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Italy – Croatia

AWASTER

INTERREG ITALY-CROATIA
PROGRAMME 2021 – 2027

AWASTER – Adopting WASTE as Resource

D.1.1.2 Regional waste management report – Istria County

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INTERREG ITALY-CROATIA PROGRAMME 2021 – 2027
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Project: AWASTER – Adopting WASTE as Resource

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Editor:	Andrea Poldrugovac		

Table of contents

1. Introduction

The regional waste management report for the Istria County presents a primary analysis of waste production and waste management in the Istria County. The purpose of the report is to analyse and address environmental issues connected with the constant increase of waste production, particularly plastic. Istria County is one of the most tourist regions in the Republic of Croatia which implies high seasonal waste production and challenges on how to deal with it.

The report analyses the current state of municipal waste management in Istria County, describes current initiatives for minimizing waste generation and provides insights and recommendations for reducing the environmental impact of waste production, supporting sustainable development, and improving the quality of life in Istria County.

The report covers the detailed geographic and socio-economic description of the Istria County, the waste management system in the Republic of Croatia, an analysis of the composition, categories and type of collected waste at the national and regional level, description of the existing waste management infrastructure, including facilities, devices, and collection systems in Istria County, detailed analysis of the types and sources of collected waste collected within the region, illegal waste disposal sites or illegal landfills, and policies, technologies, and practices for improving waste management system in Istria County.

Together with D.1.1.3 – Regional secondary market report, the Report will be used to develop Guidelines for the sustainable use of resources and for the development of AWASTER Joint Strategy and Action Plan.

2. Istria County

2.1 Geographic data

The Istria County includes a large part of Istria - the largest Adriatic peninsula. The most extreme west point of the Republic of Croatia is in the Istrian Region (Bašanija, promontory Lako) at the 45° of the northern latitude. Situated in the north-west of the Adriatic Sea, Istria is surrounded by the sea from three sides, while the northern border towards the continent is made up by a line between the Miljski Bay (Muggia) in the direct vicinity of Trieste and the Preluk Bay, right next to Rijeka. Such favourable geographic position, almost at the heart of Europe, half way between the Equator and the North Pole, Istria has always represented a bridge connecting the Middle European continental area with the Mediterranean.

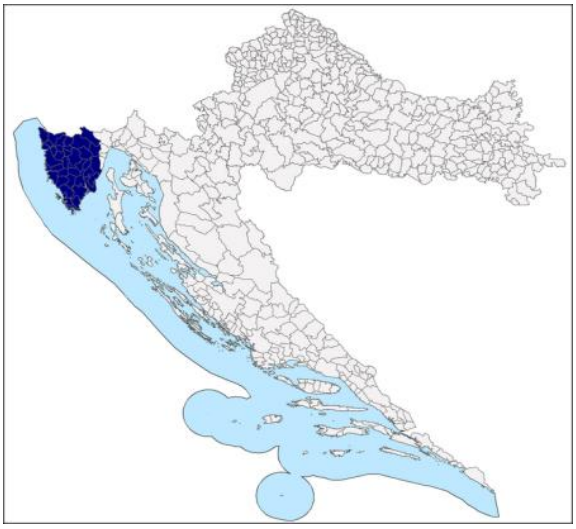

Figure 1 Geographical position of the Istria County

According to the administrative-territorial structure, the Istria County consists of 10 cities and 31 municipalities, while the total number of settlements is 655. The Istrian peninsula covers the surface of 3.476 square kilometers. The area is shared by three countries: Croatia, Slovenia, and Italy. A very small part of Istria, merely the northern part of the Miljski peninsula, belongs to the Republic of Italy. Slovenian coastline with the Kopar Bay and a part of the Piran Bay up to the mouth of the Dragonja River is a part of the Republic of Slovenia. The largest part, or 3.130 square kilometers (90% of the surface), belongs to the Republic of Croatia. Most of the Croatian part of the peninsula is situated in the Istrian Region - 2.820 square kilometers, which is 4,98 per cent of the entire surface of the Republic of Croatia. The remaining part belongs to the Primorsko-Goranska County based on the administrative and territorial subdivision.

CLIMATE - The basic characteristic of the climate of the Istrian peninsula is given by the Mediterranean climate. Along the coast, it gradually changes towards the continent and it passes into continental, due to cold air circulating from the mountains and due to the vicinity of the Alps.

WATER FLOWS - Thanks to impermeable flisch layers, Istria does not have scarce water resources. The most significant surface water-flows in the area of the Istrian Region are the Mirna, the Raša, the Boljunčica, the Dragonja Rivers, and the underground Pazinčica. In the water supply sense, there is a significant function of the surface accumulations Butoniga and Boljunčica.

Figure 2 Butoniga lake

COAST - The length of the Istrian coast, along with islands and islets is 539 kilometres. The west coast of Istria is more indented, and, together with islands, it is 327 kilometres long. East coast, together with islets, is 212 kilometres long. The majority of the Istrian coast is on the Karst and the limestone grounds. The sinking of Karst recess created specific and branched bays, such as the Pula port, the Medulin bay, the Rovinj coast, the Poreč coast and similar. Isolated limestone heights remained as islands. The coast is well developed with lots of bays, deeper small bays, and river mouths. Except for a series of smaller islets in front of the coast from Poreč to Rovinj, the Brijuni archipelago stands out in the south.

Among legally protected landscape in the Istria County are well-known natural reservations-national park Brijuni, nature park Učka, protected landscape Limski Bay, Motovunska forest, forest park Zlatni Rt and ornithologic reservation Palud near Rovinj, forest park Šijana near Pula and the protected landscape Kamenjak in the extreme south of Istria (Istrian County, 2024).

2.2. Population in the Istria County

The Istria County, along with the City of Zagreb, is the only regional self-government unit that has recorded an increase in the number of residents in the last five years. According to the 2021 population census, a total of 195.237 inhabitant's lives in the Istria County.
The average population density of the Istrian Couty is 69,41 people/km², the highest population density is in the City of Pula-Pola, 1.011 people/km², and the lowest in the Municipality of Lanišće, 1,87 people/km². The average population density is slightly higher than the national average, and it is increased by the population density in the urban centers, Pula - Pola, Rovinj - Rovigno, Labin, Umag - Umag, Novigrad - Cittanova and Poreč - Parenzo.

The population is mostly concentrated in urban centers and 68,30% live in 10 cities, while 31,70% of the County's population lives in municipalities. In addition to the spatial distribution of the population in favor of urban centers, the basic demographic characteristics of the population of the Istria County are a negative natural population movement, a positive migration balance, demographic aging and pronounced multi-ethnicity. The continuous increase in the number of inhabitants of Istria County is the result of a positive migration balance, i.e. a higher number of immigrated versus emigrated population, and not a positive natural increase. In the observed ten-year period, with the exception of 2011, a positive migration balance was continuously recorded, and the biggest difference was recorded in 2019, when a total of 5,484 people immigrated and 3,727 left, so the migration balance amounted to +1,757 people. According to the 2021 population census, 4,390 people immigrated to Istria County, and 3,579 people left, and the migration balance is +811 people (Istrian County, 2024).

2.3. Economy

The Istria County with a development index of 108.970 and an average income per inhabitant of 4.670,67 euros is the most developed county in the Republic of Croatia after the City of Zagreb. The gross domestic product (GDP) of Istria County in 2018 was 3.159.864,62 euros, and according to the value of GDP per inhabitant (15.292,06 euros), Istria County is approximately 20% above the average of the Republic of Croatia.
When it comes to the structure of the gross added value of the Istria County, in 2018 wholesale and retail trade, transport and storage, accommodation, food preparation and service dominate with

35,9%, followed by processing industry with 12,6% and public administration and defense, education, health care and social welfare activities with a 10,6% share.
There are a total of 28.701 registered business entities in the Istria County in 2020, of which 17.425 or 60,7% are trading companies, while 26,1% (7.491) relate to trades and free professions. Biggest number 92,8% of the companies are micro companies, followed by small companies with 6,3%, and medium (0,7%) and large (0,2%) companies. Among the large companies, the most are those in the processing industry (8) and the activities of providing accommodation and preparing and serving food (6). According to FINA data, in 2019, the entrepreneurs of Istria County achieved total revenues in the amount of 4,738 billion euros (4,5% growth), total expenditures of 4,499 billion euros (3,9% growth), and a profit for the period of almost 352 million EUR (down 7,3%), loss for the period of EUR 172 million (down 15,9%) and net profit of EUR 186 million (up 2,8%). Valamar Riviera from Poreč - Parenzo is in first place among companies in terms of total revenue, followed by Maistra from Rovinj - Rovigno and Plava laguna from Poreč - Parenzo. The largest number of employees (26,7%) worked in the provision of accommodation and food preparation and service, followed by the processing industry (22,8%), trade (14,1%) and construction (12,6%). According to the size of the company, the largest number of employees in 2019 worked in micro (35%) and small companies (25%). In large companies, 24% of the total number of employees are employed in two activities - providing accommodation and food preparation and serving (17%) and the processing industry (5%).
When it comes to exports, in the Istria County, the highest value of exports in 2019 was achieved in the processing industry, which accounted for 53,14% of total exports, followed by professional, scientific and technical activities (20,52%) and trade activities (19,55%).
According to data from the Chamber of Crafts of Istria County, at the end of 2020, 8.063 trades were registered. When it comes to the structure of trades, it has seen several changes in the last six years - an increase in the share of service trades, thanks primarily to an increase in the number of trades in the field of intellectual services and a decrease in the share of active trades in activities related to trade, catering and tourism. The share of manufacturing crafts, transport and personal services is stagnating. According to activities, of the total number of trades in the Istria County, the most represented are service activities, which are engaged in by almost 40% of tradesmen, followed by trade trades (17,4%) and trades in the tourism and catering sector (12,9%) (Istrian County, 2024).

3. Waste management system

This chapter provides a comprehensive description of the waste management system in the Republic of Croatia and Istria County.

3.1. Waste management system in the Republic of Croatia

About 6 million tons of waste is produced in Croatia every year (about 1,5 tons per person per year). Most of this waste comes from the construction sector and households. The waste management system in Croatia relies mainly on landfilling, 58% of the municipal waste produced in Croatia ends up in one of 80 active landfills in the country. But also, illegal landfilling remains a long-lasting problem. The waste management practice differs from city to city. Only in recent years, recycling efforts have intensified.
The quantity, composition and type of collected waste in the Republic of Croatia are published in the report on waste management in Republic of Croatia. The last one is the one prepared for the year 2022, published in July 2023 and revised in September 2023, by the Croatian Ministry of Economy and Sustainable Development.

In this document, it will be analysed the municipal waste management streams and partially specific waste types. The municipal waste is defined by the Waste Management Act as a mixed municipal waste and separately collected waste from households, including paper and cardboard, glass, plastics, metal, bio-waste, wood, textile, packaging, waste electrical and electronic equipment, waste batteries and accumulators and bulky waste, including mattresses and furniture, as well as mixed municipal waste and separately collected waste from other sources, if that waste is similar in nature and composition to waste generated by households but does not include waste from manufacturing, agriculture, forestry, fishery and aquaculture, septic tanks and sewers, and wastewater treatment plants, including sewage sludge, end-of-life vehicles and construction waste, whereby the issue of division of responsibility for waste management between public and private entities is not affected by the said definition. Methodologically, all the municipal waste providers and other operators report quantities through the electronic system called ROO (register for waste polluters).

3.1.1. Waste management policies at the national and regional level

Waste management in the Republic of Croatia is defined by the the Waste Management Act (OG 84/21). The Waste Management Act sets out the measures to achieve the objectives specified in the European Green Deal and the Action Plan for a Circular Economy, integrating waste management into circular economy. Within the waste management industry, the measures proposed by the

European Green Deal supporting the compliance with the existing national obligations arising from the said EU directives on waste are considered to be particularly important, and in particular the objectives to be achieved by 2035, as specified in the Directive 2008/98/EC – to increase waste sorting and recycling rates to 65 % and reduce waste disposal rate to 10 %. In addition to the special measures which give priority to waste prevention, reuse and recycling before final disposal at landfill sites, the directives from the so-called 'waste package ' additional requirements were added to the directive which must be included in the waste management plans of the EU Member States and waste prevention programmes.

As the overarching planning document that aligned the waste management system in Croatia with new goals and policies, the Waste Management Plan of the Republic of Croatia for the period 2023-2028 has been developed, based on the goals set for 2035.

