and glass by 2021;
- Reduce landfilling to a maximum of 20% of MSW by 2021 and 10% by 2035;
- Increase recycling and reuse of municipal waste to 55% by 2025, 60% by 2030 and to 65% by 2035.

Nevertheless, the actual implementation of the Waste Management Plan was stalled due to cross-sectoral influences dominated by investments in natural gas exploration in the Cyprus Exclusive Economic Zone, and the lack of investment in private and State waste management infrastructure (Iacovidou & Zorpas, 2022).

Recognizing that further work is needed to achieve compliance with EU objectives and to facilitate the drive towards the circular economy, a new Municipal Waste Management Strategy 2021-2027, was prepared by the IMPEL Network (the EU Network for the Implementation and Enforcement of Environmental Law) through technical support from the European Commission's Structural Reform Support Service (SRSS). The Strategy builds upon the achievements of the MWMP 2015-2021 and defines the framework of actions and measures to be implemented over the next six years for the management of municipal waste (Dikigoropoulou, n.d.).

Moving forward, planned actions include programmes for (Republic of Cyprus, 2021):

- Integrated bio-waste source separation and central small and medium-size aerobic treatment systems and home composting.
- Green kiosks for dry recyclables.
- Reuse and Repair centres and networks.
- Establishment of a compulsory system for separate collection of municipal waste by local authorities.
- Establishment of the Pay-As-You-Throw scheme.
- Decentralisation of Waste Management
- Regulations focusing on:
 - Local waste management plans & waste prevention programmes by the local authorities.
 - Obligatory establishment of separate collection systems for a number of waste streams (e.g., paper, glass, wood).
 - Operation and expansion of the Green Points Network.
 - Separate collection programmes for the recyclable and organic waste generated in the coastal tourist areas.

3 Waste production and composition in EU

3.1 Waste generation

The generation of MSW in EU-27, according to the latest Eurostat data, was 225,732 thousand tons, slightly higher than in 2000 (220,073 thousand tons) (Eurostat, 2022a). Nevertheless, as shown in Figure 3, there are significant differences between European countries.

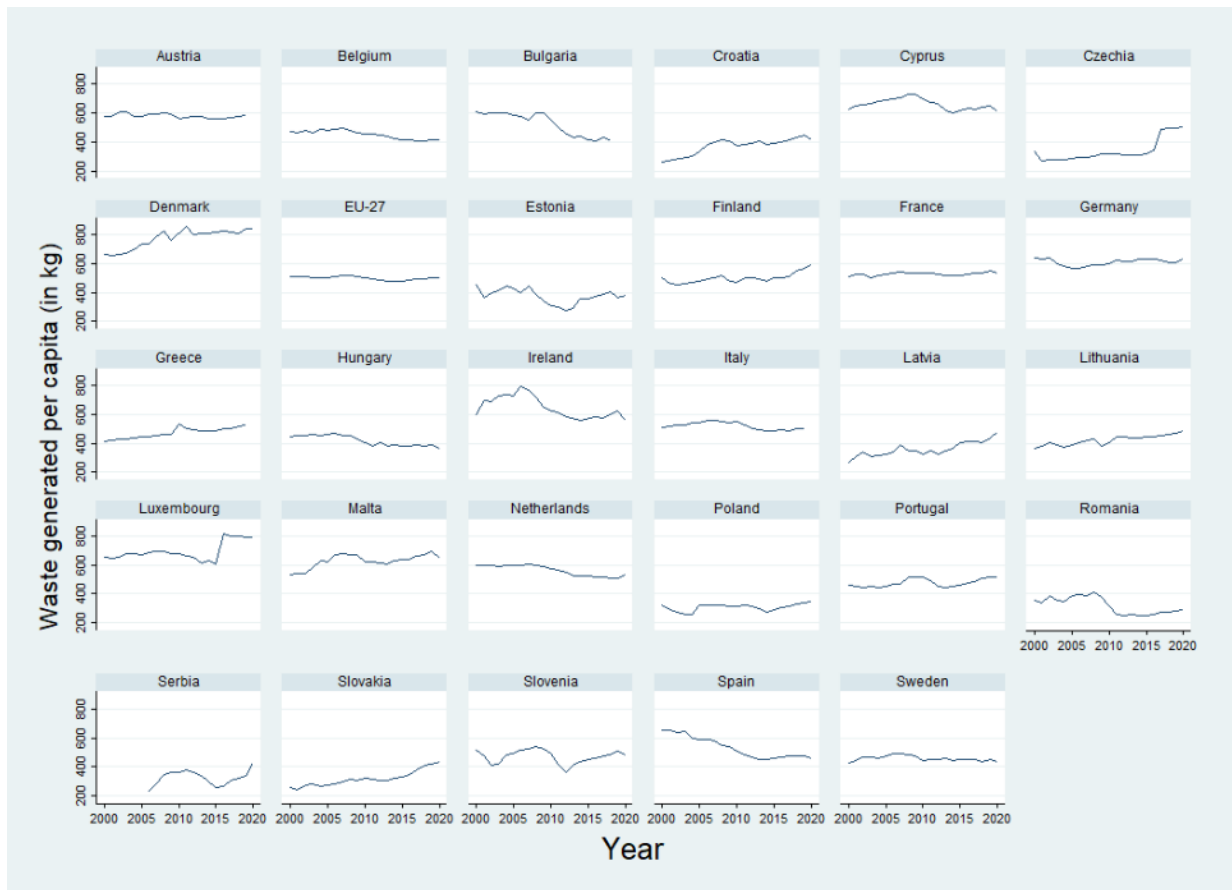


Figure 3. Municipal waste generation per capita in the EU-27 member states and Serbia between 2000 and 2020 (source of data: (Eurostat, 2022a))

In 2020, each EU-27 citizen generated, on average, 505 kg of municipal waste. Denmark generated the most municipal waste per capita (845 kg) among the EU-27, followed by Luxembourg (790 kg), Malta (643 kg) and Germany (632 kg). On the other side, Romania (287 kg), Poland (346 kg), Hungary (364 kg) and Estonia (383 kg) produced the least amount of municipal waste per capita. As far as the partner countries are concerned, in 2020, Cyprus had the highest municipal waste generation per capita (i.e., 609 kg), followed by Greece (524 kg, in 2019 – data are not available for 2020), Serbia (427 kg), Croatia (418 kg) and Belgium (416 kg). Municipal waste generation per capita in Spain (476 kg) was below the EU-27 average (i.e. 502

kg). Estonia, as mentioned before, produces far less waste (i.e., 73.5% of EU's average or 369 kg per capita).

The following tables present the total and per capita MSW generation in the partner countries and the EU-27 over the last five years.

Table 3. Total MSW generation in partner countries and the EU-29 over the last 5 years (in thousand tons)

	2016	2017	2018	2019	2020	% change between 2016-2020
EU-27	218,028	220,957	221,614	223,956	225,732	3.5%
Belgium	4,746	4,672	4,677	4,779	4,800	1.1%
Greece	5,367	5,415	5,523	5,613	n/a	4.6%
Croatia	1,680	1,716	1,768	1,812	1,693	0.8%
Cyprus	539	537	562	571	543	0.7%
Serbia	1,890	2,150	2,230	2,350	2,947	55.9%

Source: (Eurostat, 2022a)

Table 4. MSW generation per capita in partner countries and the EU-29 over the last 5 years (in kg)

	2016	2017	2018	2019	2020	% change between 2016-2020
EU-27	490	496	496	501	505	3.1%
Belgium	419	411	409	416	416	-0.7%
Greece	498	504	515	524	n/a	5.2%
Croatia	403	416	432	445	418	3.7%
Cyprus	633	625	646	648	609	-3.8%
Serbia	268	306	319	338	427	59.3%

Source: (Eurostat, 2022a)

In EU-27, the total MSW generation increased by 3.5% between 2016 and 2020. Total MSW generation was increased, but below EU-27 average, in Cyprus, Croatia and Belgium (i.e., around 1%). In Greece, the total MSW generation increased by around 5% (as mentioned, data are not available for 2020 and therefore the latest available data, i.e., for 2019, are used instead). The highest increase in MSW generation was recorded in Serbia (55.9%), which is a worrisome finding.

As far as the per capita MSW generation is concerned, the average increase in the EU-27 over the last 5 years was 3.1%. Compared to EU-27 average, the per capita MSW generation is again lower in Cyprus and Belgium (-3.8% and -0.7%, respectively). In Croatia and Greece, the per capita MSW generation increased by 3.7% and 5.2%, accordingly. Again, the highest increase was recorded in Serbia (59.3%), almost twenty times more than the EU-27 average.

As previous research also suggests, MSW generation is positively correlated to Gross Domestic Product (GDP). Considering all the observations of the dataset (i.e., the per capita MSW generation for all EU-27 member states and Serbia), the Pearson correlation coefficient is estimated at 0.66 and is statistically significant at a 1% level. Figure 4 illustrates the relationship between the per capita MSW generation and real GDP (for all EU-27 member states and Serbia), for the period 2000-2020.

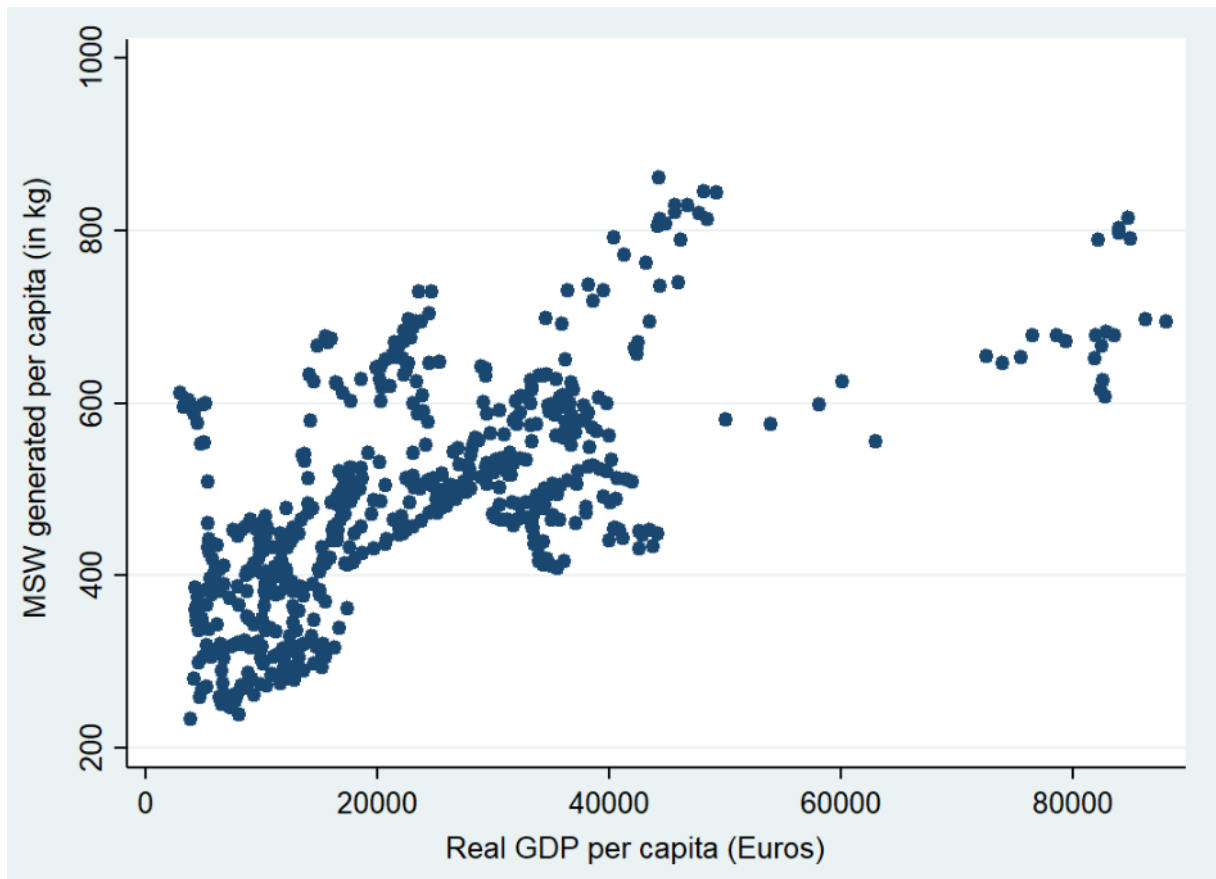


Figure 4. MSW generation per capita to real GDP per capita (Eurostat, 2022a)

Focusing on the five partner countries and using EU-27 average as a benchmark over the last decade (i.e., 2010-2020), the association between the generation of MSW and GDP per capita becomes even more obvious (Figure 5). In all cases, except for Croatia in 2013, MSW generation decreases during the economic crisis. After that, except for Belgium, the growth in GDP per capita is accompanied by a corresponding increase in MSE generation. Finally, in 2020, the decline in economic activity (due to the Covid-19 control measures) led to a reduction in the amount of MSW produced in Belgium, Croatia, and Cyprus. On the contrary, MSW generation increased in Serbia and in the EU-27, on average. As far as Greece is concerned, MSW generation data are not available for 2020, as mentioned before.