In addition to the National Plan, other planning documents for waste management include the Waste Management Plan of regional self-government units and the Waste Management Plan of the City of Zagreb, which are proposed by the executive body and adopted by the representative body of the regional self-government unit or the City of Zagreb.

In order to contribute to the circular economy of the European Union, the Republic of Croatia has committed to achieve the following goals (Ministry of Economy, 2024):

- At least 50% of the total mass of waste produced in households and waste from other sources whose waste streams are similar to the stream of household waste, including at least paper, metal, plastic and glass, must be recovered by recycling and preparation for reuse;
- At least 55% of the mass of municipal waste must be recovered by recycling and preparation for reuse by 2025;
- At least 60% of the mass of municipal waste must be recovered by recycling and preparation for reuse by 2030 and,
- At least 65% of the mass of municipal waste must be recovered by recycling and preparation for reuse by 2035.

The maximum permitted mass of biodegradable municipal waste, the disposal of which in a calendar year can be permitted by all waste management permits in the Republic of Croatia, is 264.661 tons, which is 35% of the mass of biodegradable municipal waste produced in 1997. The amount of municipal waste disposed of in landfills can be a maximum 10% of the mass of the total produced municipal waste by 2035. In order to contribute to the improvement of the environment and meet the set goals, it is important to ensure separate collection of waste, which would reduce the amount

of waste scheduled for disposal, and at the same time utilize the valuable properties of separately collected waste.

Besides the Waste law, the waste acquis in Croatia consists of 19 secondary bylaws and 8 ministerial decisions.

Pursuant to Article 111 of the Law on Waste Management (OG 84/21, 142/23), the executive body of a regional self-government unit is obliged to propose the adoption and ensure the implementation of a waste management plan in its territory. The waste management plan is adopted by the representative body of the regional self-government unit. Furthermore, the same body evaluates the Plan at least once every six years, and amends the Plan as necessary. Therefore, in accordance with Article 173, paragraph 1 of the Law, the Istria County was obliged to adopt the Waste Management Plan at the regional level by January 1, 2024 but the adoption was postponed. Cities and municipalities no longer have the obligation to adopt waste management plans.

3.1.2. Origin, composition, categories and type of collected waste at national level

Since 2016, all municipalities and cities in the Republic of Croatia have been covered by organized municipal waste collection. In the period from 2014 to 2020, the coverage of the population by organized collection of municipal waste stagnated, and it amounts to about 99%. An increase is recorded in 2021, and in 2022 it is almost 100%.

Data on the generated municipal waste in the Republic of Croatia until 2005 were mostly based on estimates. From 2006 onwards, the quantities are determined according to the data reported by the taxpayers, with an additional assessment of the data for the share of the population that is not covered by organized collection and for the municipalities for which the data was not submitted. It should be emphasized that since 2011, data on municipal waste (waste paper and cardboard, packaging waste, waste edible oils, batteries and accumulators...) from the service sector (schools, kindergartens, offices, hotels, shops...) have also been used in the calculation.) and data on special categories of waste collected within the system organized by Environmental Protection and Energy Efficiency Fund (EPEFF).

The long-term increase in the amount of municipal waste generated since 1995 stopped in 2008, after which a decrease in reported amounts was recorded until 2010, which can be attributed to the economic crisis.

According to the Report on municipal waste for 2022, developed by the Ministry of Commerce and Sustainable Development, in Croatia in 2022, 1.844.382 tons of municipal waste was generated, which made the total amount reach the highest value in the period from 1995 to 2022. Compared to 2021, this is an increase of 4%. Of the total amount, 1.270.429 tons of municipal waste was reported as part of the public service, while 28.934 tons was additionally reported from collection via containers on public areas. 1.613 tons of municipal waste was additionally collected in recycling yards through the return fee system, and 63.954 t through retail. The remaining amount of 479.451 tons refers to additionally determined amounts, namely to amounts originating from service activities (packaging waste, waste paper and cardboard, waste edible oils, etc.) that can be considered municipal waste and part of the amounts taken within the framework of the national of the system for special categories of waste organized by Environmental Protection and Energy Efficiency Fund (EPEEF), quantities of exported municipal waste, differences in quantities of treated waste (disposed of, composted, digested, etc.) and estimates for the part of the population not covered by organized collection.

In table 1, it is presented the total amount of generated municipal waste in the Republic of Croatia in 2022:

County	Collected within the framework of public service (PS) (tons)	Collected within PS, containers on public areas, return fee in recycling yards and through retail trade (tons)	Share of the county in the total collected amount	Total generated municipal waste (t)
1. Zagreb	76.933	80.868	6,06%	109.902
2. Krapina-Zagorje	21.280	22.677	1,68%	30.708
3. Sisak-Moslavina	31.972	33.753	2,52%	45.819
4. Karlovac	28.999	30.165	2,28%	41.109
5. Varaždin	30.238	34.171	2,38%	45.582
6. Koprivnica-Križevci	22.041	23.933	1,73%	32.251
7. Bjelovar-Bilogora	18.947	19.913	1,49%	27.063
8. Primorje-Gorski Kotar	134.992	136.245	10,63%	187.190
9. Lika-Senj	20.195	20.264	1,59%	27.885
10. Virovitica-Podravina	16.115	18.203	1,27%	24.285
11. Požega-Slavonija	12.166	12.255	0,96%	16.847
12. Brod-Posavina	26.793	28.043	2,11%	38.154
13. Zadar	88.668	90.519	6,98%	123.982
14. Osijek-Baranja	67.306	69.948	5,30%	95.349

15. Šibenik-Knin	41.181	44.197	3,24%	59.738
16. Vukovar-Srijem	38.321	39.007	3,02%	53.469
17. Split-Dalmatia	181.461	196.024	14,28%	264.506
18. Istria	100.947	119.868	7,95%	157.964
19. Dubrovnik-Neretva	52.835	55.283	4,16%	75.222
20. Međimurje	27.589	32.000	2,17%	42.415
21. City of Zagreb	231.453	257.596	18,22%	344.944
Total:	**121.453.226**	**181.642**		**1.844.382**

Table 1 Total amount of generated waste in the Republic of Croatia in 2022. /Tonne (source: Report on municipal waste for 2022, Ministry of Commerce and Sustainable Development)

From 2011 to 2019, the amount of generated municipal waste is again continuously increasing, ranging between 1,6 million and 1,8 million tons. In 2020, as a result of the COVID-19 pandemic, which resulted in a significant reduction in the work of the service sector (closure of catering establishments, reduced number of tourist overnight stays), the amount of municipal waste fell to the value of 2014. By strengthening the activities of the service sector (catering facilities, significantly increased number of tourist overnight stays, etc.) from 2021, there will be another increase, and the total amount of municipal waste in 2022 will be 1,844,382 t, which is the highest value in the observed period from 1995 to 2022 year (Ministry of Economy and Sustainable Development, 2023).

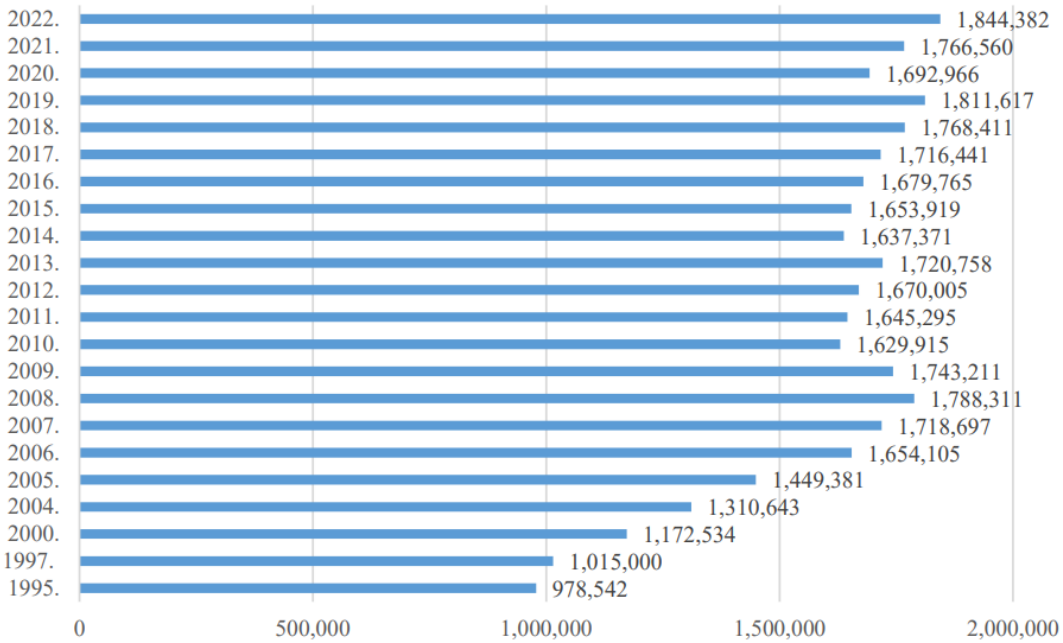

Figure 3 Amount of total generated municipal waste in the Republic of Croatia, 1995-2022.

When it comes to the separately collected municipal waste (all types of municipal waste except mixed municipal waste), the total amount of generated municipal waste with additional determined amounts in 2022 accounted to 844.387 tons or 46%, while the amount of mixed municipal waste amounted 54 % or 999.995 tons. The dynamics of the increase in the rate of separate waste collection has been somewhat slower in the last two observed years, as a result of impurities that are present in a significant proportion of separately collected waste, especially in biowaste, which in this case is categorized as mixed municipal waste. A comparison of separate collection rates within the public service between 2021 and 2022 showed an increase for 18 counties out of a total of 21. Since the 2010, the quantities of separately collected waste have increased by 370%, with 844.387 tonnes of waste separately collected in 2022. The largest increase in the separate collection of municipal waste compared to the previous year was recorded for glass (35%). There is also a significant increase in the amount of separated collection for plastic (23%) and paper and cardboard (19%).
The recycling rate in 2022 amounts to 34% and 630.882 tons of municipal waste was recycled. National and EU goal for recycling for 2020 by recycling and preparing for reuse at least 50% of the total mass of waste produced was not reached. From the point of view of separate collection of waste within the framework of the public service, in 2022 the rate of separate collection is 24% which is an increase of three percentage points compared to the data for 2021. Separate collection of at least one of the useful types of waste from municipal waste (paper and cardboard, plastic, glass, metal, bulky waste, textiles and biowaste) as part of the public service in 2022 was carried out in 528 local self-government units.
The total breakdown of separately collected waste in Republic of Croatia is shown table 2, and it shows the waste market potential in 2022.

Waste stream/material	Quantity/tonne	Share
Paper and cardboard	270.666	0,32
Bulky waste	136.837	0,16
Biowaste	118.806	0,14
Plastic	91.025	0,11
Glass	71.709	0,08
Wood	57.865	0,07
Metal	136.512	7,7%
WEEE	181.462	9,9%
Textile	4.728	0,01
Batteries	416	0,00
Other	27.519	0,03
Total	**844.837**	**1**

Table 2 Separately collected waste in 2022 / tonne (source: Report on municipal waste for 2022, Ministry of Commerce and Sustainable Development)

The breakdown shows that paper is the most collected material in Croatia (32% of total quantities) although it does not have the highest statistical potential. Bulky waste represents 16%, however, in most of the municipalities it ends up landfilled or mechanically treated. Biowaste represents 14% and plastic 11%. It has to be noted that several packaging types run through parallel system run by National Fund for Environmental Protection and Energy Efficiency and does not exactly enter the market through same channels as ones used by public service companies.

3.2. Waste management system in the Istria County

According to the Article 10 of the Waste Management Law, the executive bodies of local and regional self-government units are obliged to ensure the conditions and implementation of prescribed waste management measures in their area, and several units of local and regional self-government can, by agreement, ensure the joint implementation of waste management measures. One of the most important obligations of local self-government units is to ensure the performance of the public municipal waste collection service in a high-quality, sustainable and economically efficient manner while avoiding unreasonably high costs and in compliance with the principles of sustainable development and environmental protection. As part of using the public municipal waste collection service, producers and owners of waste are encouraged to submit waste separately with the aim of reducing the amount of mixed municipal waste, the share of biowaste in the generated amount of mixed municipal waste, which increases at the same time quantities of separately collected and recycled paper and cardboard, glass, metal, plastic, biowaste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, bulky waste, including mattresses and furniture, and waste classified into special categories waste, the management of which is governed by the regulations governing special management categories of waste.