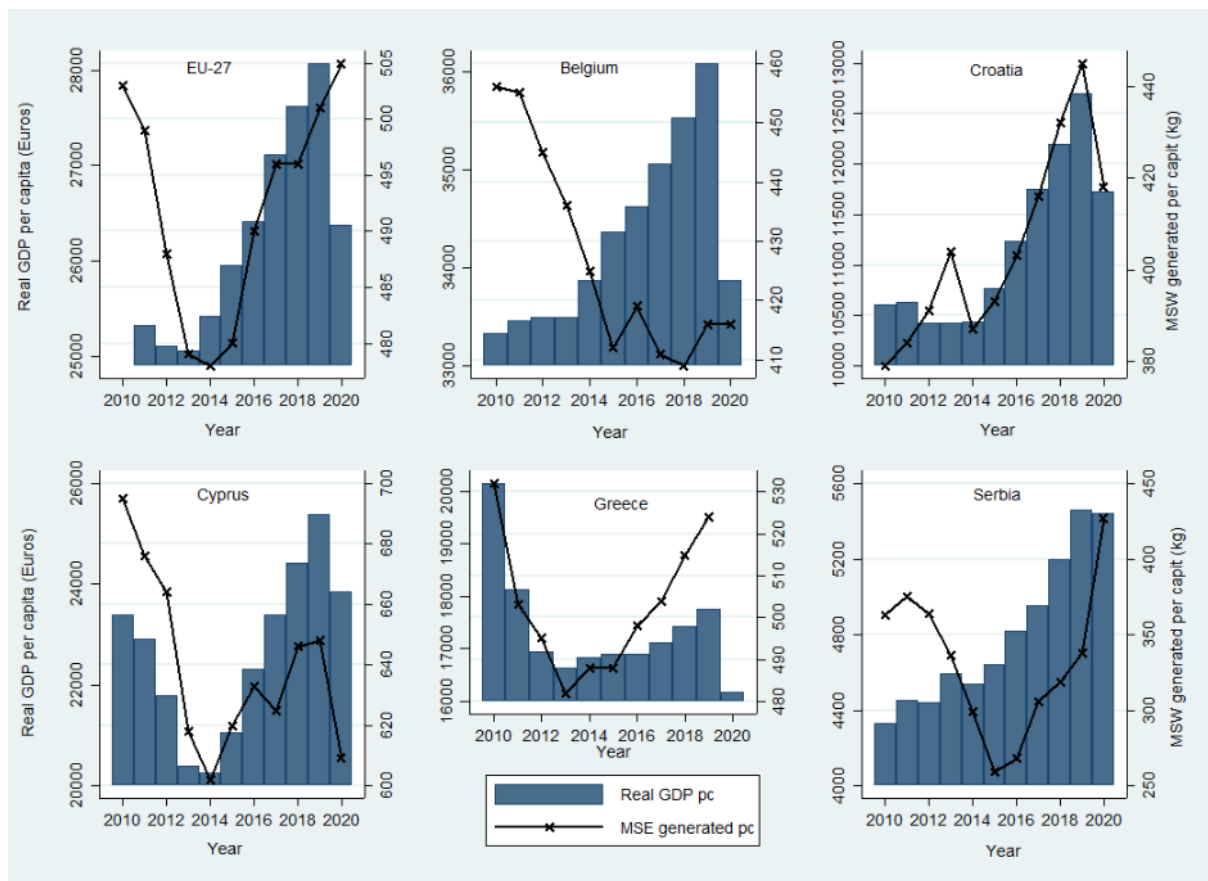


Figure 5. Association between the generation of MSW and GDP per capita in the EU-27 and project countries (Eurostat, 2022a)

The Pearson correlation coefficient is estimated at -0.76 ($p=0.007$) for Belgium, 0.93 ($p=0.000$) for Croatia, 0.39 ($p=0.24$) for Cyprus, 0.82 ($p=0.004$) for Greece and 0.16 ($p=0.63$) for Serbia. The results show that there is a positive and statistically significant correlation between the two parameters for Croatia and Greece. The results are inconclusive (i.e., the correlation coefficient is not statistically significant at 5%) for Cyprus and Serbia. In the case of Belgium, the correlation is negative and statistically significant implying that GDP growth leads to a reduction in MSW generation.

The observed discrepancies are attributed to several factors, such as the waste management options (they are discussed in the next section) which affect the municipal fees, the existence of national pollution and resource taxes (e.g. as shown in Belgium presents the highest taxes among the partner countries), the waste management payment schemes (e.g. the implementation of Pay-As-You-Throw systems or the use of flat rates based on the floor area of residences), etc.

Table 5. Pollution taxes paid by households, in million Euros

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Belgium	246.26	237.56	238.92	246.89	244.96	224.86	223.1	225.01	232.04	230.28
Greece	0	0	0	0	0	0	0	0	16.68	8.51
Croatia	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0
Serbia	42.3	42.11	30.53	29.39	41.63	29.68	38.29	43.47	47	50.34

Source: (Eurostat, 2022b)

3.2 Waste composition

Data on the composition of MSW in the EU and the partner countries are limited and usually outdated. For instance, even recent studies, e.g. (Czajczyńska et al., 2017), are based on data dated before 2000 (Figure 6).

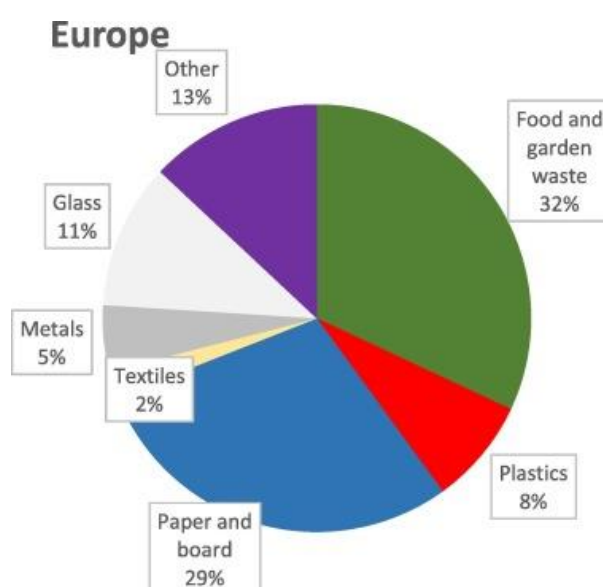


Figure 6. Composition of MSW in Europe (source: (Czajczyńska et al., 2017) based on based on OECD data for 1999)

Probably the most recent data regarding MSW composition are presented in the Annex 2A.2 “(New) Waste composition—by country and regional averages” of the “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories” (IPCC, 2019). Table 6 summarises the estimated MSW composition for different European regions, as well as for Croatia, Greece, and Serbia (data for Belgium and Cyprus are not included in the report).

Table 6. Waste composition – European regional averages and specific partner countries (%)

	Food waste	Garden (yard) and park waste	Paper and cardboard	Wood	Textiles	Nappies (disposable diapers)	Rubber and leather	Plastics	Metal	Glass (and pottery and china)	Other
Eastern Europe	31.8	2.4	17.1	2.5	3.1	0.1	0.5	4.6	0.7	1.8	35.3
Northern Europe	30.3	5.2	13.8	1.8	3.2	1.2	0	4.9	1.4	4.3	34
Southern Europe	35.8	1.4	21.4	1.2	2.8	1.1	0.2	14.1	2	3.5	16.7
Croatia	30.9	5.7	23.2	1	3.7	4	0.7	22.9	2.1	3.7	2.3
Greece	43.1	0	22.6	1	3.3	0	0	11.1	3.2	4.2	11.5
Serbia	44.3	0	13	0	4.5	4	0.4	13.9	1.4	4.2	14.4
Western Europe	33.2	2.7	17.2	2.3	5.9	3	0	20.5	1.5	1.4	12.3

Source: (IPCC, 2019)

Following the “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories” report (IPCC, 2019) and other sources of grey and scientific literature, the MSW composition per partner country is, as follows:

- Belgium: Based on 2003 data, MSW in Belgium is composed of: Organic: 39%; Paper: 17%; Plastic: 5%; Glass: 7%; Metal: 3%; Others: 29% (Hoornweg & Bhada-Tata, 2012)
- Croatia: Based on 2010 data, the separately collected municipal waste consisted mainly of bulky waste (38%), organic waste (20%), and paper (8%) (Kelevska et al., 2014). More detailed data are provided for 2008, by the Croatian Environment Agency: Bulky waste: 45%; Biodegradable waste (gardens, parks): 13%; Litter: 7%; Paper and cardboard: 7%; Sludges: 4%; Biodegradable waste (kitchen): 4%; Earth and rocks: 3%; Green waste: 3%; Glass: 2%; Metals: 2%; Wood: 1%; Textiles: 1%; Plastic: 1%; Others: 7% (Kelevska et al., 2014). According to (IPCC, 2019), the waste composition, based on 2018 data, is: Food waste: 30.9%; Garden (yard) and park waste: 5.7%; Paper and cardboard: 23.2%; Wood: 1%; Textiles: 3.7%; Nappies (disposable diapers): 4%; Rubber and leather: 0.7%; Plastics: 22.9%; Metal: 2.1%; Glass (and pottery and china): 3.7%; Other: 2.3%
- Cyprus: According to (IPCC, 2019), the waste composition, based on 2013 data by (Zorpas et al., 2015), is: Food waste: 34.2%; Garden (yard) and park waste: 13.1%; Paper and cardboard: 22.5%; Wood: 0%; Textiles: 0%; Nappies (disposable diapers): 0%; Rubber and leather: 0%; Plastics: 6.7%; Metal: 0.8%; Glass (and pottery and china): 5.3%; Other: 17.4%.
- Greece: According to the latest National Waste Management Plan (NWMP) (Government Gazette, 2020), which applies for the implementation period 2020-2030 and has been drafted in line with the provisions of art. 22 and 35 of Law 4042/2012, as amended by art. 83 of Law 4685/2020, the MSW composition is, as follows: Organics: 44.3%; Paper/cardboard: 22.2%; Glass: 4.3%; Metals: 3.9%; Plastics: 13.9%; Other: 11.4%. Based on older data (IPCC, 2019), the composition is: Food waste (organics in general): 43.1%; Paper and cardboard: 22.6%; Wood: 1%; Textiles: 3.7%; Nappies (disposable diapers): 0%; Rubber and leather: 0%; Plastics: 11.1%; Metal: 3.2%; Glass (and pottery and china): 4.2%; Other: 11.5%.
- Serbia: According to the National Waste Management Strategy 2010-2019 (reviewed version, 20 June 2009), organic waste is almost 50% in the mass of municipal waste (gardening waste: 12.14%; and other biodegradable waste: 37.62%), total plastic is 12.73% (hard plastic: 3.39%; plastic packaging: 3.37%; and plastic bags: 5.61%), cardboard amounts to 8.23%, followed by glass (5.44%), paper (5.34%), textile (5.25%), disposable diapers (3.65%) and metal (1.36%) (Kelevska et al., 2014). Based on most recent data (2011 & 2016), the MSW is composed of: Food waste (organics in general): 44.3%; Paper and cardboard: 13.0%; Wood: 0%; Textiles: 4.5%; Nappies (disposable diapers): 4.0%; Rubber and leather: 0.4%; Plastics: 13.9%; Metal: 1.4%; Glass (and pottery and china): 4.2%; Other: 14.4% (IPCC, 2019).

4 Waste management practices in EU

In general, most of the waste generated in EU Member-States (98% on average) is treated. However, as shown in Figure 7, some countries are lagging.



Figure 7. MSW treated as a percentage of MSW generated in the EU-27 and Serbia (source of data: (Eurostat, 2022a))

More specifically, based on the latest data (Eurostat, 2022a), the lowest treatment rates are found in Slovenia (79.1%), Cyprus (85.1%), Estonia (86.4%), Lithuania (88.6%) and Croatia (90.2%), followed by Italy (91.8%), Malta (93.2%) and Romania (93.7%). Treatment rates are higher than 95% in all other EU Member States, as well as in Sweden and Serbia.

There are notable differences in performance in waste treatment across EU Member States (Castillo-Giménez et al., 2019). The following figures (Figure 8 to Figure 12) illustrate the trends in MSW treatment in the EU-27 Member States and Serbia. In general, there is a downward trend over the last two decades in landfilling (except for Malta) and incineration of MSW (Figure 8). The same stands for incineration (without energy recovery), as shown in Figure 9. At the same time, as expected, energy recovery (Figure 10), recycling of materials (Figure 11) and composting (Figure 12) from MSW is increasing, although growth rates vary between countries.



Figure 8. Landfill of MSW per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a)

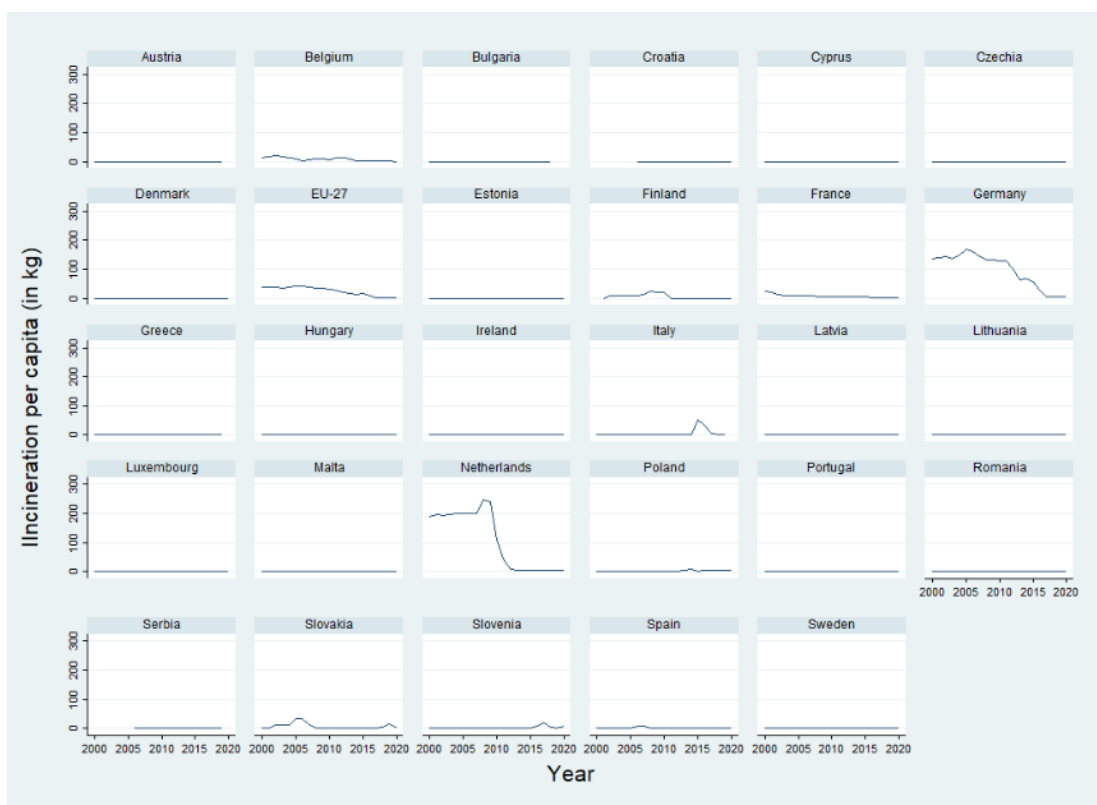


Figure 9. Incineration of MSW per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a)



Figure 10. Energy recovery from MSW) per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a)



Figure 11. Recycling materials from MSW) per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a)

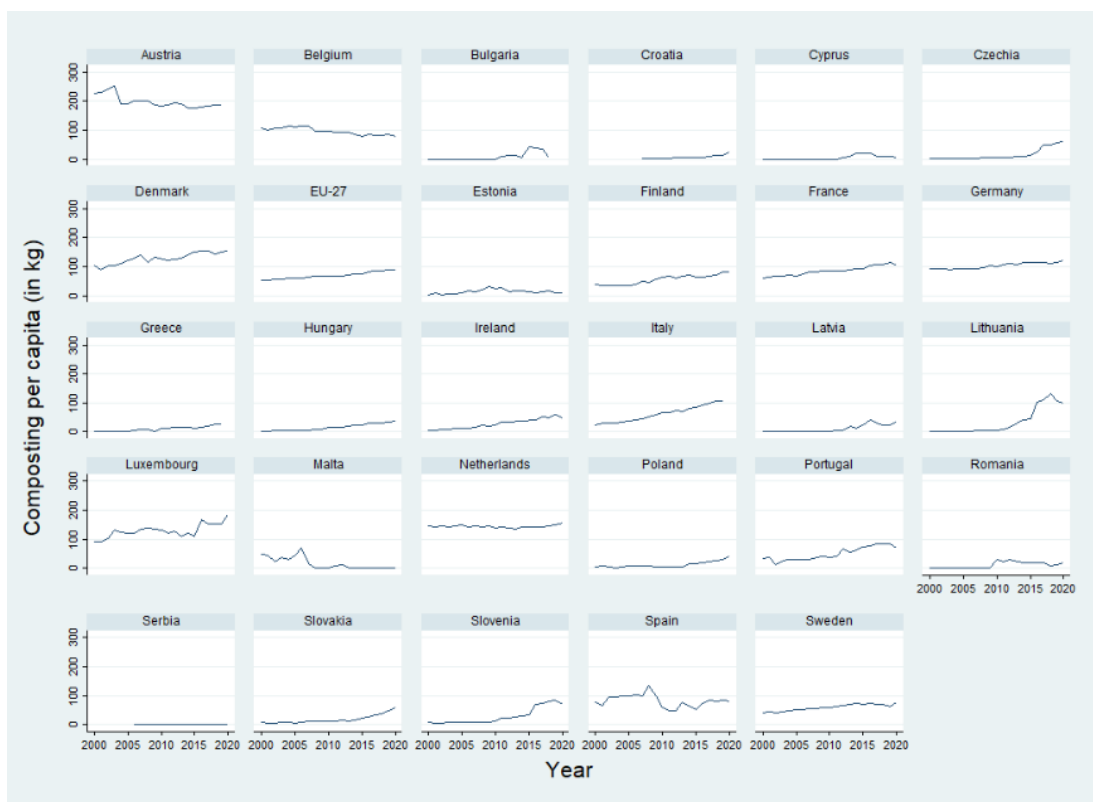


Figure 12. Composting and digestion of MSW per capita (in kg) in the EU-27 and Serbia between 2000 and 2020 (Eurostat, 2022a)

According to Figure 13, landfilling is almost non-existent in recent years (data between 2018 and 2020) in Austria, Belgium, Denmark, Finland, Germany, the Netherlands, and Sweden. On the other end, landfilling remains popular in the eastern and southern parts of Europe, e.g., in Malta, Cyprus, Greece, Serbia and Romania. Landfilling in Croatia and Bulgaria is also high (nearly 60%).

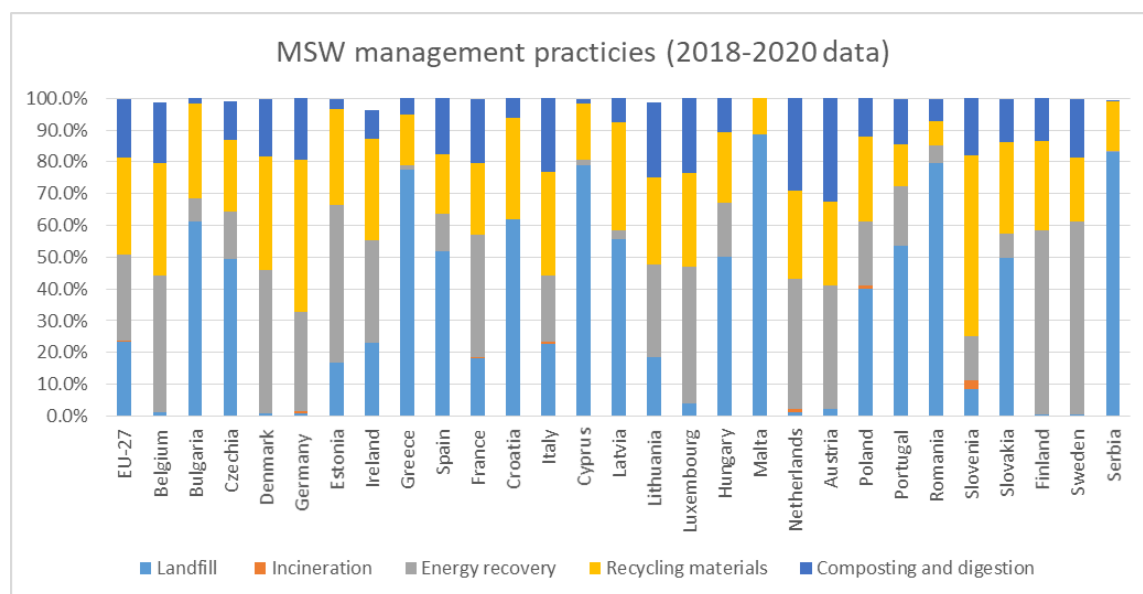


Figure 13. MSW management practices, based on 2018 data and onwards (Eurostat, 2022a)

Incineration without energy recovery is almost absent in all countries. On average, almost 27% of MSW is used for energy recovery, but there is considerable variation between countries. In Malta, Serbia, Croatia, and Greece energy recovery is less than or close to 1%, while in Finland and Sweden it reaches up to around 60%. In Austria, Belgium, Denmark, Estonia, France, Luxemburg, and the Netherlands energy recovery ranges between about 40% and 50% and in the other countries it ranges between 15% and 35%, approximately.

Also, differences exist among EU countries regarding recycling rates of materials. The EU-27 average is around 30.5%. Slovenia presents the highest rate (about 58%), followed by Germany (48%), Denmark (35.5%), Belgium (35.3%), and Latvia (34%). The lowest recycling rates are observed in Romania (7.8%), Malta (11.4%), Portugal (13.2%), Serbia (15.6%) and Greece (16%). The other countries recycle materials at a rate of 20-30%.

Finally, composting and digestion of organic MSW in the EU-27 is about 18%. In Bulgaria, Estonia, Cyprus, Greece, Malta, and Serbia composting and digestion is less than 5% (in Malta it is 0%). On the other hand, composting and digestion reaches about 30% in Austria and the Netherlands and more than 23% in Luxemburg, Lithuania, and Italy. In most countries, recycling is between 10% and 20%.

There is a clear link between recycling rates, composting and digestion and energy recovery and landfilling rates, i.e., in countries with high municipal waste recycling rates, landfilling is almost absent.

Focusing on ADVANCE project countries, the per capita recycling of materials from MSW (Figure 14) is more than 145 kg in Belgium, around 100 kg in Croatia, 85-90 kg in Cyprus and Greece and 60 kg in Serbia (data for Serbia are available for 2020 only). In all countries except Belgium there is an upward trend in recycling of materials. However, it should be noted that in the case of Belgium the downward trend is related to a decrease in waste generated per capita.

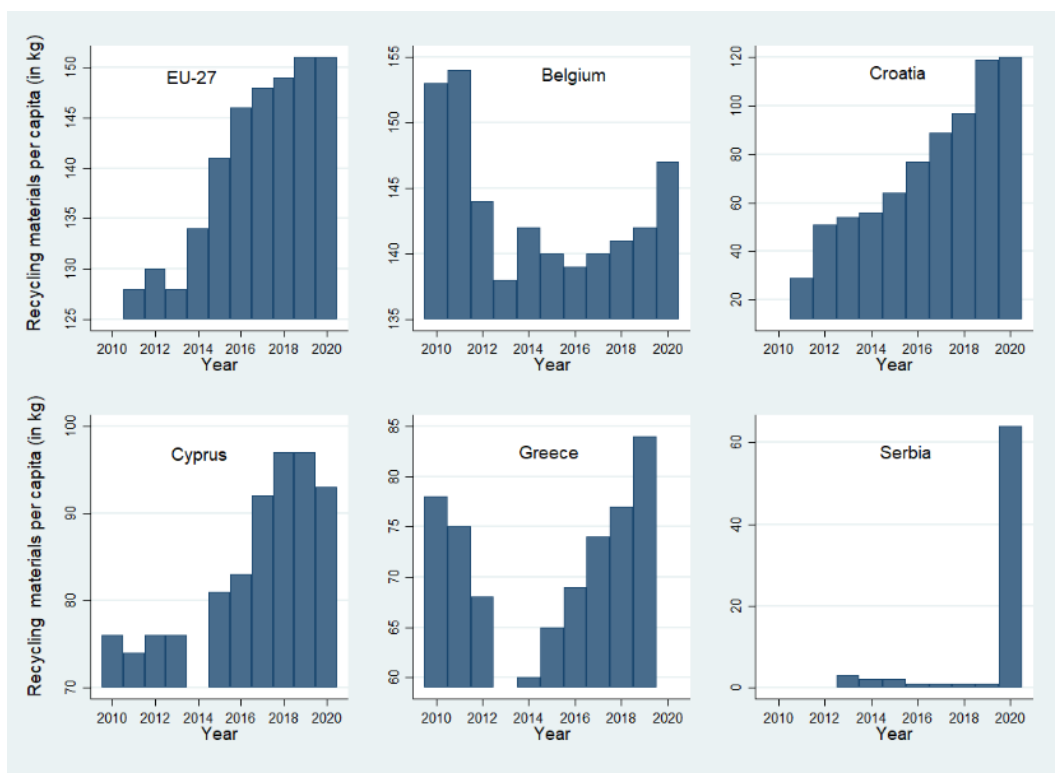


Figure 14. Recycling materials per capita (in kg) in the EU-27 and project countries, 2010-2020 (Eurostat, 2022a)

Composting and digestion of organic MSW in all project countries (in Serbia it's practically non-existent), except Belgium is about a third of EU-27 average (Figure 15). This is an important observation for the project, as the food waste consists of organic waste. Finally, in terms of energy recovery from MSW (Figure 16), all countries, except Belgium, lag significantly behind the EU-27 average. More specifically, the EU-27 average is around 140 kg per capita, while in Cyprus and Greece is less than 10 kg per capita and in Serbia and Croatia less than 1 kg per capita. In Belgium, as mentioned, the energy recovery is higher than the European average, i.e., about 180 kg per capita.