3.2.1. Waste management facilities, devices and collection systems in the Istria County

In the territory of the Istria County, the public service of municipal waste collection is organised by 9 public companies founded by the local self-government unit.

Service provider / Local self-government unit
1. MAJ d.o.o. Labin
Kršan
Labin
Raša
Pićan
Sveta Nedelja

Service provider / Local self-government unit
PULA HERCULANEA d.o.o. Pula
Barban
Fažana - Fasana
Ližnjan - Lisignano
Marčana
Pula - Pola

6. MAJ d.o.o. Umag	Svetvinčenat
Brtonigla – Verteneglio	**USLUGA d.o.o. Pazin**
Buje – Buie	Cerovlje
Grožnjan - Grisignana	Gračišće
Novigrad - Cittanova	Karojba
Oprtalj - Portole	Lupoglav
Umag - Umago	Motovun - Montona
CONTRADA d.o.o. Vodnjan	Pazin
Vodnjan - Dignano	Sveti Petar u Šumi
KOMUNALNI SERVIS d.o.o. Rovinj	Tinjan
Bale - Valle	**USLUGA POREČ d.o.o. Poreč**
Kanfanar	Funtana - Fontane
Rovinj - Rovigno	Kaštelir - Labinci - Castelliere-S. Domenica
Žminj	Poreč - Parenzo
MED EKO SERVIS d.o.o. Medulin	Sveti Lovreč
Medulin	Tar-Vabriga - Torre-Abrega
PARK d.o.o. Buzet	Višnjan - Visignano
Buzet	Vižinada - Visinada
Lanišće	Vrsar - Orsera

Table 3 Overview of public service provision in the Istria County

Waste management includes the activities of collection, transportation, recovery, including the sorting and disposal of waste, including the supervision of the performance of these activities, supervision and measures carried out at the locations where the waste was disposed of, and actions taken by the waste dealer and intermediary in waste management. Pursuant to Article 27 of the Waste Management Act, a legal or natural person is authorized to take possession of a shipment of waste if:

- has a permit for waste management,
- manages the recycling yard,
- is registered in the register of persons who perform waste management activities as a waste collector or unlicensed recycler or as a waste dealer who can take possession of waste,
- taking possession of certain waste is permitted by a regulation regulating special categories of waste,
- is a user of waste sludge in agriculture, whereby he is authorized to take over a shipment of waste sludge in accordance with a special regulation,
- manages a cemetery or crematorium and is authorized to take over waste shipments in accordance with the special regulation on medical waste.

Istria County is one of the first in Croatia which has implemented the Integrated waste management system. The system was established with the construction of the Kaštijun Waste Management Center, which serves as an organized, economically oriented and comprehensive way of managing waste from the Istria County area.

The Kaštijun Waste Management Center is managed by the public company Kaštijun d.o.o. which was was founded in 2007, and started in 2008 with with preparatory work for bringing the company into operation for providing the services for which it is registered. After the completion of the construction of the Waste Management Center, the company concluded a contract with all suppliers of the public service for the collection of mixed municipal waste from the area of Istria County, and the delivery of waste and its processing began on July 2, 2018.
The Center has a total area of 16,6 ha and consists of several technical and technological units, the most important of which are the entrance - exit zone (5,2 ha), the work zone (2,9 ha) and the zone for processing and disposal of waste (8,5 ha).

The following processes take place at the Center:

- collection and reception of collected municipal waste;
- biological processing;
- mechanical processing;
- biological processing on the bioreactor surface;
- waste water treatment.

Figure 4 Kaštijun Waste Management Center (source: www.kastijun.hr)

In ŽCGO "Kaštijun" waste is accepted from public service suppliers or delivered from transfer stations by trucks with special semi-trailers. When collecting waste, control, documentation verification and weighing are carried out, and the waste is sent for further processing. The management system of all processes (acceptance and processing waste) is fully automated. The waste is unloaded into the reception pit of the plant for mechanical-biological treatment (hereinafter MBO). Before the treatment process, the waste is shredded. Shredding and homogenization ensure more optimal management of the processing process.

For the collection of municipal waste at the local level, six transshipment stations (Labin, Pazin, Buzet, Umag, Poreč and Rovinj) were built in the Istria County, planned and distributed according to the amount of waste in the county, in order to ensure the rational transportation of waste from the transshipment stations to the center for waste management within project activities.

Figure 5 Location of the Kaštijun Waste Management Center and transshipment stations (Source: www.kastijun.hr)

With the operating start of the Kaštijun Waste Management Center, the previous method of waste management in the Istria County was abandoned. In the past, waste management in Istria County was dedicated to the activity of collecting, transporting and disposing of municipal waste and non-hazardous production waste with a low or no degree of separate collection of useful parts of waste and hazardous waste or waste recovery. Waste management was carried out by 7 public utility companies that managed 7 official waste disposal sites in the County where municipal and non-hazardous industrial waste are disposed: Donji Picudo (Umag), Košambra (Poreč), Lokva Vidoto (Rovinj), Kaštijun, (Pula), Cere (Labin), Jelenčići (Pazin), Griža (Buzet). 7 waste disposal sites had a total area of 36,8 ha, where about 120.000 tons of waste were disposed annually. Of that, about 80% represented municipal waste and about 20% non-hazardous production waste. Other non-hazardous and hazardous industrial waste was disposed of by authorized collectors and transported to authorized processors in the Istria County and Croatia or exported in accordance with international regulations[1].

During the first years of the Kaštijun Waste Management Center operation, a number of issues has arisen, mainly due to fact that the design documentation for the construction and equipping of the

[1] https://www.kastijun.hr/hr/zeleno-srce-istre/gospodarenje-otpadom/

Center was created several years ago, some projected parameters, especially regarding the planned quantities and delivery dynamics, did not prove to be realistic. It was also determined that the moisture content in the composition of the waste brought for processing is higher than the planned values.

The mentioned problem was tried to be solved during the summer season of 2019, when the biodrying process was shortened, which occasionally caused the spread of unpleasant odors from the area of ŽCGO Kaštijun. On the initiative of the Istria County, a working group was formed in December 2019 to coordinate the work of the County Center for Waste Management "Kaštijun". Tasks of the Working Group to co-determine, propose and coordinate the undertaking of necessary activities by recognized stakeholders with the main goal of preventing excessive daily amounts and inappropriate content of waste that is processed, which ultimately leads to the appearance of unpleasant odors, especially in the tourist season. The work of the Working Group, which is still active, is focused on goals related to the composition of mixed municipal waste that enters the mechanical-biological treatment plant for processing. With the aim of reducing unpleasant odors during the previous period, two new bioboxes were added to the MBO plant, which extended the drying time, and the ventilation and air filtration system from the biological treatment process was upgraded. Improvements in the process of operation of the bioreactor disposal site included the horizontal degassing system and connection to the flare and covering of the bioreactor disposal site. The company also expanded the capacity of transport equipment by acquiring 6 additional trailers, and a device for the purification of ferrous and non-ferrous metals was acquired, which is planned to increase the share and quality of the separated metal fraction from waste (secondary raw material). During 2023, the Center received 69.194 tons of mixed municipal waste, the processing of which resulted in 44.719 tons of non-composted fraction intended for further processing and 7.375 tons of fuel from waste (SRF).

3.2.2. Origin, composition, categories and type of collected waste at regional level

According to the Report on municipal waste for 2022, developed by the Ministry of Commerce and Sustainable Development, in 2022, 100.947 tons of municipal waste were collected in the Istria County as part of public service, of which 32.038 tons were collected separately, i.e. 32% of the total amount collected, which represents an increase of 5% percentage points in separately collected waste in compared to 2021. When the additionally determined amounts are added, the total amount of municipal waste generated in the Istria County amounts to 119.868 tons, of which 50.958 tons or 57% were collected separately.

Table no. 4 presents an overview of the total amount of municipal waste collected as part of the public service, the amount of mixed municipal waste, the number of inhabitants covered by organized collection, the amount of municipal waste per inhabitant and the rate of separate collection, in the Istria County for the year 2022.

Local government unit	Total collected municipal waste within the framework of public service per LGU (t)	Mixed municipal waste collected as part of a public service (t)	Number of inhabitants covered by organized municipal waste collection (t)	Kg/per inhabitant (t)	Rate of separate collection within the framework of the public service
Balle – Valle	826	772	1.170	706	6%
Barban	877	660	2.494	352	25%
Brtonigla – Verteneglio	920	830	1.523	604	10%
Buje – Buie	1.989	1.472	4.451	447	26%
Buzet	1.553	814	5.997	259	48%
Cerovlje	301	212	1.458	206	29%
Fažana – Fasana	2.364	1.310	3.463	683	45%
Funtana – Fontane	1.863	1.489	907	2054	20%
Gračišće	235	184	1.311	179	22%
Grožnjan - Grisignana	313	245	662	473	22%
Kanfanar	660	564	1.498	440	14%
Karojba	313	237	1.415	221	24%
Kaštelir Labinci – Castelliere S. Domenica	626	332	1.463	428	47%
Kršan	618	423	2.838	218	32%
Labin	3.529	1.944	10.488	336	45%
Lanišće	36	27	270	132	25%
Ližnjan – Lisignano	1.672	1.111	4.087	409	34%
Lupoglav	196	153	836	234	22%
Marčana	2.050	1.326	4.225	485	35%
Medulin	5.641	4.064	6.481	870	28%
Motovun – Montona	286	222	912	313	22%
Novigrad – Cittanova	3.143	2.559	3.883	809	19%
Oprtalj – Portole	321	267	746	430	17%
Pazin	1.616	1.126	8.306	195	30%

Pićan	405	253	1.719	236	37%
Poreč – Parenzo	12.810	7.820	16.666	769	39%
Pula – Pola	23.834	15.909	52.220	456	33%
Raša	876	522	2.811	311	40%
Rovinj – Rovigno	10.750	6.690	12.968	829	38%
Sveta Nedelja	700	450	2.898	242	36%
Sveti Lovreč	398	199	962	414	50%
Sveti Petar u Šumi	370	303	1.043	355	18%
Svetvinčenat	741	519	2.179	340	30%
Tar-Vabriga – Torre-Abrega	2.612	1.943	1.990	1312	26%
Tinjan	400	303	1.728	232	24%
Umag - Umago	7.558	6.301	12.767	592	17%
Višnjan – Visignano	817	461	2.098	390	44%
Vižinada – Visinada	425	236	1.136	374	44%
Vodnjan – Dignano	2.704	1.914	5.838	463	29%
Vrsar – Orsera	2.671	1.982	1.944	1.374	26%
Žminj	927	761	3.363	276	18%
TOTAL	**100.947**	**68.909**	**195.211**	**517**	**32%**

Table 4 total amount of municipal waste collected as part of the public service in the Istria County

The quantities of individual types of separately collected municipal waste in 2022 in the Istria County are shown in table 5:

Waste stream	Quantity/tonnes
Paper	6.934
Plastic	4.330
Glass	2.391
Metal	323
Bulky waste	10.888
Textile	468
Biowaste	3.539
Total	**28.873**

Table 5 Quantities of individual types of separately collected municipal waste in 2022 in the Istria County (source: Report on municipal waste for 2022, Ministry of Commerce and Sustainable Development)

Regarding the recovery and disposal of municipal waste, Istria County had a recovery rate of 24% within the framework of public services, while 4% was disposed of in landfills. The largest part of municipal waste collected as part of the public service, 72%, ended up in the Kaštijun county waste management center.

Amounts of separately collected municipal waste fractions collected within the framework of public service with included amounts of municipal waste collected through containers on public surfaces for the year 2022 for each local government unit in the Istria County is presented in the table 6.