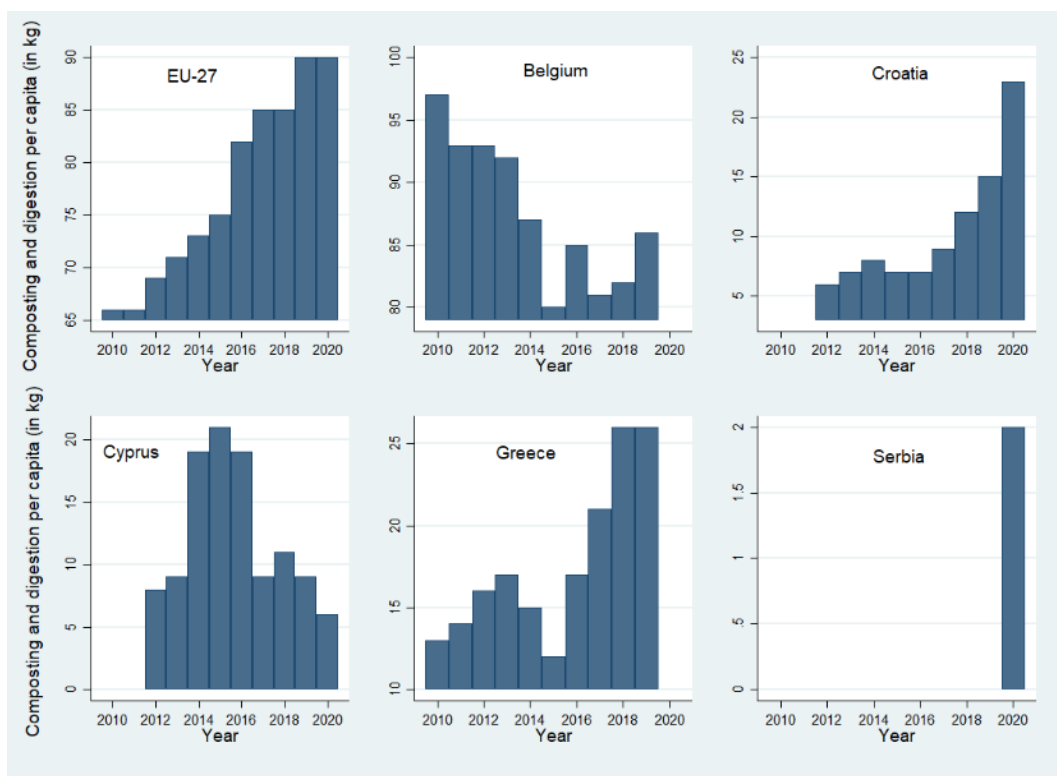


Figure 15. Composting and digestion per capita (in kg) in the EU-27 and project countries, 2010-2020 (Eurostat, 2022a)

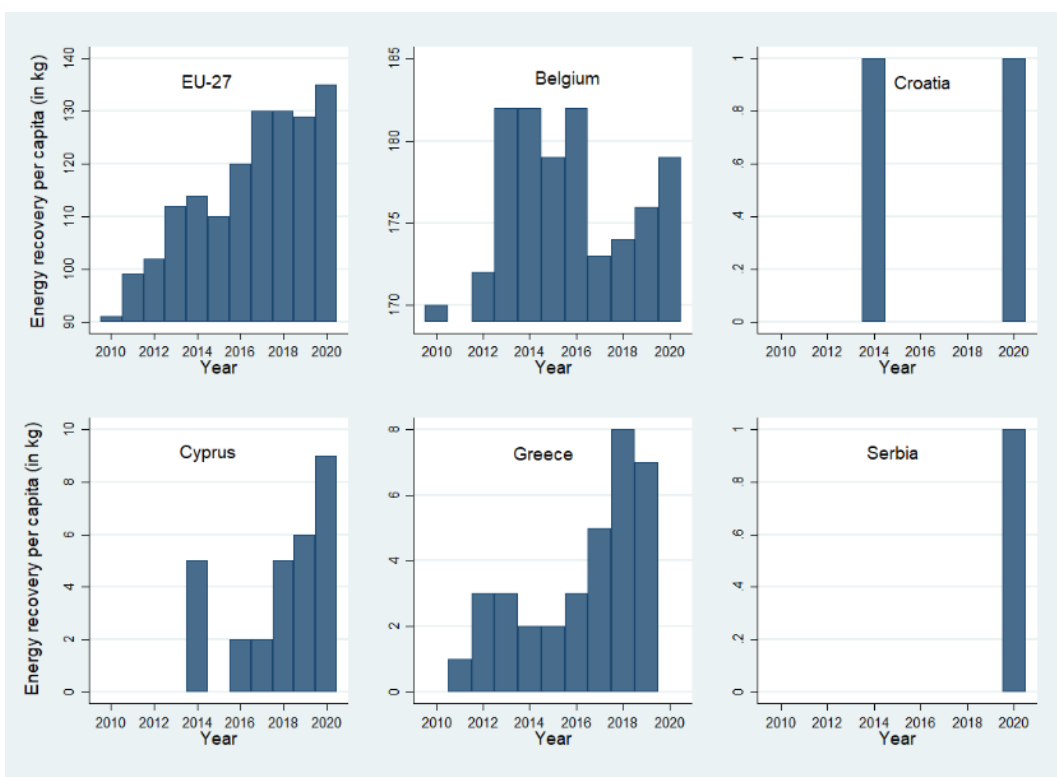


Figure 16. Energy recovery per capita (in kg) in the EU-27 and project countries, 2010-2020 (Eurostat, 2022a)

5 Challenges and opportunities

Although significant progress has been made in MSW management in recent years, there are still challenges that need to be addressed. The first and perhaps most important challenge is to reduce the amount of MSW generated. From both an environmental and economic point of view, it is undoubtedly a better option than any other MSW management option, but evidence shows that MSW generation per capita has been increasing over the last twenty years in many countries (Scientific Foresight Unit, 2017). A second challenge for society is to understand and manage waste as a resource, instead of as a problem. In this direction, the recovery and recycling of useful raw materials and, if this is not possible, energy from MSW should be increased. Recycling and composting are the most sustainable practices, as they allow recovery of materials without or limiting the production of further waste resulting, for example, from incineration processes (Romano et al., 2021). The current recycling rate for MSW is estimated at 43% while the maximum recycling potential is assessed to 80-90% (Trionomics, 2020).

However, this also means that in order to reach the circular economy targets significant investments are required to enable waste segregation, so as to move away from landfilling and incineration (Scientific Foresight Unit, 2017). Apart from finding the resources for the necessary investments, there are technical, legislative, market and awareness barriers, e.g., bureaucratic barriers for recycling permits, ambiguous definitions and calculation of recycling rates, lack of recycling technologies for some materials, contamination of waste streams and insufficient financial incentives for separate collection, lack of markets for secondary materials, need to divert waste from incineration while honouring long-term contracts with incinerator operations, lack of end of waste criteria, lack of active participation of citizens, lack of appropriate market-based incentives, etc. (Magrini et al., 2020; Scientific Foresight Unit, 2017; Trionomics, 2020).

On the other hand, the change from the "collect and throw away" model to the "collect and reuse" model in the context of a circular economy creates new opportunities, as well. Diverting MSW from landfill through the circular economy model helps to avoid the consumption of raw materials, reduce the energy used in production, increase employment, improve productivity and grow the economy (Busu, 2019; Liu et al., 2020; McKinsey & Company, 2015; Trica et al., 2019). For instance, according to McKinsey & Company (2015) adopting a more circular economic model in Europe would generate a primary-resource benefit of €0.6 trillion per year by 2030 and, additionally, €1.2 trillion in non-resource and externality benefits. Further and focusing on waste, it is estimated that the implementation of existing legislation on waste prevention and management could create more than 400,000 new jobs (Scientific Foresight Unit, 2017). Finally, regarding environmental implications, it is argued that increasing the capture rates of packaging waste could lead to a 13% reduction in greenhouse gas production associated with the packaging and packaging waste (Tallentire & Steubing, 2020). Also, using life-cycle analysis other scholars have estimated that diverting 13% of the waste entering the waste management system would result in 45% net reduction for nutrient enrichment and 12%

reduction for global warming potential, with the greatest benefits coming from the food waste stream (Gentil et al., 2011).

6 Current waste management practices on enterprise level

6.1 Greece

6.1.1 Food waste behaviours of enterprises and consumers

According to Figure 17 based on a survey of approximately 500 consumers in Greece, it seems that most consumers have limited-moderate knowledge (and therefore awareness) about food waste (Kitsara, 2017). In general, the food waste occurs in developed economies because of the inefficiency of marketing chains, the underdeveloped distribution channels of businesses, and the "aesthetic" standards set by large supermarket chains. Approximately, one million tons are produced by households and almost 400,000 come from commercial enterprises and services (e.g., food retailing, hotels, food wholesalers, educational institutions, hospitals, restaurants, etc.). The hospitality and food service sector, as well as the wholesale and retail sectors produce 260,000 and 80,000 tons of food waste per year, respectively. Of this, almost 90,000 tons come from hotels, over 20% of all food waste generated by commercial businesses and services in Greece. Along the supply chain (food production→ control processing→ trade→ food/households) there are dozens of ways-reasons that cause food waste (for example, losses in transportation and storage/production that does not meet specifications/spent products/meals not consumed). Therefore, the overall data reveals a lack of, and almost non-existent, care to mitigate the production of waste.

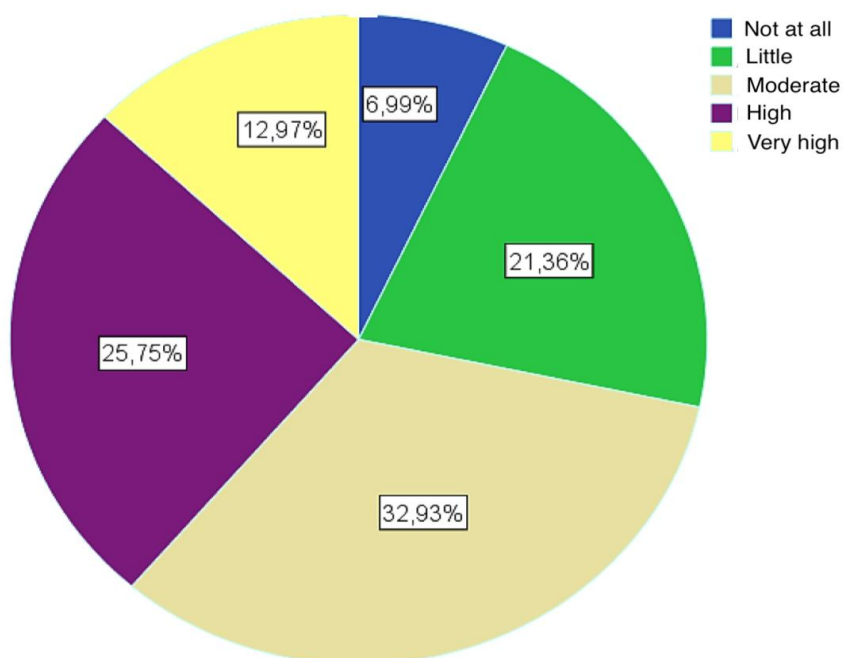


Figure 17. Level of knowledge in Greece about food waste between consumers (Kitsara, 2017)

6.1.2 Identifying crucial links

In Greece, during the last decade, some dynamic initiatives of institutions and businesses have been developed in the field of the circular economy. The guidelines have been provided by the latest legislation that requires the adoption of provisions and mechanisms for waste reduction or exploitation.

At the business level, the SEPAN cooperative, an association of industrial enterprises specializing in the energy recovery of non-recyclable materials, appears to have a leading role in Greece. Various forms of energy are produced through special waste treatment processes. It is a joint initiative, which exploits natural resources with respect for the environment. The "Laconian Bioenergy S.A." is a pioneer company in the field of Waste Management. It was established by a group of thirty (30) Shareholders in order to promote best practices, ecological solutions, economically advantageous for the legal solution of waste in our region. Some other similar companies are:

- Arcadian Alternative SA, in Tripoli
- the KOIN.S.E.P. "Kalloni - Kellia", in Tinos
- the civil non-profit cooperative MoikonNOS, in Mykonos
- the KOIN.S.E.P. of Patras
- the KOIN.S.E.P. in Ikaria

Example of waste utilisation to produce raw materials by another company.

The Pindos company has sterilization furnaces for the utilization of poultry meal in animal feed. In particular, slaughterhouse by-products (bird heads, feathers, legs, etc.) are left in the sterilization furnace for 5-6 hours until they reach a temperature of 133°C for 20 minutes. This is followed by the separation of the fat, which produces two different types of fat by-products, animal fat and meal. The animal fat is used to produce animal feed (pet food) and biodiesel while the resulting meal is used for animal feed.

At the same time, in recent years, the interest of Greek universities and private companies that manage waste has increasingly focused on the recycling and recovery of waste, by-products and secondary raw materials. More specifically, active academic studies and companies operating in Greece and industrial activity are dealing with recycling and recovery of waste, by-products, and secondary raw materials with the aim of processing waste to produce usable materials or for energy recovery.

For example, the Laboratory of Food Processing and Food Engineering of the Aristotle University of Thessaloniki carries out studies on the recovery of waste from the fruit industry. Innovative functional foods have been produced through the recovery of useful ingredients from food waste.

At the national level, the integrated LIFE-IP CEI-Greece project aspires to contribute to the implementation of the National Waste Management Plan, the National Strategic Plan for Waste Generation Prevention, and the National Strategy for the Circular Economy (2019-2027). The project highlights a new concept in the waste sector based on the principles of the circular

economy, adopting practices and behavioural change to increase the life cycle of products, the conversion of waste into resources and the effective implementation of the legislative package of measures for the prevention of waste generation. The project involves national bodies (ministries), municipalities and public limited companies.