LGU	Paper (t)	Plastic (t)	Glass (t)	Metal (t)	Bulky waste (t)	Textile (t)	Biowaste (t)
Balle – Valle	33,22	21,46	0,00	0,04	0,00	0,01	0,05
Barban	60,55	106,52	29,14	0,00	21,08	0,00	0,00
Brtonigla – Verteneglio	47,38	0,00	33,60	0,00	0,00	0,00	0,00
Buje – Buie	130,07	11,04	94,00	8,32	103,08	2,87	6,07
Buzet	181,64	170,05	65,70	14,22	142,58	33,62	104,76
Cerovlje	19,55	32,32	9,93	1,96	6,73	4,13	2,04
Fažana – Fasana	84,64	89,59	59,75	1,57	504,32	11,34	299,78
Funtana – Fontane	58,22	52,94	40,49	0,00	153,64	0,00	69,12
Gračišće	11,88	22,98	3,96	0,64	3,38	1,65	0,73
Grožnjan - Grisignana	41,76	0,00	17,33	0,00	0,00	0,00	0,00
Kanfanar	41,76	52,81	0,00	0,02	0,36	0,02	0,01
Karojba	18,64	29,06	7,26	0,86	4,95	3,50	1,47
Kaštelir Labinci – Castelliere S. Domenica	55,36	61,24	31,76	0,00	110,60	0,00	34,98
Kršan	37,59	6,75	7,89	2,00	104,17	2,97	0,00
Labin	481,87	128,06	144,12	21,53	456,05	14,87	15,26
Lanišće	1,42	4,40	2,40	0,00	0,58	0,00	0,00
Ližnjan – Lisignano	94,23	113,85	70,04	0,00	276,43	6,72	0,00
Lupoglav	11,32	17,26	3,89	0,63	2,71	1,52	0,59
Marčana	80,55	114,42	56,09	2,18	466,35	2,72	0,00
Medulin	312,45	241,16	148,51	59,27	311,45	5,81	463,48
Motovun – Montona	18,30	21,63	6,90	1,04	4,95	2,50	0,84
Novigrad – Cittanova	238,33	7,00	146,92	2,90	89,32	0,60	12,51
Oprtalj – Portole	28,06	0,00	13,99	0,00	0,00	0,00	0,00
Pazin	115,46	132,90	26,54	11,24	41,59	36,31	38,36

Pićan	38,71	9,38	11,04	2,00	59,38	1,49	0,00
Poreč – Parenzo	843,45	503,07	282,10	16,26	2.366,18	1,08	697,79
Pula – Pola	1.695,86	1.147,65	316,02	22,86	3.130,14	276,05	1.251,19
Raša	95,02	29,89	28,38	10,00	122,51	1,49	0,00
Rovinj – Rovigno	1.219,43	552,39	278,89	80,62	1.046,58	40,92	181,62
Sveta Nedelja	87,91	23,55	15,85	2,00	100,68	1,49	0,00
Sveti Lovreč	30,15	34,48	21,18	0,00	87,58	0,00	26,32
Sveti Petar u Šumi	17,32	22,62	9,07	1,03	4,71	3,04	1,08
Svetvinčenat	64,21	67,49	31,62	0,00	56,58	1,68	0,00
Tar-Vabriga – Torre-Abrega	79,73	88,36	29,97	0,00	375,28	0,00	95,57
Tinjan	24,14	36,35	9,96	1,23	7,43	3,96	1,65
Umag - Umago	495,50	15,77	243,39	11,87	148,26	1,30	66,48
Višnjan – Visignano	70,28	72,18	39,97	0,00	134,02	0,00	39,54
Vižinada – Visinada	31,94	43,22	24,03	0,00	63,57	0,00	25,39
Vodnjan – Dignano	174,41	164,72	81,43	36,81	90,65	0,00	1,07
Vrsar – Orsera	78,89	73,22	51,95	5,87	269,90	0,72	101,17
Žminj	56,07	60,92	10,06	4,44	20,46	3,50	0,00

Table 6 Separately collected municipal waste fractions collected within the framework of public service in the Istria County

3.2.3. Illegal waste disposal sites or illegal landfills

Although a lot has been said and written about the harmful impact of illegal waste disposal on the environment, and thus on human health, in recent years, all produced waste is not always properly processed by recovery or disposal procedures. Unfortunately, citizens and companies do not hand over a certain amount of waste to authorized waste collectors, but rather dispose of it outside the designated locations. In previous years, the reasons for this behavior could possibly be sought in the unavailability of the service, i.e. the area not being covered by organized waste collection. Today, the public waste removal service is available in all parts of the Istria County, and considerable funds have been invested over the past years in addition to the infrastructure for the selective collection of certain useful types of waste, and in education about sustainable waste management.
Despite the above, there are still locations with improperly disposed waste in the territory of the Istria County, the reasons for the creation and "survival" of which can be found in the irresponsible behavior of natural and legal persons who carry out economic activities, but also in the local

population, which avoids paying fees for waste removal through its irresponsible behavior. Unfortunately, due to the large area and the inability of the competent services to control the entire area, it is very difficult to accurately determine the total number of locations and the total amount of improperly disposed waste.

The first official list and rehabilitation plan of illegal landfills was prepared by the Istria County in 2006. The list has undergone several revisions, the last of which was in October 2010, when locations were added to the list for which the competent environmental protection inspection of the Ministry of Nature and Environment of the Republic of Croatia issued decisions to local self-government units on the need to remove improperly disposed waste by unknown perpetrators. Furthermore, the Istria County, as part of the implementation of the EU project DIVA - Remediation of illegal landfills and raising awareness of their harmfulness, created and put into operation a network application for recording and monitoring the remediation of discarded waste in the territory of the Istria County.
The project was implemented as part of the IPA CBC SI-HR 2007-2013. of the pre-accession EU program in the period from 04/2011 to 03/2013.
In accordance with the reports on the implementation of the Waste Management Plan of the Croatian local self-government units, most cities and municipalities in the Istria County have enabled citizens to report possible new locations where waste has been improperly disposed of via the LGUs' websites. As an additional measure to reduce the number of illegal landfills where waste is improperly disposed of, LGUs have mostly organized communal services that visit the site and monitor rehabilitated and possibly newly created locations (Istrian County, 2023).

4. Measures and initiatives for the development and improvement of the waste management system in the Istria County

Most of the local self-government units in the Istria County educate the population about the obligation to collect municipal waste separately, usually through providers of public services for the collection of mixed and biodegradable municipal waste. The educations are primarily related to obligations and the method of separate collection of municipal waste, and are carried out through circular letters sent with invoices, announcements on websites and information leaflets. Some local self-government units also educate the population through local daily newspapers, announcements through radio stations and leaflets, promotional actions and workshops.

In the following paragraphs we will describe some of the examples of good practice in the Istria County in the field of raising awareness and improvement of the waste management system in the Istria County.

City of Labin is working intensively and responsibly on preserving the environment so that its citizens can all enjoy the benefits of a clean and healthy environment. One of the successful projects implemented by the City of Labin and the utility company 1. MAJ d.o.o. was the „Green Habits for a Sustainable Labin Area ". The purpose of the project was to build and raise awareness of citizens and guests of Labin and municipalities of Labin area about the importance of responsible municipal waste handling, waste prevention, proper household waste separation, household composting, and reusing objects in order to reduce the amount of waste disposed at landfills. 21 activities that were carried out through the project included design and implementation of: leaflets, brochures, posters, specialized TV and radio shows and commercials, specialized website, public educational forums, workshops for children, educational and informative materials for preschool and school children, costumed plays and performances for preschool children, competition in schools, educational picture and coloring books for children, marking dates related to environmental protection, banners for publication on Internet portals, paid advertisements in electronic and print media, leaflets for foreign tourists at tourist centers, workshops for people with disabilities and children with special needs and social media campaigns. As part of the project City of Labin has also joined the initiative of the European Waste Reduction Week and was selected by EWWR Secretariat among the three best projects in Europe.

Figure 6 Green habits for a sustainable Labin area

Utility company 1.MAJ from Labin is also very active in education of end users in various topics such as proper separation of waste, the structure of the waste management system in Labinština, the possibilities available to users, the benefits of environmental care through the care of waste, commemoration of the "European Waste Reduction Week", collection schedule, etc. Among other things, these channels promoted the conclusions, visuals and ideas of the projects "Green Habits for Sustainable Labin Area" and "Plastic-Free Market". In addition, "Plastic-free Brands" emblems were placed next to the football field of the City Stadium in Labin and in the SC "Franko Mileta" hall. Direct education is conducted by sending information leaflets to all users from the household category along with bills.

5. Conclusion

The regional waste management report for the Istria County presents a primary analysis of waste production and waste management in the Istria County. The purpose of the report is to analyse and address environmental issues connected with the constant increase of waste production, particularly plastic. Istria County is one of the most tourist regions in the Republic of Croatia which implies high seasonal waste production and challenges on how to deal with it.

Istrian County is one of three counties in the Republic of Croatia with established centralised collection of municipal waste in the scope of the County Waste Management Centre Kaštijun. With the operating start of the Kaštijun Waste Management Center, the previous method of waste management in the Istria County was abandoned. During the first years of the Kaštijun Waste Management Center operation, a number of issues has arisen, mainly due to fact that the design documentation for the construction and equipping of the Center was created several years ago, some projected parameters, especially regarding the planned quantities and delivery dynamics, did not prove to be realistic. It was also determined that the moisture content in the composition of the waste brought for processing is higher than the planned values. This is the reason why on the county level it is important to foster the increase of the separate collection of waste and to ensure processing of collected waste through the development of sorting plant and compost plant.

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List of tables and figures

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PROGRAMME 2021 – 2027

AWASTER – Adopting WASTE as Resource

D.1.1.2 Regional waste management report – Split-Dalmatia County

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Specific objective: 2.2: Enhancing protection and preservation of nature, biodiversity and green infrastructure, including in urban areas, and reducing all forms of pollution
Project: AWASTER – Adopting WASTE as Resource

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Table of contents

1. Introduction

The purpose of Regional waste management report is analysing and addressing environmental issues in the context of waste production and waste management in Split-Dalmatia County. The impact of increased waste, particularly plastic waste, has significant negative ecological and socioeconomic implications. Report aims to provide a comprehensive analysis of the current state of municipal waste management in Split-Dalmatia County, focusing on the trends in waste generation as a base for minimizing waste generation. By achieving these objectives, Report will provide insights and recommendations that will help reduce the environmental impact of waste production, support sustainable development, and improve the quality of life for Split-Dalmatia County and beyond.

Main topics covered in the Report are detailed socio-economic, topography and demographic description of Split- Dalmatia County, waste management system in the Republic of Croatia, analysis of the composition, categories and type of collected waste at national and regional level, description of the existing waste management infrastructure, including facilities, devices, and collection systems in Split-Dalmatia County, detailed analysis of the types and sources of collected waste collected within the region, illegal waste disposal sites or illegal landfills, and policies, technologies, and practices for improving waste management system in Split-Dalmatia County.

Historically, the increase in waste production can be attributed to factors such as population growth, urbanization, and changes in consumption patterns. Despite efforts to enhance waste management infrastructure and policies, challenges persist. Prompted by the need to address these challenges, this report aims to provide a comprehensive analysis of municipal waste management in Split-Dalmatia County. It seeks to offer data-driven insights and actionable recommendations that will aid in mitigating negative ecological impacts, reducing pollution and associated health risks, and reducing waste generation.

2. Split-Dalmatia County

1.1 Socioeconomic description

Split-Dalmatia County is located in the southern part of Croatia, along the Adriatic Sea. It is encompassing around 14,045 square kilometres. The county is characterized by a diverse landscape that includes coastal regions, islands, and inland mountainous areas. The coastal areas experience a Mediterranean climate with hot, dry summers and mild, wet winters, while the mountainous regions have a more continental climate, with colder winters and hotter summers compared to the coast.

1.2 Topography

The county boasts a long and indented coastline with numerous bays, coves, and over 1,000 islands, the most notable being Brač, Hvar, and Vis.
Mountains: The Dinaric Alps dominate the inland areas, with prominent peaks such as Biokovo and Mosor.
Plains and Valleys: Fertile plains and valleys, such as the Cetina River canyon, are also significant features, supporting agriculture.

The county is divided between 16 cities and 39 municipalities with population density of 93,26 sq/m. The city of Split is the administrative centre and largest city, with a population of around 178,000. It is a significant cultural, economic, and transportation hub. Other important cities are Makarska, Sinj, Trogir, and Solin.

Tourism is a vital sector, especially in coastal towns and islands. The county is a major tourist destination due to its historical sites, natural beauty, and Mediterranean climate. Besides tourism, Agriculture is Important in rural and inland areas, focusing on olive oil, wine, and fruit production. Industry is mostly concentrated in and around Split, with shipbuilding, food processing, and manufacturing being key industries. In services sector, Split-Dalmatia County is growing, particularly in finance, real estate, and IT, centred in urban areas.

Considering transport infrastructure, it is fairly well-developed with a network of roads, including the A1 motorway, the Split International Airport and existing rail connection which is under-used and infrastructurally outdated. Ferry services are crucial for connectivity to the islands, and Port of Split has one of the busiest passenger ports in the Adriatic, crucial for both tourism and trade.

Split-Dalmatia County is a region of remarkable geographical diversity and cultural richness. It plays a crucial role in Croatia's tourism industry while also maintaining significant agricultural and industrial activities. The county is focusing on sustainable development and diversification of its economy to ensure long-term growth and prosperity.