In general, levels of information, awareness, and cooperation in the field of circular economy and especially in food waste management are at an early stage. More businesses are slowly becoming active in this area, but Greek businesses shall and must aim more at cooperative practices to produce materials for new products. Greece has all the potential to make a difference and become a leading force in the Europe of future.

6.1.3 Qualitative analysis for separate collection of specific materials streams

The latest Greek state guidelines on waste sorting are strict and specific. The state shares the European directive on "Source separation", i.e., the process of separating waste before mixing it together. More specifically, the latest Greek legislation Law 4819/2021, is a major institutional reform that incorporates the European Directives 2018/851 and 2018/852 and unifies the provisions for the proper management of waste with those of recycling and the circular economy. In order to implement these regulations, several businesses, such as food processing and manufacturing plants, supermarkets, hotels, large restaurants, catering businesses, etc., are required to comply with the waste hierarchy, in order of priority:

1. prevention,
2. preparation for reuse,
3. recycling,
4. other types of recovery, such as energy recovery, and
5. disposal.

In addition, a database is being created to record food waste, thus enhancing the digitization of waste data in the country. Moreover, mandatory separate collection is established for at least seven (7) new waste streams and an obligation is placed on the producers of these products to organize and forward them for recycling with the associated costs covered. From 2022, it is foreseen that businesses that are large producers of bio-waste (such as garden, park, and food waste) are required to collect it separately in order to be transported for recycling on their own responsibility with a parallel reduction of municipal fees. The mandatory use of animal waste in biogas or composting plants is also promoted, if available in the area. From 31 December 2022 onwards, catering businesses will be required to ensure the separate collection of bio-waste resulting from their activity by providing containers of sufficient capacity within their establishment. It should be noted that the communal recycling bins of municipalities is not covered by the above obligation (Law 4819/2021).

6.1.4 Identifying specific challenges and opportunities

As far as the creation of a space for action and opportunities in Greece for the proper management or utilization of waste, steps are being taken in this direction by the State. At the individual level, through recent provisions, citizens are given the opportunity to pay lower municipal fees if they produce less waste and/or recycle more (i.e., the European principle of "pay as you throw" is introduced).

Fines imposed by the EU are also transferred to municipalities and businesses that cause them, relieving taxpayers of the burden. At the same time, through European funding (NSRF), waste management facilities are being supported. In particular, through financing investment projects for the business recovery of liquid and solid waste, so that the waste, after treatment, can be reintroduced into the production cycle and reused as raw materials, materials or substances in order to serve again either their original use or other uses (for businesses).

Overall, circularity has also created new business opportunities, generated new business models, and developed new markets, both within and outside the EU. In 2016, circular activities, such as repair, reuse or recycling, generated an added value of around €147 billion, while the value of related investments amounted to around €17.5 billion. It creates new jobs, fosters small and medium-sized entrepreneurship, the creation of new professions and the social economy, which is still at a very low level in Greece. It supports the competitiveness and viability of enterprises, as it ensures cheap raw materials, addresses the upcoming increase in the prices of scarce raw materials and helps to save costs in industries. The aim here, however, is to ensure that the materials that return to the economy are cost-effective and safe for citizens and the environment. To this end, the EU should continue to support research, investment, and innovation.

In general, more emphasis should be placed on incentives to develop social entrepreneurship, synergies and the social economy in the areas of resource and material reuse (eco-industrial clusters, patent pools).

The State should aim more at facilitating circular economy and industrial symbiosis business initiatives with possible reduction of administrative costs, premiums in public procurement, eco-industrial parks, creation of an appropriate regulatory framework and adaptation of the existing one).

6.1.5 Challenges

The Environment Sector in Greece has evolved rapidly in recent years, mainly due to the pressing obligations to comply with European Union directives and regulations and, secondarily, because of planning on the part of political leaders and public administration, in order to address environmental protection issues in a timely and proactive manner. The dynamics of continuous changes and developments in environmental issues create multiple challenges that can be transformed into opportunities for business development and job creation in the environmental industry.

Regarding waste recycling or recovery, what was previously considered 'waste' can now be turned into raw material. But such a mechanism requires the involvement and commitment of many different groups of people, with business playing a central role in changing the existing system.

The catering business is therefore the key business sector that can contribute to the sustainable management of food waste, but also to achieving the key goal of the circular economy, which is to reduce landfill waste to less than 10% by 2030 (from the 80% landfill we currently have in Greece).

There are several inhibiting factors that prevent businesses from 'recycling' leftover food waste. A major challenge is the cost at which businesses are slowed down to dispose of the waste they produce and the overall management and disposal of the waste. A similar factor that can be mentioned is the limited availability of "recycling" facilities, thus increasing the management costs by burdening the operators who have the intention to contribute to recycling with an additional transport cost, which often requires special conditions, e.g., refrigeration. It is compulsory for businesses to have spacious waste bins and appropriate staff to manage them, including the cost of waste collection and removal companies. With these activities occurring on a daily or weekly basis, the total cost, for waste management alone, can become economically significant and quite calculable in the operating costs of a business.

Another factor is the strict legislation that ensures the safety of food and thereby limits the reuse of some of it and prevents the donation of leftovers. In terms of donation, an additional inhibiting factor is that the legal responsibility for the quality of the food, which belongs solely to the donor, which makes businesses very cautious, as they cannot provide additional storage space for the leftovers, or often additional staff to be responsible for them.

In addition to legal regulatory barriers, the diversity of leftovers and the different way each mass catering business operates, make it more challenging for operators to address food waste management. More specifically, the approach to managing this can differ between traditional restaurants with higher quality food and quick service restaurants, and from a 3-star hotel restaurant to a 5-star hotel restaurant. On the other hand, companies with franchise-based business models face difficulties in creating and implementing a universal food waste tracking system and creating a sustainable corporate culture among their employees.

In summary, businesses face the below challenges and difficulties:

- collection - transport - temporary storage - transshipment – recovery;
- carrying out the studies required for obtaining permits;
- operating existing waste management facilities;
- implementing the projects or activities envisaged and organizing the means of temporary storage of waste under the responsibility of the site owner;
- The new waste management standards increase the cost of treatment.

6.1.6 Percentage/Level of waste reuse

The average recycling rate in the European Union is 46%. The country with the Germany is the best performing country, with 67.2% in 2017, followed by Slovenia and Austria. Malta has the lowest rate, 7.1%, followed by Romania and Cyprus. According to Eurostat data, Greece ranks fourth from the bottom, with a rate of 18.9% (Eurostat). By simply comparing Greece's recycling performance (18.9%) with the target for 2020 target (50%), it is clear that this target is unlikely to be met within 2020. This year, therefore, Greece must make great efforts to achieve the target in order to improve its performance as soon as possible. Raising awareness and educating citizens are a crucial parameter in the context of these efforts. Today in Greece, the level of waste recycling/reuse is much lower than the European targets, while uncontrolled waste disposal sites still exist, and fines continue to be imposed. However, the latest data show that a gradual development is taking place. At the level of general management in Greece, the largest share of waste generated ends up in landfills (77.6% in 2019), while recycling is at 21.0%. Compared to the EU Member States, Greece ranks 4th in terms of landfilling of municipal waste as well as in the percentage of recycling, following Malta, Romania and Cyprus. More specifically, the country ranks 23rd in Europe-27 in terms of material cyclicity, i.e., the percentage of materials that are recycled and redistributed to manufacturing. In the plastic waste stream category, waste generation per capita in Greece decreased significantly in the period 2006 - 2012 and has since remained below the European average. The annual per capita packaging waste generation in Greece in 2019 was 81.1 kg per capita, well below the EU27 average of over 177 kg per capita. Also in 2019, 60% of packaging waste was recycled. Greece has better rates on recycling paper and cardboard packaging and on recycling metal packaging. However, the recycling of plastic packaging is still far from the 2025 target (50%).

6.1.7 Mandatory separation of waste streams

Mandatory separate collection of four packaging waste streams - Separate collection of individual packaging waste and at least for glass, plastic, metal, paper. By way of derogation from the obligation in the previous subparagraph, plastics may be collected with metals if this is justified for technical or economic reasons and if their subsequent complete separation is technically ensured. Isolated geographical island or mountainous areas may be exempted from the obligation of separate collection of multiple streams in accordance with the two previous subparagraphs, solely for technical, environmental or economic reasons, following a request from the alternative packaging management system (APMS), accompanied by a documented proposal for the organization of packaging waste collection in those areas, indicating at least the reasons for the exemption and the proposed way of serving the areas.

- Biological waste: Mandatory separate collection by 31 December 2022.
- Introduction of mandatory separate collection at least for metals, paper, glass and plastic, textiles, and other special streams such as mattresses, furniture, expired medicines, other hazardous waste from households.
- Mandatory separate collection of plastic beverage bottles up to three litres.

- Mandatory use of exclusively reusable items (for cups, food containers) for on-site consumption in catering establishments, excluding canteens.
- Activation of the provision of Article 12 of Law No. 4496/2017, which provides for the activation of the provision of Article 11 of the article of Article 12 of the Act No. 4496/2017 the mandatory separate collection of packaging materials. Activation of the obligation to separate packaging waste from large tourist establishments, and the gradual extension of this obligation to other materials as well.

6.1.8 Best practices

In March 2020, the European Commission presented a Circular Economy Action Plan that aims to reduce waste through better resource management.

1) Sustainable products should become the norm in the EU.

The Commission will propose legislation on sustainable products policy to ensure that products placed on the EU market are designed to last longer, to be reused, repaired, and recycled more easily and contain as many recycled materials as possible instead of primary raw materials. It will limit single-use products, tackle premature wastage, and prohibit the destruction of unsold durable goods.

2) Empowering consumers.

Consumers will have access to reliable information on issues such as repairability and product lifetime, so that they can make more sustainable choices from an environmental perspective. Citizens will exercise a real "right to repair".

3) Emphasis will be placed on the sectors that use the most resources and where there is great potential for cyclicity.

In 2018, the EU set new targets for recycling, packaging, and landfill of waste. The new rules aim to promote the transition to a more sustainable circular economy model. In February 2021, the Parliament adopted the new Circular Economy Action Plan calling for additional measures to achieve a carbon-neutral, environmentally sustainable, toxic-free and fully circular economy by 2050, including stronger recycling rules and binding targets for material use and consumption by 2030. It is worth noting the action of the National Waste Management Plan (NWMP). The National Waste Management Plan (NWMP) is formulated by the Ministry of Environment and Energy and the Ministry of Interior and Administrative Reconstruction and constitutes the political and strategic planning for the management of waste streams. According to it, the Specific National Waste Management Plans for the specific waste streams of Greece are prepared. Thus, the introduction of separate collection of bio-waste and the organization of a bio-waste recovery network is achieved. Its purpose is to reduce waste production, to reduce the negative consequences of both waste production and waste management, to increase the efficiency of the resources used and to protect the environment and public health. Shops of sanitary interest are required to have a license to establish and operate from the relevant Competent Authority-ISO 14001. The certification company TÜV Austria, responding to the increased needs for certification of Environmental Claims, has

developed the Zero Waste-To-Landfill service in Greece. The Zero Waste-To-Landfill Service promotes the efforts of an organization to reduce its environmental impact, setting as a goal the continuous reduction of waste to landfill. If the inspection is successful, an official certificate is issued stating that the organization has been verified as a Zero Waste to Landfill Organization. The recycling rate (%) of waste is stated in a document and logo to accompany the certificate.

- The environmental profile of the Agency is improved,
- The Agency gains a comparative advantage in the market,
- Savings in natural and financial resources are achieved,
- Meeting consumer demand for greater transparency,
- Procurement requirements and customer expectations are met.

Also, the Greek initiative Polygreen, a circular economy company, aims to educate and support interested companies to achieve zero waste production. A well-known example of working with this company is Tilos, the first island in the world to achieve 100% waste diversion from landfill. With the cooperation of the Municipality of Tilos, through this program, the public bins have been removed, as well as the Landfill Site, where the Cyclic Innovation Centre is now located for the sorting and preparation of waste for recycling, composting or energy recovery. The waste includes a total of 25 streams: e.g., plastics, packaging paper, printed paper, aluminium, tetra packs, metal containers, cooking oil, light bulbs, glass, electrical appliances, nappies, etc.) This waste is collected through the program and an average of 86% waste is recycled. It is noteworthy that this program has stimulated interest for implementation in other Greek islands as well. As far as Tilos is concerned, the program has also benefited the island in terms of jobs, as it employs 10 people so far and is the largest company in Tilos, contributing to the strengthening of the local economy.

6.2 Belgium

As a consequence of the Belgian State reforms initiated in the 1980s, the three regions of the country (Flemish, Walloon and Brussels Capital) have become virtually exclusively competent for all environmental matters, including waste management. Taking into account that the Belgian partner for this project (Horeca Partners) is located in Flanders, the remainder of this section focuses primarily on the Flemish region.

6.2.1 Food waste behaviours of enterprises and consumers

In May 2017, the Flemish Food Supply Chain Platform for Food Loss published a monitoring report aimed at gaining an insight into the efficiency with which the agri-food chain, from harvest to consumption, dealt with food commodities in 2015. In 2019, the monitoring report was updated on the basis of data pertaining to 2017. However, since the latter report failed to contain data for all relevant links of the agri-food chain, we focus on the base report. Before providing an overview of some of the main findings, it is important to clarify the terminology used in the monitor: according to the report, a 'food product' consists of an edible fraction (= 'food') and an inedible fraction (= 'residues'). Food consumed by people is supposed to have achieved its final purpose (= 'food consumption'), while food not consumed by people is

referred to as 'food loss'. Finally, the combination of 'food losses' and 'residues' constitutes what is called 'food waste' in the monitoring report.