1.3 Demographic indicators

According to the 2021 Census, Split-Dalmatia County has 423,407 inhabitants, of which 205,299 are men (48.5%) and 218,108 are women (51.5%). Compared to the 2011 Census, the population has decreased by 31,391 people, or 6.9%.

The continuous aging of the County's population persists. The number and proportion of elderly people aged 65 and over are steadily increasing, and according to the 2021 Census, they account for 21.8% (92,110 inhabitants). Most populated city in the County is the city of Split with 160,577 inhabitants while gravitation to it is visible from cities of Solin and Kaštela who are forming new Split suburbs.

City	Population
Komiža	1.394
Vrlika	1.728
Vis	1.918
Stari Grad	2.772
Hvar	3.979
Supetar	4.325
Vrgorac	5.698
Trilj	8.182
Imotski	9.153
Trogir	12.393
Makarska	13.301
Omiš	14.139
Sinj	23.452
Solin	24.862
Kaštela	37.794
Split	160.577

Largest municipalities are Podstrana (10.403 inh.) and Dugi Rat (6.876 inh.), while smallest municipalities are Zadvarje with 289 inhabitants and Sućuraj with 426 inhabitants.

Importance of tourism is also visible from touristic statistic which reveal that total of 3.58 million tourists visited the County and produced 17,7 million overnight stays. When calculating the waste management indicators, we account those as additional 48.493 inhabitants/equivalent daily. However, this number can also be divided by monthly visits where pressure is put in summer season months with peak months like August with 183.333 additional inhabitants/equivalent daily.

3. Waste management system

This chapter provides a comprehensive description of the waste management system in the Republic of Croatia and Split-Dalmatia County.

3.1. Waste management system in the Republic of Croatia

The last published report on waste management in Republic of Croatia is the one prepared for the year 2022, published in July 2023 and revised in September 2023, by the Croatian Ministry of Economy and Sustainable Development. When we are talking about the waste management in general, we analyse the municipal waste management streams and partially specific waste types that are similar to municipal waste (excluding the waste from various types of production, agriculture, forestry, wastewater treatment, vehicles and construction and demolition waste. Methodologically, all the municipal waste providers and other operators report quantities through the electronic system called ROO (register for waste polluters).

3.1.1. Waste management policies at the national and regional level

Croatian legislation is aligned with the EU directives, and the Waste Management Act (NN 84/2021) prescribes measures to achieve the goals of the European Green Deal, particularly a 65% recycling rate for municipal waste and a reduction of waste disposal to 10% of the total amount of waste generated by 2035.

According to the Waste Management Act (2021), waste is any substance or object that the holder discards, intends to discard, or is required to discard. Waste management, therefore, is the process of conducting and directing activities to achieve set goals and relates to activities such as the collection, transportation, recovery including sorting, and disposal of waste, the

supervision of these activities, as well as the monitoring and measures implemented at locations where waste has been disposed of (Republic of Croatia, 2021).

As the overarching planning document that aligned the waste management system in Croatia with new goals and policies, the Waste Management Plan of the Republic of Croatia for the period 2023-2028 has been developed, based on the goals set for 2035.

In addition to the National Plan, other planning documents for waste management include the Waste Management Plan of regional self-government units and the Waste Management Plan of the City of Zagreb, which are proposed by the executive body and adopted by the representative body of the regional self-government unit or the City of Zagreb.

The goals of national waste management plan summarized all the obligations and goals set in primary and secondary national legislation and following table presents major waste stream goals:

Br.	Waste type	objective
1.	Municipal waste	Recover through recycling and preparation for reuse at least: • 55% of the mass of municipal waste by 2025, • 60% of the mass of municipal waste by 2030, and • 65% of the mass of municipal waste by 2035. To landfill less than 264.661 tonnes of biodegradable waste ; To landfill less than 10% of total waste mass produced by 2035; Increase the collection and treatment of biowaste.
2.	Packaging waste	Separately collect and recover, materially or energetically, at least 60% of the total mass waste packaging produced in the territory of the Republic of Croatia. Recycle at least 70% of the mass of total waste packaging by December 31, 2030, at least the following mass of material in the recycling process: • 55% plastic • 30% wood • 80% of unpainted metals • 60% aluminium • 75% glass • 85% paper and cardboard

Besides the Waste law, the waste acquis in Croatia consists of 19 secondary bylaws and 8 ministerial decisions.

Article 111 of the Waste Management Act prescribes the obligations of regional self-government units regarding the development, adoption, and evaluation of the Waste Management Plan of the regional self-government unit. The content of the regional Plan is specified in Appendix VI of the Waste Management Act. Unfortunately, the Split-Dalmatia County did not prepare the regional waste management plan, however the public procurement for development of the plan has been started in April of 2024.

3.1.2. Origin, composition, categories and type of collected waste at national level

Since 2011, the amounts of municipal waste generated have been continuously increasing, ranging between 1.6 million and 1.8 million tons. In 2020, because of the COVID-19 pandemic, which led to a significant reduction in the service sector (closure of hospitality establishments, a decrease in the number of tourist overnight stays), the amounts of municipal waste fell to the levels of 2014. With the increase in service sector activities (hospitality establishments, a significant increase in the number of tourist overnight stays, etc.) from 2021, the amount of municipal waste rise again, and in 2022, the total amount of municipal waste reached 1,844,382 tons, which is the highest value in the observed period from 1995 to 2022. (Ministry of Economy and Sustainable Development, 2023)

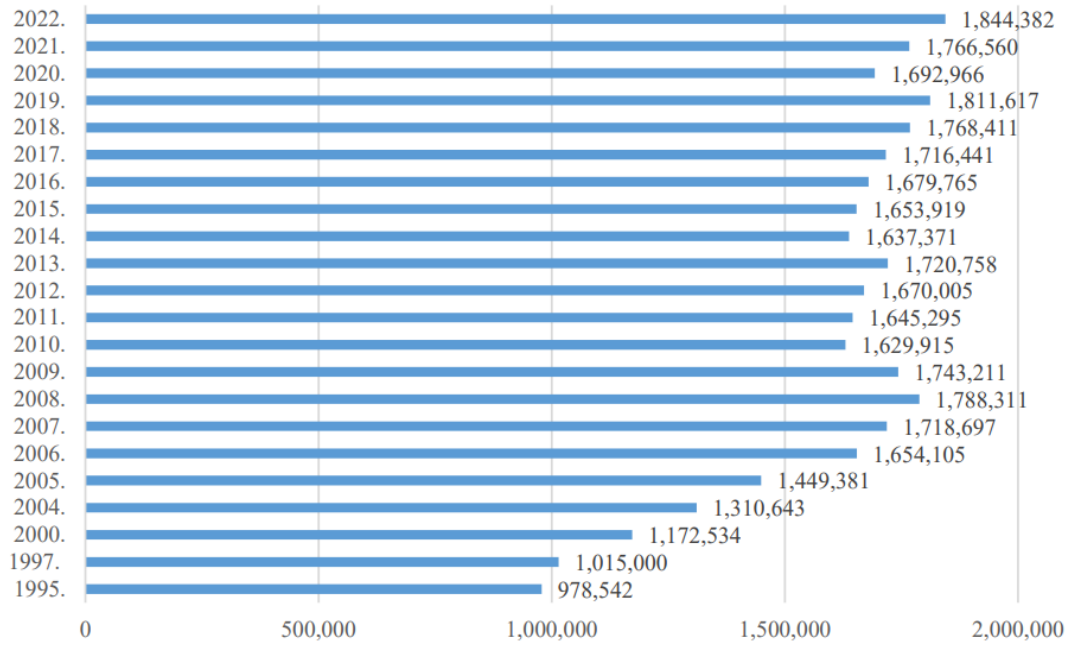

Figure 1. overall waste production in Croatia (year/tonne)

When observing the annual amount of municipal waste generated per capita, it amounted to 474 kg, which is the highest value in the observed period from 1995 to 2022. This can be attributed to the use of the 2021 census, which resulted in significantly lower values compared to the Eurostat population estimates used in previous years.

3.2. Waste management system in the Split-Dalmatia County

Unfortunately, no official regional document has been prepared recently in order to summarize the data for the County, and we will use other national sources to summarize the description of current state of play in the waste management sector in the region.

3.2.1. Waste management facilities, devices and collection systems in the SD County

According to the national waste management plan, in the Split-Dalmatia County region 10 landfills still operated in 2021 with estimated remaining landfilling capacities of 626.520 t of waste. The closure of current waste landfills which are spread on 331.024 sqm additionally requires 13.18 M Euros of investment. Following this table presents last 15 landfills and status of sanitation and closure prediction (Ministry of Economy and Sustainable Development, 2023.):

No.	Name	Operator	Status of operability	Status of sanitation and closure	Commence of sanitation	End of sanitation
1.	Ajdanovac	Gradska Čistoća I usluge d.o.o.	Closed	Closed for landfilling	in preparation	
2.	Borovik	Komunalno Basilija d.o.o.	Active	Ongoing	22.08.2016.	31.12.2025
3.	Brdo Košer	Micheli Tomić d.o.o.	Closed		01.12.2016	
4.	Dolci	Komunalno Stari Grad d.o.o.	Closed	Finished		October 2019.
5.	Karepovac	Čistoća Split d.o.o.	Active	Ongoing	22.11.2017	
6.	Kozjačić	Komunalno društvo Imotski	Active	In preparation		
7.	Kupinovica	Komunalno društvo Grad	Active	In preparation		
8.	Mala Prapatna	Jelkom d.o.o.	Active	Ongoing	23.06.2016	

9.	Mojanka	Čistoća Cetinske Krajine d.o.o.	Active	Ongoing	01.01.2021	
10.	Poljanak	Eko Vrlika d.o.o.	Active	Finished – operational on standardized surfaces	04.01.2011	31.12.2023
11.	Prapatna	Jelkom d.o.o.	Closed	In preparation	30.10.2015	
12.	Stanišće	Komunalno Hvar d.o.o.	Active	In preparation		
13.	Šćeće	JKD Komiža	Closed	Ongoing	04.10.2019.	
14.	Vučje Brdo	Trogir Holding d.o.o.	Active	Ongoing	24.12.2019	
15.	Wellington	Gradina Vis d.o.o.	Active	In preparation		

Figure 2. list of landfills in SD County (source: haop.hr)

One of the largest and oldest operating landfills in Croatia is definitely Karepovac located in Split. Over the years, it has been a subject of concern due to environmental and health issues associated with its operation. Since it has been in operation for several decades, gradually expanded to accommodate growing amounts of waste every year, currently accumulated more than 7 million cubic meters. Before the start of sanitation and reconstruction of the landfill in 2017, the landfill was located directly on karst with basically more than 50 years of direct impact on soil, water and air of the City of Split.

Figure 3. Karepovac landfill location (source: google maps)

Figure 4. Karepovac Landfill - sanitation works (Source: www.split.hr)

Sanitation of the landfill has started in 2017 and the project value was estimated at 38,35 million Euros out of which 15,35 were secured through the Cohesion funds. The public welcomes the sanitation, however expert NGO Sunce Split has repeatedly criticized the lack of City of Split efforts for development of sound integrated waste management from waste collection methodology to lack of supporting infrastructure such as composting plants and sorting facilities. Special focus of the Sunce NGO has been put on separate collection of biowaste which was planned through local waste management plan already in 2007 together with composting facility, which unfortunately up to date were never implemented.
The future of WM facilities is predominantly dependant on the development of the waste management centre Lećevica which will replace all the existing landfills and introduce mechanical-biological treatment for the mixed residual waste and provide composting infrastructure for further empowering of the separated biowaste collection. The planned capacity od the new WM centre is 110.000 tonnes per year, and it should cover entire SD County.

According to national waste management plan, the SD County currently owns only 200 tonne per year capacity for separately collected waste while total needed capacity is around 108.926 tonnes per year. The needed investment in next few years is summed up to 50 million Euros. Regarding biowaste treatment facilities such as composting plants and anaerobic digestion plants, SD County currently has no installed capacities. According to the national WM plan, 63.942 tonne capacities should be installed with 42,4 M Euros investments planned.

Besides the municipal solid waste, capacities are not needed in the construction and demolition waste sector where 772.000 tonnes of capacities have been installed.