According to the report, 3,485,000 tons of food waste were generated throughout the entire Flemish agri-food chain in 2015. As can be seen in Table 7 below, most of the Flemish food waste was released in the food industry (67%) and, to a lesser extent, by agriculture and households (13% each). Firstly, this can be explained by the fact that both agriculture and the food industry in Flanders have a strong focus on exports and consequently very high production volumes, with for example exports accounting for about half the turnover of the food industry. As such, a large portion of the food waste generated in agriculture and the food industry is actually attributable to production for foreign markets, whereas the links from retail to households, on the other hand, only concern the domestic market. Secondly, it is also the food industry where the process takes place that releases the most inedible food waste, namely the processing of raw materials into finished food products.

For the agri-food chain as a whole, around three quarters (74%) of food waste were residues and only one quarter (26%) was food losses in 2015. In absolute figures, this came down to 2,578,000 tons of residues and 907,000 tons of food losses across the chain in its entirety.

Of all food waste, 92% was valorised in 2015, with animal feed (43% of all food waste) being the largest proportion in this respect. Anaerobic digestion (i.e. processes through which bacteria break down organic matter in the absence of oxygen) and the destination of soil accounted for the valorisation of 21% and 17% of food waste, respectively. On a scale of 0 (no valorisation) to 10 (maximum valorisation), the cascade index weighing the food waste according to its position on the food waste cascade, was 8.2 for the Flemish agri-food chain in 2015. This indicates that the Flemish agri-food chain is quite strong in terms of the valorisation of food waste. Figure 18 provides an overview of the distribution of destinations of food waste in Flanders in 2015.

Table 7: Overview of food waste (food losses + inedible unavoidable residues in the Flemish agri-food chain, in tons, 2015

Sector	Food waste	
	tonnes	proportion in the total chain
Fisheries	10,402	>1%
Agriculture*	449,352	13%
Auctions	15,277	>1%
Food industry*	2,349,445	67%
Retail	64,828	2%
Hospitality sector	67,450	2%
Catering	60,098	2%
Households	468,305	13%
Total chain	3,485,157	100%

*Flemish agriculture and food industry are strongly and increasingly export-oriented. Production for export is included in the figures.

Source: Flemish Food Supply Chain Platform for Food Loss, Food Waste and Food Losses: Prevention and Valorisation – Monitoring Flanders 2015, May 2017, p. 23.

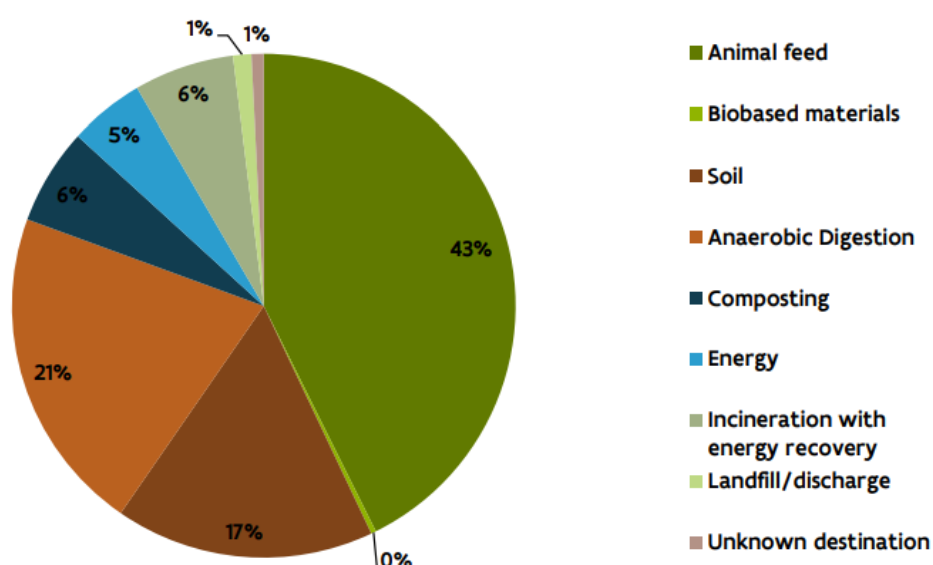


Figure 18: Distribution of destinations of food waste in Flanders, in tons, 2015

Source: Flemish Food Supply Chain Platform for Food Loss, Food Waste and Food Losses: Prevention and Valorisation – Monitoring Flanders 2015, May 2017, p. 24.

Specifically, as far as households are concerned, the Flemish Department of Environment and Health mapped the causes and magnitude of food waste on the basis of a diary study, an online

survey and an analysis of actual purchasing behaviour. On average, 37 kg of food per year per inhabitant is not consumed, with coffee & tea (14%), bread & pastries (12%) and fruit (12%) constituting the top 3. The food waste of an average Flemish household comes down to about 8% of the purchased amount of food and beverages. The main causes that have been identified with respect to the generation of food waste in Flemish households are (1) lack of planning, (2) buying too large quantities, for example because of impulse purchases, (3) faulty interpretations of expiration dates, (4) suboptimal storage conditions reducing the shelf life of food products, (5) flawed estimations of portion sizes inducing the creation of leftovers, and (6) inadequate storage and/or reuse of leftovers.

6.2.2 Identifying crucial links

Circular Flanders was established in 2017. This public-private partnership constitutes the hub and the inspiration for the Flemish circular economy. Its partners include governmental institutions/departments (e.g. the Flemish Public Waste Agency, the Flemish Department of Economy, Science & Innovation, the Flemish Department of Agriculture and Fisheries, the Flemish Environmental Department), industry federations (e.g. Agoria representing technological companies, Essenscia representing the chemical & life sciences industries, Febelfin representing the financial sector, Fedustria representing manufacturing companies in the textile, wood & furniture industries, Fevia representing the food industry, Embuild representing the construction industry, Denuo representing the waste handling and recycling industry), and the knowledge community (e.g. KU Leuven university, the independent Flemish research organization in the area of cleantech and sustainable development VITO). The main objective of Circular Flanders is to ensure Flanders' transition to the circular economy by 2050. The partnership works along six themed strategic agendas: (1) circular construction, (2) chemistry & plastics, (3) water loops, (4) bioeconomy, (5) food chain, and (6) manufacturing. Amongst a lot of other information, its website identifies five business model types towards more circularity:

- the use of circular inputs; an example is Cabosse Naturals. This start-up by the world's leading manufacturer of chocolate and cocoa products Barry Callebaut seeks to tackle the fact that generally speaking about 70% of the fruit surrounding cocoa beans is thrown away in the context of the production process of chocolate. Cabosse Naturals aims to upcycle the pulp and skin and introduce it into the food chain. The pulp is pressed into a fruity juice and the dried skin is ground into a powder that can be used for various applications;
- raw materials and/or energy recovery, with Building Integrated Greenhouses (BIGH) as an example. With more and more people living in urban areas, there is an increasing need for fresh and safe food. This need can be met in a sustainable, innovative and effective way by integrated urban farming systems. BIGH grows local produce in aquaponic farms installed into/on existing buildings and uses the energy loss from the buildings to provide the heat required by the farm. Overall farm design is conducted with a view to achieving maximum circularity;

- extension of the functional life cycle of a product; an example is Babytheek, which can be translated as 'Baby Library'. In short, this initiative revolves around a lending system for sustainable baby(-related) materials that most people only need to use for a short time;
- sharing platforms, such as Wingparent, which strives to unburden nurseries/childcare companies by setting up an ecosystem around all products (food, pharmaceuticals, etc.) and services (waste processing, maintenance, etc.). Wingparent manages the entire chain on behalf of the nurseries, enabling it to steer purchasing behavior towards circular products and services;
- product as a service; an example is the UP project by Cordium, the social housing company of the Belgian province of Limburg. Often, outdated homes with high renovation costs are removed from the rental market and sold on the public market. Even if in such circumstances people with limited financial resources can manage to acquire their own homes, they generally do not have the means to carry out sustainable renovations. In the context of the UP project, Cordium looks for legal and financial solutions aimed at selling outdated social housing to the target group in an affordable manner, with sustainable renovations, maintenance and repairs being guaranteed.

There are also a number of initiatives and co-operations pertaining specifically to the reduction and/or reuse of food waste:

- a first example is Colruyt Group, one of Belgium's leading supermarket chains. Colruyt has partnered up with the urban farm ECLO (formerly known as 'Le Champignon de Bruxelles'), to grow mushrooms from its own bread waste. ECLO has the know-how to process bread into substrate and grow different types of mushrooms on it. After 1.5 years of testing, the first mushrooms grown on Colruyt's bread residual streams were sold in the fall of 2021;
- a second example is the Belgian city of Ghent, which was one of the first cities in Europe to launch its own urban food policy, labelled 'Ghent en Garde', in 2013. This initiative seeks to strengthen short food supply chains, increase sustainable food production and consumption, allow for better access to food, and decrease food waste. It has achieved structural changes to the city's food system through participative governance models, including the establishment of a food policy council. Under the Ghent en Garde policy, suburban farmers markets and a new logistics platform for professional buyers have been installed. In its first two years alone, already 1,000 tons of surplus food were distributed to more than 57,000 people in need. Since 2014, more than 40 schools have received training regarding how to develop community garden beds on their campuses. It is also believed that Ghent was the very first city in the world to introduce a vegetarian day, thus significantly altering the eating habits of local residents. Furthermore, the city's local version of a doggy bag, a cardboard box named 'Restorestje', has been widely copied in other Belgian cities and regions;
- another example is the 'No Food to Waste' initiative. In March 2014, the Flemish government and a number of partners among which the HoReCa sector federation

‘Horeca Vlaanderen’, the federation of the food industry ‘Fevia’, the Farmers’ Union (‘Boerenbond’) and the Union of Belgian Caterers (‘Unie Belgische Catering’) signed the commitment statement ‘Together Against Food Waste’. The ‘No Food to Waste’ website offers a number of tips & tricks to fight food waste and Horeca Vlaanderen has developed a checklist with a view to reducing food waste in restaurants and hotels. By now, about 470 kitchen chefs have signed the charter, thus committing to actively reducing food waste;

- a final example is the ‘Too Good to Go’ mobile application, connecting customers to restaurants and stores that have surplus unsold food. This company of Danish origin has been active in Belgium since 2018, with over 6,800 partnering businesses at the moment.

6.2.3 Qualitative analysis for separate collection of materials streams

In Flanders, the most important obligations with regard to sorting waste are determined by the ‘Materials decree (December 23rd 2011)’, i.e. a decree on the sustainable management of material cycles and waste, and ‘VLAREMA (February 27th 2012)’, i.e. a decision of the Flemish Government establishing the Flemish regulation on the sustainable management of material cycles and waste.

In Flanders, sorting regulations exist with respect to the following 24 types of waste fractions:

- PMD waste (plastic, metal cans & drink cartons);
- small hazardous waste;
- glass waste;
- paper and cardboard waste;
- used animal and vegetable oils and fats;
- green waste;
- textile waste;
- waste electrical and electronic equipment;
- waste tyres;
- rubble;
- waste oil;
- hazardous waste (solvents, paints and varnishes, etc.);
- asbestos-cement based waste;
- end-of-life equipment and containers containing ozone-depleting substances or fluorinated greenhouse gases;
- waste construction films;
- waste batteries and accumulators;
- wood waste;
- metal waste;
- plastic films;
- hard plastics;
- polystyrene;

- kitchen waste and food waste;
- food waste (packaged food);
- mattresses;

The obligation to separate kitchen waste and food waste applies to companies that serve hot meals at least once a week (regardless of whether the catering is internal or external).

6.2.4 Identifying specific challenges and opportunities

The fact that natural resources are limited probably constitutes the main worldwide challenge underlying the need for a transition to a circular economy. The exhaustion of both non-renewable and renewable natural resources has serious and sometimes irreversible consequences for the environment and for the biodiversity. Also, the “low carbon” transition, which is necessary to limit the emission of greenhouse gases and to tackle global warming, requires the use of new types of raw materials, for which the production and accessibility are not always guaranteed due to economic, social, political or environmental reasons. Governing those challenges demands an actual shift in our production and consumption patterns, taking into account complete product life cycles. Thus, more needs to be done than merely recycling, and innovative industrial practices such as the circular economy, industrial symbiosis, the functionality economy and/or eco-conception are required. With a view to shaping such transitions, the commitment and effort of all economic agents will be necessary: product designers, production managers, distributors, company directors, policymakers, trade unions, non-governmental organisations and consumers.

In terms of overall opportunities, a more efficient and economical use of resources will limit the pressure on the environment and on society as a whole. Circularity can also have a significant positive impact on air pollution and the emission of carbon dioxide. Through an improved informing of consumers regarding the real full life cycle cost of products (including external costs), overconsumption ought to be reduced. A more efficient use of resources should also contribute directly to an increase in companies’ investments, innovation, productivity and competitiveness. As far as Belgium is concerned, PricewaterhouseCoopers published a study in 2016, in which four industries were analysed with regard to the opportunities offered by the circular economy: the chemical industry, the food industry, the machines and equipment industry, and the automobile industry. According to the study, the circular economy should make it possible to create between 293 million EUR and 1.2 billion EUR of added value in the concerned industries in Belgium by 2030. The report by PricewaterhouseCoopers also claims that the circular economy could enable the direct creation of 3,700 to 11,600 additional jobs in the aforementioned industries by 2030.