Regarding the post sorting phase, National plan envisages also development of recycling capacities for plastic recycling (33.939 tonnes/year plant), glass recycling (8.533 tonnes/year plant) and paper recycling (44.000 tonnes/year plant). +

3.2.2. Origin, composition, categories and type of collected waste at regional level

In 2022. The amount of waste collected was 187.185 tonnes, out of which 150.659 t were collected from households, 29.330 tonnes from hospitality business sector (mostly mixed waste) and 6207,03 tonnes from other business users. 989,33 tonnes of waste were additionally collected through street containers infrastructure.

Waste stream	Quantity/tonne	Share
Mixed municipal waste	160.738	86%
Biodegradable waste	2.202	1%
Wood	1.077	1%
Metal	105	0%
Textile	124	0%
WEEE	29	0%
Paper	5.925	3%
Plastics	2.388	1%
Glass	549	0%
Other	14.047	8%
Total	187.185	100%

Figure 5. quantities of collected MSW in 2022. (source: ROO public database)

From statistical data, it is visible that majority of waste is still landfilled or treated with other recovery option as 86% of collected waste is mixed municipal waste.

Total amount of waste generated as part of public service in SD County is 184.807 t of waste, out of which 148.903,26 t have been landfilled, which leaves the capacities for further landfilling for less than 3 years of operation. The total amount of separately collected waste through collection service was 30.326 tonnes, while drop-off option through civil amenity site (recycling yard) resulted with 5534,42 tonnes of separately collected waste. Since none of the cities or municipalities have reached the recycling targets set by legislation (50% by 2020), all of them have to pay the national fee for landfilling for total of 56.499 tonnes resulting with damages in taxes worth approximately 1.694.970 EUR.

Outside of municipal waste streams (public service stream) additional 377.598 t was collected by the economic operators where 20.475 t are similar to municipal waste and 15.803 t were sent for recycling. It is also interesting that 365.112,15 t of materials were recycled as those are dominantly various types of ferrous and non-ferrous metals. (Environmental Protection Agency, n.d.)

Major companies outside of public service-related waste streams are:

Number.	Operator	Quantities/tonne
1.	CEMEX HRVATSKA D.D.	233.066,17
2.	CE-ZA-R d.o.o.	38.595,58
3.	INNECTO, za trgovinu i usluge društvo s ograničenom odgovornošću	33.768
4.	EKO IMOTSKI j.d.o.o.	17.371

Figure 6. major waste producer/collector in SD County

First operator CEMEX HRVATSKA actually produces 229.827 t of sludge that is used under recovery code R5 - Recycling/reclamation of other inorganic materials, CE-ZA-R d.o.o. focuses on various metal types, INNECTO d.o.o. is major C&D waste operator and EKO IMOTSKI j.d.o.o. which collects 20 various types of waste.

Waste composition analyses in SD County has not been conducted in last few years, so in order to further analyse the effectiveness of the waste management system, we will enclose the analyses presented in the national waste management plan which was adopted in 2023. (Republika Hrvatska , 2023.)

Waste type	Share (%)
Kitchen biowaste	25,11
Garden biowaste	6,77
Paper	25,72
Wood	0,99
Textiles	2,93
Bones and leathers	0,36
Glass	4,89
Plastics	19,45
Metal	2,54
Rubber	0,17
Bulky	4,08
Other	6,99
Total	**100**

Figure 7. waste composition in Republic of Croatia

3.2.3. Illegal waste disposal sites or illegal landfills

Croatia has been struggling with the problem of illegal waste disposal sites for decades. Their exact number is impossible to determine, and it is about locations with a few bags of garbage on the one hand and locations of large illegal landfills on the other. From time to time, the competent services or volunteers in their voluntary actions succeed in remediating them by taking waste to official landfills, but due to irresponsible behaviour and insufficiently developed environmental awareness of people (whom we will call "Someone" for the purposes of this text), they are created again, in the same or nearby place.

Environmental awareness also strengthens citizens, individuals have the opportunity to report illegal landfills in their surroundings. According to the report of the Green Telephone Association, the largest number of reports from citizens, over 30%, refers to the Waste category. Namely, as early as 1992, the first service for citizens was established, where information could be obtained and problems related to the environment, nature and their protection could be reported - the Green Phone. Additionally, since 1st of January 2020, the state has implemented electronic system for evidencing and reporting illegal landfills and fly tipping locations called Records of the locations of discarded waste (Croatian - Evidencija lokacija odbačenog otpada ELOO).

Since the implementation of the ELOO system, the illegal landfills were reported on 306 occasions on officially recognized 71 spots, and local authorities have resolved 83 cases (27,1%) and definitely closed 12 spots.

4. Measures and initiatives for the development and improvement of the waste management system at regional level

The problematics of measures and initiatives is at this moment rather unknown due to the fact that national waste management plan relieved the local planning obligation and shift it to operational planning on regional level. Since the planning still has not started, we will analyse only publicly available initiatives and measures and present best cases from the region.

The construction of the RWMC "Lećevica" is one of the major investment projects aimed at improving waste management in the region. This center will serve as a modern facility for waste treatment and disposal, reducing the reliance on landfills. However, this project is only an “end of pipe” solution as serious investments and organizational changes need to happen on higher hierarchy levels such as waste prevention, waste collection and transportation of waste.

One of the positive examples of waste collection reorganization is the waste management company in the city of Hvar located on the Island of Hvar. Although the door-to-door system has been introduced in 2018, the separate collection has reached 31%. It has to be emphasised that improvement of the results will be possible only upon the construction of the composting facilities on the island as the shipping from the island is extremely expensive. On the same Island, the city of Stari Grad has also introduced several measures since 2021, such as plastic free initiative, home composting programmes, door to door waste collection and removal of majority of the street collection elements. The most important result of the system organizing is reduction of produced waste for 9,5% and landfilled waste reduction for 31% compared to 2019 which was touristically comparable with 2023. The result of the Stari Grad is similar, total waste reduction for 10%, and waste landfilled reduction for 25% in only 1 year since the project has been implemented. City of Omiš and its Municipal company Peovica also increased the results drastically in last few years. Their system is also based on individualized waste collection through individual bins or electronic gate street containers. In 2023 recycling rate has reached 33% which is almost maximum potential for recycling systems which do not include biowaste collection (which is not possible due to lack of infrastructure). The efforts resulted with 40% production reduction and almost 53% landfill reduction compared to year 2019.

Led by the "Sunce" association, projects like "Plastic Smart Cities Croatia" and "For Plastic Free Croatia Island" aim to analyse plastic use, implement plastic-free plans, and raise public awareness through workshops and campaigns. The efforts include organizing plastic-free events and forums, promoting sustainable solutions, and advocating for the adoption of EU directives on plastic waste reduction in Croatia. In SD County, participating cities are Trogir and Stari Grad

(Hvar) who both signed plastic free declarations and introduced plastic free policies on city level. (Sunce, 2022.)

The organization Sunce in Split has several educational projects focused on waste management and environmental sustainability such as **WASTEREDUCE** that aims to improve waste management in protected areas and Natura 2000 sites through monitoring, prevention, and mitigation strategies. It includes educational and training activities, awareness-raising campaigns, and the implementation of waste sorting and disposal solutions. Additionally, project School Composting teaches students to create and maintain compost bins, integrating composting into their STEM education. It encourages responsible waste handling and sustainability practices in schools across Split-Dalmatia County.

5. Conclusion

The comprehensive analysis of waste management in Split-Dalmatia County reveals significant strides and ongoing challenges in addressing municipal solid waste. The report shows slight improvements such as reduction of waste on landfills, reduction of number of operational landfills and significant investments in separate waste collection – namely waste bins and containers. These efforts currently account only as far as reaching the third last position in waste management effectiveness in the Country of Croatia.

However, despite these positive steps, the increase in waste production driven by factors such as population growth, urbanization, and changing consumption patterns continues to pose ecological and socioeconomic challenges. Additional threat for the county is also slow development of supporting infrastructure for separately collected waste such as composting and sorting facilities thus leaving the waste systems heavily dependent on landfilling which in future (2035) has to be limited up to 10% of waste produced.

To sustain the momentum, it is crucial for regional authorities to implement the obligations provided by the national and European legislation, which include improving waste management technologies, and methodologies. By doing so, Split-Dalmatia County can reduce its environmental footprint, enhance the quality of life for its residents, and set a benchmark for other regions in sustainable waste management practices.

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List of tables and illustrations

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AWASTER

INTERREG ITALY-CROATIA
PROGRAMME 2021 – 2027

AWASTER – Adopting WASTE as Resource

D.1.1.2 Regional waste management report – Veneto Region

Version: Final
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Italy – Croatia

AWASTER

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Standard Call for Proposals
Programme priority: Green and resilient shared environment
Specific objective: 2.2: Enhancing protection and preservation of nature, biodiversity and green infrastructure, including in urban areas, and reducing all forms of pollution

Project: AWASTER – Adopting WASTE as Resource

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Table of contents

1. Introduction

The present deliverable is one of the five regional reports foreseen by Activity 1.1 Regional background analysis, which is part of the WP1 Circular economy – current state analysis of the Interreg IT-HR AWASTER project.

The report assesses the primary analysis of waste management services in the partner's regions. Together with D.1.1.3 Secondary market report, the present deliverable represents a high-quality database on which stakeholders can base their requests for financing the measures provided for in the Joint Action Plan from EU funds and other sources.

The report will assess the quantity and composition of collected waste, waste collection schemes, seasonality, and list existing waste prevention policies. Deliverable consists of 5 regional reports.

2. Veneto Region, Italy

Veneto is an Italian region with ordinary statute and a population of 4,853,176 inhabitants, located in north-eastern Italy, with Venice as its capital. It is named after the Veneti people, an Indo-European population that settled in the territory after the mid-2nd millennium BC. With 560 municipalities within its territory, Veneto ranks as the third region in Italy for municipal division. It is divided into 7 extensive area entities (including 6 provinces and 1 metropolitan city). It is the fourth most populous region in Italy, following Lombardy, Lazio, and Campania, and it borders Austria to the north, Trentino-Alto Adige to the north-west, Emilia-Romagna to the south, Lombardy to the south-west, Friuli-Venezia Giulia to the east, and the Adriatic Sea to the south-east. Along with Trentino-Alto Adige and Friuli-Venezia Giulia, it forms the macro-area known as Triveneto or the Three Venices.

Veneto is the fifth most visited region in Europe and the first in Italy according to Eurostat data, with 71.9 million tourist presences in 2023. The geography of Veneto is extraordinarily diverse, offering a mix of mountains, hills, plains, lakes, and coastline. To the north, the region is dominated by the Dolomites, a section of the Italian Alps, renowned for its spectacular peaks and designated as a UNESCO World Heritage Site. Moving southwards, one encounters the Prosecco hills, characterised by gentle slopes cultivated with vineyards where the famous sparkling wine of the same name is produced. Other important hilly areas include the Colli Euganei and the Berici Hills, known for their picturesque rural landscapes and production of high-quality wines and olive oils.
The vast Po Valley occupies a significant portion of Veneto's territory, providing fertile land for intensive agriculture. This area is traversed by some of Italy's major rivers, such as the Adige, the Po (which marks the southern boundary of the region), and the Piave. Lake Garda, situated at the border between Veneto, Lombardy, and Trentino-Alto Adige, is the largest lake in Italy and a popular tourist destination. Veneto's Adriatic coastline, extending over 150 kilometres, is dotted with renowned seaside resorts like Jesolo, Caorle, and Bibione, offering expansive sandy beaches and a vibrant tourist life. The Venetian lagoon, with its islands and canals, represents a unique ecosystem on a global scale and hosts the historic city of Venice. Beyond the Venetian lagoon, the Po Delta is a vast wetland area that provides a remarkable natural habitat for many species of flora and fauna. It is a cherished destination for nature enthusiasts and birdwatchers.
The population of Veneto is not evenly distributed. While the central plain boasts the highest densities (especially along the strip from Verona to Venice passing through Vicenza, Padua, and Treviso), the lower Veronese area (except within the quadrilateral including Bovolone, Isola della Scala, Nogara, Cerea, and Legnago) and Polesine are less populated (especially following the 1951 flood). Even less inhabited are the Pre-Alps and mountainous areas (with the province of Belluno

showing the lowest densities), except for upper Vicentino (with Schio, Valdagno, Thiene, Bassano del Grappa) and the Valbelluna. Starting in the 1980s, there was a widespread phenomenon throughout northern Italy of depopulation of major cities (Venice with Mestre leading) in favour of small and medium-sized municipalities in peri-urban "belts". This led to significant urban development with the formation of a large megalopolis, particularly extending between Padua, Mestre, and Treviso.