With respect to food waste in particular, the monitoring report published in 2017 by the Flemish Food Supply Chain Platform for Food Loss has, among other things, identified the following challenges for some of the main links in the agri-food chain in Flanders: as for the food industry, continued attention to optimising processes and operations as well as reprocessing surpluses as much as possible internally or externally into food products suitable for human consumption, is required. The report also states that remaining surpluses should be

passed on to social organisations wherever possible. Furthermore, it is emphasized that in view of the strong interdependency between the food industry and agriculture (with the food industry being dependent on agriculture for its raw materials and agriculture being dependent on livestock feeds which are often a food waste-based output of the food industry), the symbiosis between both industries should be strengthened further. Also, the monitoring report stresses the importance of conducting research into the high-quality valorisation of (substances from) inedible food waste to human food. With respect to hospitality and catering, the report identifies valorisation as the main focal point and designates the fairly low selective collection of food waste (24% in catering and 31% in the hospitality sector) as an important cause. Thanks to the recent additional obligations regarding the separate collection of kitchen and food waste (see section 6.2.3), this issue should at least partly be addressed. Finally, as for households/consumers, the major challenges continue to lie in further raising awareness as well as providing them with information and educational initiatives with respect to food waste.

6.2.5 Percentage/Level of waste reuse

According to Eurostat data, in 2016 Belgium ranked second in the EU with almost 77% of total waste being recycled, while the EU average (EU-28) amounted only to 37.8%. Whereas nearly half of total waste was not recovered but disposed of (45.7% through landfilling and 1% through incineration without energy recovery) in the EU, overall waste recovery in Belgium was close to 90% (89.5%).

With a recycling rate of municipal waste equal to 52.3% in 2020 (compared to an EU-27 average of 48.6%), Belgium ranked 7th within the EU. The Belgian recycling rate of municipal waste has been quite stable for nearly 20 years now.

Also, as far as the management of packaging waste is concerned, Belgium is among the “top pupils in Europe’s class”: according to Eurostat, nearly 99% of Belgian packaging waste was recovered or incinerated with energy recovery in 2020, compared to an EU-27 average of 80.2%. The recycling rate for packaging waste was 79.7% in Belgium, with an overall EU-27 average of 64.3%. For both statistics, Belgium ranked first in the EU.

In terms of the recycling of e-waste (waste electrical and electronic equipment; WEEE), however, Belgium was much closer to the EU-27 average in 2018, with a recycling rate of 39.3% compared to an EU average of 38.9%. Although Belgium’s recycling proportion of e-waste has increased considerably in recent years (in 2008 the recycling rate was still at 28.3%), the country only ranked 19th within the EU on this aspect.

6.2.6 Mandatory separation of waste streams

As already described in section 6.2.3, the ‘Materials decree (December 23rd 2011)’, i.e. a decree on the sustainable management of material cycles and waste, and ‘VLAREMA (February 27th 2012)’, i.e. a decision of the Flemish Government establishing the Flemish regulation on the sustainable management of material cycles and waste, impose far-reaching mandatory separation of waste streams in Flanders, with sorting regulations in place for no fewer than 24 types of waste fractions (the overview of those waste types is provided in section 6.2.3).

Furthermore, while it is the responsibility of the municipality or an intermunicipal waste association to collect household waste, municipalities are not obliged to collect company waste. As a consequence, companies have the additional obligation to enter into a contract with a collector of residual waste registered with the Flemish Public Waste Agency (OVAM). Such a contract must provide detailed information regarding the mandatory separation of waste streams. On top of that, the VLAREMA regulation requires that the collectors visually inspect the residual waste containers of their clients in order to trace and register sorting anomalies.

6.2.7 Best practices

As far as certifying circular business practices is concerned, the Cradle to Cradle Certified® certification is probably the most renowned label. The basic vision behind the concept of Cradle to Cradle was established in the 2002 book “Cradle to Cradle: Remaking the Way We Make Things” by architect William McDonough and chemist Michael Braungart.

The general underlying idea is that ‘waste equals food’. Cradle to Cradle products or applications are designed in such a manner that their every fibre (‘waste’) can be reused (‘food’) without loss of quality or environmental damage. Thus, the focus is not on 'less waste', but on 'no waste', with a wasteless society as the ultimate goal.

To achieve the Cradle to Cradle Certified® certification, products are assessed according to five critical categories of sustainability performance: (1) material health, (2) product circularity, (3) clean air & climate protection, (4) water & soil stewardship, and (5) social fairness. For each category, assessed products receive an achievement level (Bronze, Silver, Gold or Platinum), with each level having a set of different criteria. It is obvious that the higher the level, the more severe the criteria. The overall score of a product is determined by the lowest level obtained in one of the five categories.

7 Current waste management practices on municipal level

7.1 City of Zadar

7.1.1 Evaluation of regional and local policies and strategies on waste management

At the regional level Waste Management Plan for Zadar's County was adopted in 2009. as a strategic document, but still hasn't been harmonized with new Waste Management Act.

At the local level Waste Management Plan for City of Zadar 2018.-2023. (Official Gazette 3/18) was adopted. Plan analyses the current state of waste management in Zadar, sets the main goals and sub-goals of waste management aligned with the national goals, defines measures for implementation of the Plan, defines important projects and financial resources. An integral part of this document is the Waste Prevention Plan, which analyses the current state of waste prevention and defines waste prevention measures at the local level.

Goals in waste management proscribed by the Waste Management Act are as follows:

Goals for municipal and construction waste: At least 50% of the total mass of the waste generated in households and other sources similar to household, including paper, metal, plastics and glass shall be recovered through recycling and preparation for re-use. At least 55% of the mass of municipal waste must be recovered by recycling and preparation for re-use by 2025, 60% by 2030 and 65% by 2035. At least 70% of the mass of non-hazardous construction waste, shall be recovered by recycling, preparing for re-use and other material recovery operations.

Goals for landfilling: The maximum allowed mass of biodegradable municipal waste that may be landfilled in a calendar year, for all waste management licenses in the Republic of Croatia is 264.661 tons, which is 35% of the mass of biodegradable municipal waste produced in 1997. By 2035 the maximal amount of municipal waste landfilled may only be 10% of the total mass of generated municipal waste.

Goals for waste single-use plastic: The following content by weight of single-use plastic shall be collected separately for recycling, which are placed on the market within one year: 77% by 2025 and 90% by 2029. Beverage bottles which are made out of polyethylene terephthalate as the main component (PET), should contain at least 25% recycled plastics from 2025 and at least 30% from 2030.

Goals for waste vehicles: The rate of reuse and recovery must be at least 95% of the average mass of vehicles submitted for processing, i.e., the rate of reuse and recycling of vehicles submitted for processing during the year must be at least 85% of the average mass of vehicles submitted for processing.

Goals for waste batteries and accumulators: The annual rate of separate collection of waste batteries and accumulators shall be at least 45% of the average annual amount which was placed on the market over the past three years.

Goals for waste electrical and electronic equipment: Annually, for heat exchange equipment or large equipment bigger than 50 cm: at least 85% must be recovered or at least 80% must be prepared for reuse and recycling. For collected screens, monitors and equipment containing screens larger than 100 cm²: at least 80% of the mass must be processed to recovery process or 70% processed for reuse and recycling. For small equipment whose dimensions are no larger than 50 cm or small IT equipment with dimensions greater than 50 cm: at least 75% of the collected mass must be processed to recovery process. At least 80% of the mass of the collected light bulbs must be recycled.

Goals for packaging waste: At least 60% by weight for packaging waste produced within the territory of the Republic of Croatia shall be separately collected and recovered, either as material or energy. At least 55% and up to a maximum of 80% by weight intended for material recovery shall be recycled. Following minimum mass of materials in packaging waste shall be recycled: 60% for glass, 60% for paper and cardboard, 50% for metals, 22,5% for plastics, 15% for wood. By 31 December 2025, at least 65% by weight of all packaging waste will be recycled.

By 31 December 2025, at least the following mass of materials in packaging waste shall be recycled: 50% of plastics, 25% of wood, 70% of ferrous metals, 50% of aluminium, 70% of glass and 75% of paper and cardboard. By 31 December 2030, at least 70% by weight of all packaging waste shall be recycled. By 31 December 2030, at least the following total mass of materials in packaging waste shall be recycled: 55% of plastics, 30% of wood, 80% of ferrous metals, 60% of aluminium, 75% of glass and 85% of paper and cardboard.

Goals for waste tires: To ensure the recycling of at least 80% of the mass of the separately collected waste tires in a calendar year.

Goals for waste oil: To ensure separate collection and treatment of waste oil.

7.1.2 Collection systems

Waste is collected by waste management company Čistoća d.o.o. which is 59,49% in cities ownership while remaining owners are other smaller municipalities in Zadar's region. Collected waste is transported to Zadar's official landfill Diklo.

Municipal waste in Zadar's urban area is collected through two types of containers: containers for mixed municipal waste and containers for recyclable waste. In some parts of the city waste is also collected by containers for biowaste. The introduction of bio-waste collection is in progress, and it is expected that in the very near future bio-waste will be collected throughout the City.

Mixed municipal waste - Mixed municipal waste is collected through containers of 80, 120 and 240 litres for households in individual housing (family houses) and through shared containers with a volume of 1,100 litres for households in residential buildings. Containers for mixed waste with a volume of 80, 120 and 240 litres are emptied 2 times a week, while containers with a volume of 1,100 litres are emptied 3 times a week. In areas closest to city centre, containers are emptied daily. The emptying schedule is pre-defined by zone and published on the website of Čistoća d.o.o.: www.cistoca-zadar.hr

Containers for mixed municipal waste are equipped with RFID transponders (chips) for electronic reading of emptying. The chipping of the containers is part of the preparation for the transition to the charging system according to the number of emptying of the containers, for which the conditions will be met after the installation of containers for recyclable and biodegradable waste.

Recyclable waste - This waste is collected in containers of 240 litres for households and containers with volume 1100 litres for residential buildings. Recyclable containers are green with an orange lid and are intended for disposal of recyclable following waste: plastic, metal, paper, glass, and other types intended for recycling (e.g., textiles, wood, etc.). In the city centre (on the Peninsula) recyclable waste is deposited in 2 recyclable containers with a volume of 2 m³, which are located within 2 sets of underground containers (each set consists of a container for mixed municipal waste, recyclable waste, and biodegradable waste). Recyclable waste, especially big ones can also be disposed in recycling yards. The emptying schedule is pre-defined by zone and published on the website of Čistoća d.o.o.: www.cistoca-zadar.hr. Containers with a volume of 240 litres from households are emptied every 15 days while those from the residential buildings with volume of 1,100 litres are emptied once a week or every 15 days, depends on the needs. In areas closest to city centre, containers are emptied daily.

Biodegradable municipal waste - Biodegradable municipal waste has been collected through containers with a volume of 80 litres for family houses and containers with a volume of 240 and 360 litres for residential buildings. Containers for biowaste is coloured brown. In the strict city centre, there are 2 tanks with a volume of 1 m³ are located as part of the underground tank. Collection of biowaste has still not been introduced in the whole city but just in several areas (8 of total 36 local boards). Containers are emptied once a week while in areas closest to city centre, containers are emptied daily. The emptying schedule is pre-defined by zone and published on the website of Čistoća d.o.o.: www.cistoca-zadar.hr

Bulky waste - Once in a year, waste is collected from the user free of charge. The amount of bulky waste that is removed free of charge is limited to 4 m³ per removal. Each subsequent collection of bulky waste is charged according to the Price List of waste company Čistoća d.o.o. Bulky waste can also be deposited in the recycling yards, which is free of charge for Zadar's citizens.

Recycling yards - City of Zadar has 3 recycling yards: two fixed/built (Diklo and Gaženica) and one mobile. Gaženica covers the eastern part of the city, Diklo covers the western part of the city, while the mobile recycling yard covers the central part. Considering the number of inhabitants City of Zadar meets the needs for recycling yards according to the Law on Sustainable Waste Management.

Waste management on the islands - On Zadar's administrative area there are 7 small islands. Mixed municipal waste on islands is collected through 80, 120 and 240 litres. Plastic waste is collected by yellow plastic bags and wastepaper is collected by blue plastic bags. The bags are deposited directly next to the container for mixed municipal waste. There are no containers for biowaste on islands, but 228 composters have been distributed to those households that

wanted to use them. The others dispose bio waste in containers for mixed municipal waste. Also in 2021, a mobile bio-composter, type EcoKompos T30 30GG EI, with an estimated annual capacity of 30 tons, has been installed on island Ist (financed by EU funds as part of the NETWAP project).

Waste collected from households is transported to a transfer stations - one on each island (with an exception of island Molat that has 3 settlements and 3 collection points). Transfer stations are points where waste is temporarily stored in press containers. From the transfer stations waste is transported by special ship to the land for disposal or recycling. Waste is transported by a ship that meets the necessary technical characteristics, based on the contract signed by Čistoća d.o.o. and ship company selected through the public procurement procedure. Activities of harmonizing the existing transfer stations with legal regulations are in the procedure: the preparation of project documentation and the issuance of building permits. Currently, there are valid building permits for 2 islands: Rava and Ist.