The rate of natural population increase was once one of the highest in Italy, but since 1983 it has become negative for the first time. Although this trend persists today (and has even strengthened), Veneto remains one of the regions in northern Italy with the highest birth rate. However, this phenomenon varies considerably from province to province, even as the resident population continues to grow due to immigration from abroad, becoming significant since 1990.
From the late 19th century onwards, there was intense emigration of Venetians abroad due to the region's extreme poverty. Residents of Veneto particularly migrated to Australia, Argentina, Uruguay, and Brazil. Indeed, until the 1970s, Veneto was a land of emigration (over 3 million departures between 1870 and 1970) due to the poor agrarian economy, lacking significant industrial facilities. The considerable industrial development starting in the 1970s transformed Veneto from a land of emigration to one of immigration. Rather than returns, there have been many immigrants from the South and later from abroad (North Africa, Eastern Europe), making Veneto the fifth region in terms of population (after Lombardy, Campania, Lazio, and Sicily) and one of the leading regions in terms of foreign residents.

Veneto's economy is one of the most dynamic and advanced in Italy, characterised by a strong entrepreneurial spirit and a wide range of productive sectors. This region, traditionally considered one of the country's economic engines, stands out for its ability to innovate and maintain competitiveness in international markets. One of the pillars of the Venetian economy is the manufacturing sector, which includes a variety of industries, such as mechanical engineering, plastic processing, clothing, and footwear. The eyewear industry district, centred around Belluno, is particularly renowned for producing high-quality glasses, with brands like Luxottica having a global presence.
Veneto is also a leader in agricultural production. The region is famous for its viticulture, with internationally renowned wines such as Prosecco, Amarone, and Soave. Agricultural production also extends to sectors like the red radicchio of Treviso, Bassano's asparagus, and Vialone Nano rice, to name a few. Tourism plays a fundamental role in the regional economy, with iconic destinations like Venice, Verona, and the Dolomites attracting millions of visitors each year. The tourism sector

encompasses cultural, seaside, and mountain tourism, providing employment and stimulating investment in infrastructure and services.
The service sector is growing, supported by flourishing e-commerce and increasing digitalisation. Banks, insurance companies, and professional and technical services significantly contribute to the regional GDP. Logistically, Veneto benefits from a strategic position that facilitates trade with the rest of Italy and Europe. The presence of important transport infrastructures, including the port of Venice, the airports in Venice, Treviso, and Verona, and an extensive motorway and railway network, support the region's high commercial capacity.

3. Waste management system

3.1. Waste management system in the Italian Republic

Italy has four administrative levels: national, regional, provincial and municipal. Administrative levels in charge for waste management are the national one, the regional one and the municipal one. The latter, also in a form of aggregation called AROs or ATOs, as it will be seen further in this report.
The Ministry of Environment outlines the overall waste management strategy by establishing the legislative framework, setting targets at national level and drawing up the National Waste Management Plan. In turn, regions prepare regional waste management plans based on criteria defined in the national legislation. The regions issue regulations in compliance with the national legislation and define some optimal aggregation of municipalities called "Optimal Territorial Basins" (ATOs) or "Optimal Collection Basins" (AROs). The latter are responsible for meeting the targets on landfilling biodegradable municipal waste (BMW) and separate collection of municipal waste. Moreover, the ATOs or AROs are supposed to represent a geographical entity where waste management is economically feasible. Every region must formulate a plan for reducing landfilling of biodegradable waste. The regions define the waste streams to be collected separately and issue permits on constructing new treatment capacity and upgrading existing plants. The regions also coordinate the municipalities' waste management and identify instruments for separate collection, enhancing implementation of the regional waste management plan. Aggregation of municipalities in the form of ATOs or AROs are in charge of municipal waste collection and disposal and collect charges for managing waste.[2]

The legislative decree 152 of April 3, 2006, Section IV (and subsequent updates), addresses the question of waste management outlining some priorities for the implementation of integrated solid waste management program. In particular, the legislative decree establishes two priorities: (1) prevention of waste production (Art. 180); and (2) Recovery of waste (Art 181). Therefore, if the first attention level is targeted to the prevention of waste and the reduction of its hazardousness (art. 180), the next step concerns the need of re-use of certain materials (e.g. returnable bottles) or recycling if they are not re-usable (e.g. paper recycling) (art. 181). Finally, only as regards the material that cannot be reused and then recycled (e.g., paper napkins), there are two solutions: (1) the energetic recovery through the bio-oxidation (aerobic or anaerobic), gasification, pyrolysis and incineration; or (2) the disposal in landfills. Therefore, even in an ideal world of complete recycling and recovery, there will be a percentage of residual waste to dispose of in landfills or to be oxidize

for energy recovery. From an ideal viewpoint the use of incineration and undifferentiated landfills should be limited to a minimum.

The Legislative Decree No. 152 also set targets for separate waste collection, i.e., 35% by 2006; 45% by 2008; 65% by 2012. To meet those targets, a system of incentives and sanctions was adopted, in order to reduce or increase municipal waste tariffs where targets are met or not. Even if separate collection rates of municipal waste increased in all the Italian regions and Italy seems to be on the right path to reach the EU recycling target of 55% in 2025, it continues to suffer from huge cross-regional differences. The deeply heterogeneous design of ATOs/AROs and their organizational differences have determined dissimilar efficiency standards in waste management across Italy. Spatial pattern analysis highlights a clear degree of performance between regions, and Italy is a paradigmatic case study for stressing this issue.
Italy may be categorized under two waste management groups, according to its regional strategy of coping with environmental problems. The first group comprises Northern regions with high levels of waste management and relatively high levels of separate collection. The second group includes Southern regions with low recovery rates, poor waste management infrastructures and relatively low dependence on separate collection.[3]

3.1.1. Waste management policies in Veneto Region

The Veneto Region has embarked on a rigorous and articulated path for the management of urban and special waste, culminating in the adoption and subsequent updating of the Regional Urban and Special Waste Management Plan[1]. This planning aims to ensure sustainable management that complies with both European and national environmental regulations.
The process began with the adoption of the new plan through the Deliberation of the Regional Council (D.G.R.) no. 264 of 05 March 2013, which introduced an update to the previous planning instruments in compliance with art. 199 of Legislative Decree no. 152/2006. This plan, which was finally approved in the meeting of 29 April 2015, dealt with various practical and administrative aspects - including ten opinions, twenty-two comments on the proposed environmental report (RA) and fifty-two comments on the proposed Plan - and received technical and administrative guidance from the regional SEA Commission.

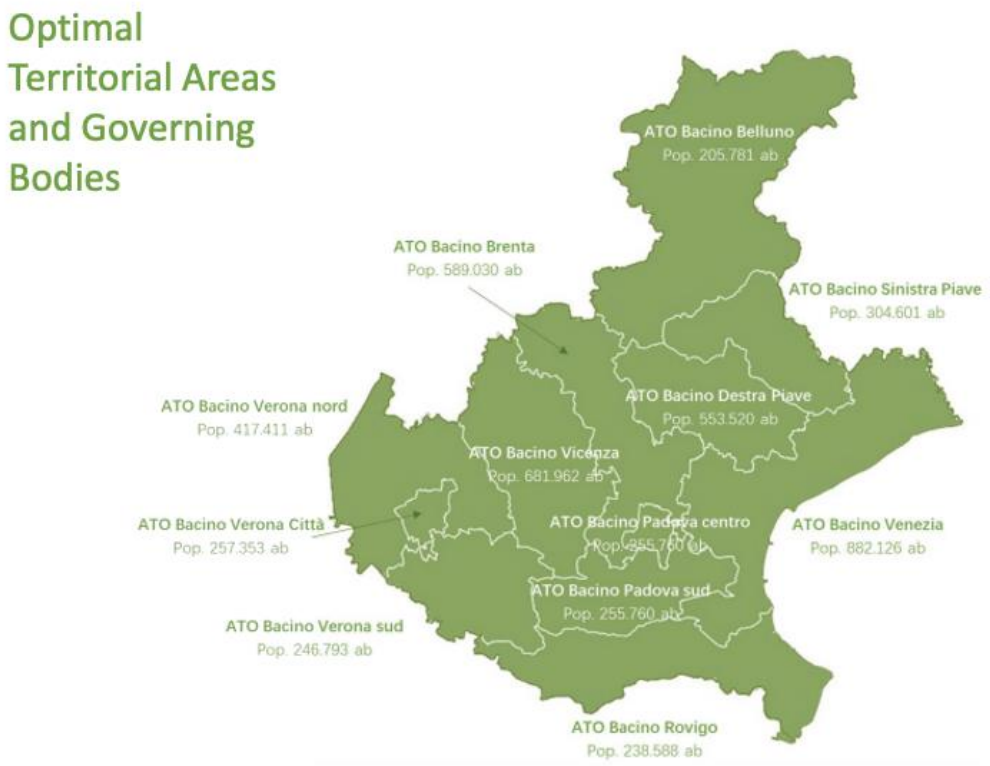
[1] Evaluating waste collection management: the case of macro-areas and municipalities in Italy | Environment, Development and Sustainability (springer.com)

Subsequently, in response to regulatory changes and emerging needs, an update of the Plan was carried out in 2022. With DGR no. 988 of 09 August 2022, the Regional Council approved the Update of the Regional Urban and Special Waste Management Plan. This update introduced new criteria, objectives and actions, reflecting the changed regulatory landscape and circular economy directives.
The update of the plan, consisting of various papers, focuses not only on evaluating and updating the objectives of the previous 2015 plan, but also on integrating new strategic actions and measures to address emerging critical issues. The drafts contain specific insights, new regulations, updated scenarios and criteria for the management of unsuitable areas, as well as a plan for the remediation of polluted areas.
The updating process was characterized by a strong participatory component, with a public consultation phase and the acquisition of opinions from environmentally competent subjects, culminating in the final approval by the Second Council Commission in July 2022.
According to the National System for the Protection of the Environment Veneto[2] is one of the most advanced Italian regions in terms of waste management and is one of the few that presents a substantial correspondence between regional regulations on the organization of the service, on the one hand, and the actual situation of management, on the other[3]. In the territory there is an accentuated aggregation of supply and demand, generally referring to direct entrusting, arranged in associated form by municipalities, in favour of in-house companies. This level of integration allows the achievement of positive results in terms of containing waste production and levels of excellence in separate waste collection.
As shown by the Monitor Rifiuti Veneto 2020[4] report, the good performance recorded in terms of both management organization and efficiency and quality of the service provided can also be attributed to the particular territorial, demographic and economic context of the Region. The orographic characteristics of the territory, which is mainly flat, mean that there are no natural obstacles that could have a negative impact on the efficiency of waste collection and transport. The choices made in organizing the sector have evidently taken into account the demographic variability in terms of population density, as well as the substantial tourist flows affecting the territory - just think of the arrivals recorded daily in the city of Venice. Finally, it is appropriate to highlight the economic weight of the Region in the national picture: indeed, Veneto ranks third in

[2] https://www.snpambiente.it/
[3] Il modello veneto di gestione dei rifiuti urbani. https://www.snpambiente.it/snpa/arpa-veneto/il-modello-veneto-di-gestione-dei-rifiuti-urbani/
[4] Monitor Rifiuti Veneto 2020. https://reopenspl.invitalia.it/banche-dati/monitor-spl/monitor-rifiuti-old/monitor-rifiuti---veneto

Italy in terms of regional GDP and boasts a high rate of entrepreneurship. It is therefore reasonable to assume that these economic dynamics also have a positive effect on waste management performance.
The Approval of the Update of the Regional Plan for the Management of Urban and Special Waste by the Veneto Region[5] marks a fundamental moment in the management of waste in this Region. Bearing in mind that European legislation provides for regional self-sufficiency with a single homogeneous territorial sphere as regards municipal solid waste and free movement to and from the regional territory as regards special waste, the Plan update focused on both fronts, although with real possibilities of intervention obviously much more incisive on the municipal solid waste front. The plan's aim was to guarantee as far as possible the waste management hierarchy, which envisages, in order: upstream reduction of potential waste, extension of product life cycle, recycling of materials, energy recovery, and landfilling[6]. The plan's objectives are to reach 84% separate waste collection by 2030, a result already surpassed by several Veneto municipalities, and a reduction in the production of residual urban waste equal to 80 kilograms per inhabitant per year compared to the current 119.
These objectives would guarantee the expected results of having no more new landfills or landfill extensions compared to what has already been authorized, no more waste-to-energy plants or increases in capacity compared to what has already been authorized, with only improvements to existing plants remaining possible. The plan also envisages arriving at a single regional tariff for the delivery of residual waste with the introduction of an incentive contribution for virtuous territories and an inconvenience contribution for territories hosting disposal plants.
As far as special waste is concerned, although the regions cannot constrain the flows, specific focuses are envisaged, especially on the end-of-life of photovoltaic panels, lithium batteries, conventional vehicles, waste containing asbestos, Pfas and more.