7.1.3 Waste production and composition

Total waste generation in 2021 was 1.766.560 t at national level and 35.106 t at municipal level (according to National report on municipal waste for 2021).

Annual per capita total waste generation is 454 kg/capita/year at national level and 496 kg/capita/year at municipal level (according to National report on municipal waste for 2021).

Rate of separated collection for City of Zadar in 2021 was 9,5% (according to National report on municipal waste for 2021).

Recycling rate on national level in 2021 was 31%, municipal waste recycling rate within the public service: 15%; Regional level (Zadar County) 2% (according to National report on municipal waste for 2021).

Waste composition expressed as percentages of the various streams at municipal level is: paper 572,26 t=17,74%; plastic 383,74 t=11,9%; glass: 61,54 t=1,91%; metal: 68,61 t=2,13%; bulky: 1.210,17 t=37,52%; textile: 82,99 t=2,57%; biowaste: 846,05 t=26,23%.

Landfilling percentage is 90,47%. Out of 35.106 total generated waste in Zadar, 31.762,12 t was disposed on the landfill.

7.1.4 Waste management practices

Location for construction waste disposal - There is no recycling yard for construction waste in the City of Zadar. Construction waste is just disposed on official landfill Diklo. Furthermore, citizens can dispose small amounts of construction waste from households, for free in the recycling yards "Diklo" and "Gaženica", if they bring it personal by personal vehicle or by an axle trailer for personal vehicles. Construction waste that can be deposited in the recycling yard refers only to construction waste generated by maintenance and minor repairs performed by the owner himself in an amount not exceeding 200 kg in six consecutive months.

Asbestos cassette - Built on official landfill Diklo in 2009, with national funds. It is a special cassette for the disposal of waste containing tightly bound asbestos and was handed over for

further use to waste company "Čistoća" d.o.o. The area is 670 m² and the total projected capacity of the cassette is about 7,000.00 m³.

Landfill Diklo is Zadar's official disposal for municipal and non-hazard waste. It exists since 1963 and it is managed by waste management company Čistoća d.o.o. which is 59,49% in city's ownership. It is located outside the inhabited area, about 4.5 km northwest of city centre but only about 1 km from nearest inhabited part. Landfill serves City of Zadar and another 20 smaller local self-government units.

Landfill area consists of several parts: entry-exit zone with weighting scale, manual sorter for separate collected recyclable waste, recycling yard (in which citizens can bring bulky and bigger recyclable waste which is not predicted for recyclable containers in households), cassette for asbestos waste disposal, temporary storage of biowaste, construction waste and mineral raw materials. After entering the landfill, vehicles are weighted and evidenced on enter-exit zone. Vehicles with mixed waste are sent directly to the active part of landfill where waste is thrown, spread, compacted and covered with earth at the end of the day. Vehicles with recyclable waste are sent to the small manual sorter where waste is sorted (plastic, paper, glass, wood, textile), packed for handing over to authorized companies or proceed to recycle yard. Vehicles with biowaste are sent to the specific part of landfill which is reserved for biowaste only. There is no composting facility or any kind of composting device and biowaste is just thrown on the land.

Regarding to digital technologies, there is a lack of digital technologies but once the new waste management centre will be in function, larger use of digital technologies is expected. From 2021 containers for mixed municipal waste are equipped with RFID transponders (chips) for electronic reading of the number of discharges. This way the service provider has information about the number of containers emptying which is a key for creation of monthly bill. Also, an interactive map on provider's web site has been established. After entering the address or code from the monthly bill, emptying schedule for each type of waste is displayed. Link: <http://www.cistoca-zadar.hr/>. The whole existing system needs to be upgraded, especially landfill Diklo which does not meet the regulations and must be closed and rehabilitated.

For that reason, construction of new regional waste management centre is planned.

New waste management centre Biljane Donje "is already under construction. Opening is planned for the beginning of 2023 and it consists of: administrative buildings, recycling yard, transport centre, mechanical-biological treatment (MBO) plant with a total capacity of approx. 88,000 t/year (75,000 t/year of mixed municipal waste, 10,000 t/year of biowaste and 3,000 t/year of structural material), landfill for non-hazardous waste with an area of 12 ha, covered warehouse, space for the treatment of waste water and landfill gas, recycling yard for construction waste, landfill for inert waste with an area of 5.9 ha, entry-exit zones. The expected outputs of the mechanical-biological treatment process are: inertised, biostabilate, fuel from waste (GIO/SRF), recoverable waste (metals), compost, evaporated water, waste technological (leachate) water. Project is co-financed by EU funds as part of the Operational Program Competitiveness and Cohesion 2014-2020, Priority axis 6 - Environmental protection and sustainability of resources, investment priority 6i - Investment in the waste sector, in order

to fulfil the requirements of the acquis of the EU. Total value of the project is 682.044.680,80 kunas.

7.2 City of Novi Sad

7.3 Evaluation of regional and local policies and strategies on waste management

The national waste management strategy is an umbrella document that provides conditions for rational and sustainable waste management. Short-term and long-term goals are determined by the strategy.

Waste management in the Republic of Serbia is regulated by: The Law on Waste Management, The Law on Packaging and Packaging Waste and a multitude of lower-level documents

Twinning project Support of the European Union to the development of the strategic framework in the area of waste management, the following planning documents were prepared at the level of the Government Republic of Serbia:

- Waste management strategy for the period from 2019 to 2024 and
- Waste prevention program - WASTE MANAGEMENT PROGRAM OF THE REPUBLIC OF SERBIA FOR THE PERIOD 2022-2031

The new Waste Management Strategy has not yet been adopted but is planned for the period of five years (2019–2024) and focuses on the transition from the regional concept sanitary disposal on the model of a regional waste management centre, which means separate: collection, separation and recycling.

The waste prevention program is based on the principle of waste prevention, and it is not a legal obligation. The purpose of the program is to analyse the current situation in the field of waste prevention in Serbia and the advantages of the measures described in the Framework EU directives on waste, set goals and priority areas of the program, measures for its implementation for the period 2020–2025. year, as well as quantitative criteria or program evaluation indicators.

At the level of the City of Novi Sad, an important strategic document, the Regional Waste Management Plan for the City of Novi Sad and the municipalities of Bačka Palanka, Bački Petrovac, Beočin, Žabalj, Srbobran, Temerin and Vrbas for the period 2019 - 2028, was adopted. Local waste management plans are also being developed for Novi Sad and other member municipalities of the region.

7.4 Collection systems

Collection, transport and disposal of municipal waste from the territory of the city of Novi Sad is performed by PUK "Čistoća", which was founded by the Assembly of the City of Novi Sad. The activities of PUC "Čistoća" include collection, transport and depositing of non-hazardous waste. Organized collection and transport of waste has been established in all 16 populated areas with 100% coverage.

Based on the data obtained from the utility company, waste is also collected from over 7,000 economic entities, most of which are based in Novi Sad. Plastic bins (120 L) as well as containers of 1.1 m³ and 5 m³ are used for the collection of municipal waste. Also, underground containers were installed in the urban part of Novi Sad. Bins of 120 L are used in parts of the city with individual housing, while containers are placed in the zone of residential buildings, i.e., collective housing. Most of the installed containers are intended for the disposal of a mixed flow of municipal waste, noting that as part of the pilot project, 75 underground containers were installed for the disposal of recyclable materials, as well as additional bins for this fraction within individual households in certain parts of the city.

Municipal waste collection in the City of Novi Sad is carried out using 28 garbage trucks and 4 forklift trucks. Garbage trucks have different capacities, most often 16 m³ and 22 m³ and are used to collect mixed municipal waste from 1.1 m³ containers as well as from 120 L buckets. Of the mentioned number, 7 trucks with a capacity of 16 m³ have a special upgrade that enables the lifting of underground containers, whereby one of them is used exclusively for emptying underground containers intended for the primarily separated recyclable fraction.

Within the complex of the city landfill in Novi Sad, there has been an operational facility for secondary waste separation since 2002. Currently, the plant separates over 20 different recyclable materials, which are then baled and put on the market. Recyclable materials such as PET, PVC, plastic, plastic film, glass, aluminium, iron, batteries, tires and other materials that have value on the market are singled out. However, the quantities of separated secondary raw materials are still insufficient, primarily because the primary separated recyclable waste of lower quality (i.e., with a large proportion of impurities) enters the plant as an input waste stream, and a mixed waste stream also appears, which means that the separation process is not efficient enough and the percentage of separated raw materials does not exceed 10% in relation to the total generated waste.

On the territory of the city, there are several companies that deal with the purchase of recyclable materials and companies that deal with recycling, i.e., the processing of recyclable raw materials.

There are many informal collectors. Data on the number of collectors and the collected quantities are not reliable. Based on research in representative municipalities in Serbia, it was concluded that the largest number of informal waste collectors, about 80% of them are men, middle-aged (40-65 years old) and that they are most often members of the Roma population (about 60-70% of the total).

Looking at the categories of waste collected, food, PET and paper/cardboard are the most common. Based on data from the field, on average about 20% of collectors collect food.

Although the current municipal waste collection in Novi Sad is based to the greatest extent on the collection of a mixed waste stream, on November 1, 2016, PUK "Čistoća" implemented a pilot project for the introduction of primary waste separation for about 15,000 households, mainly in the wider city centre and for this purpose in addition to the underground containers for the mixed flow of waste, 75 underground containers for the collection of the dry recyclable

fraction were installed. According to the data of PUC "Čistoća", currently around 2,910 t are collected annually through the primary waste separation system, which is further sorted on the waste separation line.

7.5 Waste production and composition

In 2020, 2.95 million tons of municipal waste were generated in the Republic of Serbia. A total of 2.34 million tons was collected and disposed of, while 558,568 tons of waste, that is, 19% of the generated municipal waste, were disposed of at the regional sanitary landfills in 2020, according to the data of the Environmental Protection Agency. A total of 79.45% of municipal waste was disposed of in landfills. There is no waste treatment before landfilling. In the Republic of Serbia, the average coverage of municipal waste collection is 86.4%. 455,457t of municipal waste was recycled, at the recycling rate of 15.45%. As mentioned above, the reason for the change in the level of recycling compared to previous reporting is the new calculation methodology applied in the EU. The average daily amount of municipal waste is 1.17 kg/inhabitant, or 0.43 t/year.

Table 8. Quantities of municipal waste in the Republic of Serbia in the period 2011-2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total amount of generated waste (Million tons)	2.71	2.62	2.41	2.13	1.84	1.89	2.71	2.79	2.83	2.95
The amount of waste collected and disposed of by municipal PUC (Million tons)	2.09	1.83	1.92	1.67	1.36	1.49	2.33	2.22	2.24	2.34
Average volume of waste collection (%)	77	~ 70	80	~80	82	~82	83.7	87.2	86.2	86.4
Average daily amount of municipal waste per inhabitant (kg)	1.01	0.99	0.92	0.81	0.71	0.73	1.06	1.1	1.12	1.17
Average annual quantity per inhabitant (t)	0.37	0.36	0.34	0.3	0.26	0.27	0.39	0.4	0.41	0.43

Weighing of collected waste is carried out only in Novi Sad, at the entrance to the city landfill, where a truck scale is installed. The amount of municipal waste collected in 2017 is slightly more than 135,000 tons. PUC "Čistoća" also conducts seasonal analyses of the morphological composition of municipal waste. The provided composition of municipal waste was used to calculate the necessary number of bins/containers as well as the size of the waste collection vehicle, in order to establish the primary separation of waste. Based on the submitted composition of municipal waste, it can be concluded that mixed recyclable materials (which

include: paper and cardboard, composite materials - tetra Pak, metal - packaging and others, aluminium cans, plastic packaging waste, plastic bags and HDPE plastic) and glass make up 32% that is, 3%, while 65% is biodegradable and other waste (which includes: garden and "green" waste, other biodegradable (kitchen) waste, textiles, leather, diapers and fine fraction < 20mm).

The municipality of Novi Sad has 341,625 inhabitants and 128,876 households. The average daily amount of waste per inhabitant generated in the municipality of Novi Sad is 1.09 kilograms.

7.6 Waste management practices

Within the complex of the city landfill in Novi Sad, there has been an operational facility for secondary waste separation since 2002. Currently, the plant separates over 20 different recyclable materials, which are then baled and put on the market. Recyclable materials such as PET, PVC, plastic, plastic film, glass, aluminium, iron, batteries, tires and other materials that have value on the market are singled out. Nevertheless, the quantities of separated secondary raw materials are still insufficient, primarily because the primary separated recyclable waste of lower quality (i.e., with a large proportion of impurities) comes into the plant as an input stream of waste, and a mixed stream of waste also appears, which means that the separation process is not efficient enough and the percentage of separated raw materials does not exceed 10% in relation to the total generated waste.

In addition, the capacity of the plant is not sufficient and only about 15% of municipal waste can be "let" through the line. PUK "Čistoća" has a contract with several companies that deal with recycling, depending on the type of secondary raw material that they deliver to them. On the territory of the city, there are several companies that deal with the purchase of recyclable materials and companies that deal with recycling, i.e., the processing of recyclable raw materials.

There is many informal collectors. Data on the number of collectors and the collected quantities are not reliable. Based on research in representative municipalities in Serbia, it was concluded that the largest number of informal waste collectors, about 80% of them are men, middle-aged (40-65 years old) and that they are most often members of the Roma population (about 60-70% of the total).

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