[5] https://bur.regione.veneto.it/BurvServices/pubblica/DettaglioDgr.aspx?id=483320
[6] https://www.regione.veneto.it/article-detail?articleId=12413296



T01 - Optimal Territorial Areas and Governing Bodies in Veneto Region

For each basin (rectius ATO), the governing body is the association of the respective municipalities within the Basin Council[7].

Governance at the regional level is delegated to the Regional Basin Committee, composed of the President of the Region and the presidents of the Basin Councils (or their delegates). The Regional Basin Committee, does not perform the typical functions of the ATO governance body, but monitors the 1 Undertakings pursuant to current national legislation (Legislative Decree 152/2006, Art. 200, and Decree-Law 138/2011, Art. 3-bis). 3 service quality levels, monitors compliance with regulations and planning, provides guidelines to the basin councils, and supervises tariff policies.

[7] https://bur.regione.veneto.it/BurvServices/pubblica/DettaglioDgr.aspx?id=483320

catchment area	entrusted management		
	numero gestori	comuni	abitanti
Bacino Verona Nord	2	48	390.657
Bacino Belluno	2	2	41.728
Bacino Brenta	1	33	298.786
Bacino Destra Piave	1	50	553.520
Bacino Padova Centro	1	1	25.869
Bacino Padova Sud	1	53	249.922
Bacino Rovigo	1	50	238.588
Bacino Sinistra Piave	1	44	304.601
Bacino Venezia	3	45	882.126
Bacino Verona Città	1	1	257.353
Bacino Verona Sud	4	32	202.944
Bacino Vicenza	3	26	366.068
total region	**20**	**385**	**3.812.162**

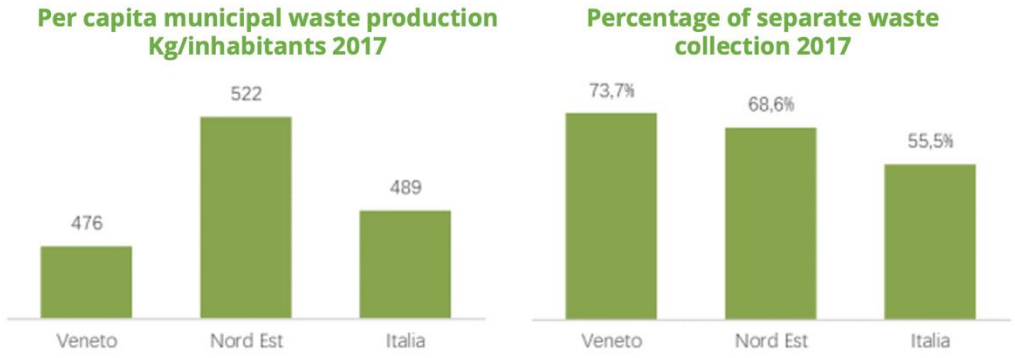
T02 - Optimal Territorial Areas and Governing Bodies in Veneto Region

The surveys carried out show a significant degree of management aggregation, with substantial conformity with the territorial organisation defined by the regional regulations: in most cases, in fact, each territorial basin corresponds to a single entrustment. A **total of 20 collection managers** were surveyed in the Region, each of which serves on average a basin of approximately 182,000 inhabitants (Reference sample: 67% of the municipalities, 78% of the regional population)[8].
In the prevailing management model (found in 70% of municipalities) the service is provided by operators holding direct entrustment as in-house companies of the entrusting bodies. The vast majority of the entrustments are inter-municipal (98%), with the exception of a small number of

[8] Monitor Rifiuti Veneto 2020. https://reopenspl.invitalia.it/banche-dati/monitor-spl/monitor-rifiuti-old/monitor-rifiuti---veneto

cases involving, among others, two important centres (the municipality of Verona, corresponding to the Verona City Basin, and the municipality of Vicenza). The concessions surveyed have an average duration of about 17 years, a medium-long time span, which can be attributed to the mode of concession, mainly direct in favour of in-house companies. In the face of this long-term commitment, the entrusting entity can thus enjoy a more economically convenient situation and greater financial sustainability. Most of the operators mapped can be classified as medium-sized or large companies, while the presence of small companies is residual. Compared to other regions, Veneto is also characterised by a significant share of multi-service companies.

The Veneto Region is probably the most virtuous example of waste management in Italy. The Region achieves positive results in terms of waste containment: in fact, although the total production of urban waste is higher than the national average, per capita values are lower than both the Italian and the North-Eastern data[9]. Veneto ranks first in terms of percentage of separate waste collection (73.7%), a trend that has distinguished the Region over the last ten years and which confirms the investments made in the area to increase the quality of the service.



T03 – Pro capita waste production and percentage of separate waste comparison Veneto/Italy

[9] The Veneto model of urban waste management. https://www.snpambiente.it/snpa/arpa-veneto/il-modello-veneto-di-gestione-dei-rifiuti-urbani/

3.1.2. Waste management facilities, devices and collection systems in Veneto

COLLECTION SYSTEMS

The collection system, i.e. the way in which waste is intercepted, is considered by the Veneto Region[10] strategic for achieving the separate collection targets set by the regulations because it conditions the quantity and quality of waste.

Therefore, in order to be efficient, the system must take into account not only the heterogeneity of the materials, but also the different territorial, urban and socio-economic factors, and last but not least the plant situation and the agreements stipulated with CONAI[11] and the Consortia. These consortia in fact guarantee collection and only pay an economic consideration for particular categories (e.g. packaging). In the Veneto Region, the collection system that involves over 90% of citizens is the so-called **dry-moist collection**[12]. Urban waste is separated into 3 main streams: wet or damp **fraction**, **recoverable dry fractions** (paper, glass, plastic, metal packaging, etc.) and **non-recyclable dry residual**. Separate collection of the organic fraction is essential to achieve high levels of separate collection and reduce the impacts of landfill.

Collection systems are then further classified into:

- **Street collection**: waste collection by means of containers placed on roads or public areas. Access to the street containers is free and not subject to any type of control, with no obligation on the user to comply with pre-determined times and dates for collection.
- **Home collection or door-to-door collection**: collection of waste from each individual user using special containers provided to them. Waste collection takes place at predetermined times and dates, when users display the containers outside their homes. When all of the above fractions are collected door-to-door, the collection system is referred to as pushed home collection.

The **collection** centre, also known as '**ecocentre**', is an area intended only for the reception of municipal waste and its fractions, as well as waste assimilated therewith, produced by domestic and non-domestic users, coming from the area of jurisdiction, and delivered directly by private individuals and/or by separate collection operators and public service managers. The ecocentre is

[10] https://www.arpa.veneto.it/temi-ambientali/rifiuti/rifiuti-urbani/i-sistemi-di-raccolta

[11] Consorzio Nazionale Imballaggi. https://www.conai.org/

[12] Collection systems in Veneto. https://www.arpa.veneto.it/temi-ambientali/rifiuti/rifiuti-urbani/i-sistemi-di-raccolta

an area that does not involve the installation of technological facilities or treatment processes. Only citizens resident in their municipality may deliver waste to the collection centre, subject to any agreements between neighbouring municipalities. Waste must be delivered clean as for street/household collections.
Integrated waste management requires the presence of an adequate plant system in the territory, in terms of potential, flexibility and efficiency.
While policies to reduce waste production at source are encountering difficulties in their application, in Veneto the recovery of the organic fraction and the recovery of dry fractions are now consolidated realities. The processing at various levels of these fractions makes use of a network of plants spread throughout the territory and allows on the one hand a saving of raw materials, energy and consequent reduction of greenhouse gas emissions, and on the other hand contributes decisively to the reduction of waste to be sent for disposal and landfilled. Today, more than one million tonnes of waste is collected separately in our region and sent to material recovery plants. Widespread is also the presence of mechanical biological treatment plants (MBT) that allow the stabilisation of waste to be sent to landfills and the production of RDF (refuse derived fuel) for energy recovery. **In Veneto, over 20% of urban waste is sent to mechanical biological treatment (MBT) plants** with the primary objective of reducing and stabilising the residue to be sent to landfills and, secondly, producing RDF to be sent for energy recovery. At present in Veneto, only the Enel power plant in Fusina, after an experimental phase, is authorised to use this material as a partial replacement for coal dust used to produce electricity. **Incineration**, although present, has not developed to the extent of other Italian regions. Finally, residual dry waste from dry-wet collection or stabilised waste is sent to landfill. In recent years the use of landfill has been gradually decreasing (37% in 5 years)[13].

3.1.3. Origin, composition, categories and type of collected waste at regional level

COLLECTION SYSTEMS IN VENETO[14]
In Veneto, the collection system that affects more than 90% of citizens is the so-called dry-moist collection. Urban waste is separated into 3 main streams:

1. wet waste;
2. recoverable dry fractions (paper, glass, plastic, metal packaging, etc.);
3. non-recyclable dry residue.

[13] Dati ARPA Veneto. https://www.arpa.veneto.it/temi-ambientali/rifiuti/rifiuti-urbani/gestione/il-trattamento-meccanico-biologico-e-la-produzione-di-cdr
[14] Collection systems. https://www.arpa.veneto.it/temi-ambientali/rifiuti/rifiuti-urbani/i-sistemi-di-raccolta

Separate collection of the organic fraction is essential to achieve high levels of separate collection and reduce landfill impacts.

THE WET OR ORGANIC FRACTION OF MUNICIPAL WASTE (FORSU)

Wet waste is the waste fraction from kitchens (domestic users) and canteens (large users) and consists of separately collected food waste. GREEN WASTE is material consisting of residues from the maintenance of public and private green areas made up of clippings, leaves, prunings, whole plants and stumps. The recovery of the organic fraction from separate dry-wet collections plays a strategic role in the integrated management of urban waste[15]. The quality of the compost produced in composting plants is a function of the characteristics of the organic fraction and the type of bag used for its collection: the use of a container made of biodegradable material (maize starch, paper, etc.) guarantees its complete biodegradation during the composting process, reduces the amount of waste (dirty plastic) to be disposed of and allows a compost free of impurities to be obtained. In the Veneto Region, the management of the organic fraction of municipal waste is based on a system consisting of 20 plants, of which 15 composting plants, 3 anaerobic digestion plants and 2 integrated plants (composting + anaerobic digestion), for a total treatment capacity of about 1,000,000 t/year of waste[16].

RECOVERABLE DRY FRACTIONS

These are those waste categories such as paper, glass, plastic, metals, etc. that are commonly intercepted in separate streams and sent for recycling/recovery. From a regulatory point of view, because material recovery from waste is indicated as a priority in European guidelines and directives on integrated waste management. Moreover, waste recovery activities aimed at transforming waste into secondary raw materials (SRMs) suitable for reuse in other production processes represent an indispensable source of supply for a significant part of the industrial system. In addition to this, there is the environmental dimension of the recovery/recycling system, as these operations result in less resource withdrawals, reduced energy consumption and reduced greenhouse gases. **Paper and cardboard** represent the fraction that has been collected separately for the longest time. Pulp represents the predominant raw material of paper production (50%) and comes for the most part from separate collection. Over the last few years, the availability of pulp has gradually increased, making it possible both to fully meet the needs of domestic paper and board producers and to allocate a share of it for export. **Cullet** from separate waste collection and used in glassworks as a

[15] Compost: a source of new fertility. https://www.venetoagricoltura.org/upload/pubblicazioni/COMPOST_E287/low_00.pdf

[16] Recovery of the organic fraction. https://www.arpa.veneto.it/temi-ambientali/rifiuti/rifiuti-urbani/gestione/recupero-della-frazione-organica-compostaggio-e-digestione-anaerobica.

secondary raw material plays a key role in Italian and Veneto glass production, constituting 95% of the total employed in these companies[17].

Scrap glass is an inert material (unlike paper and plastic), which can be used to produce food containers again without any hygienic drawbacks. The secondary raw material (the so-called 'ready-to-bake') can be fed into the production cycle allowing high energy, technological and environmental savings. Plastic packaging waste has progressively increased over the years to become a decisively important share of the separate collection from households (about 7% of the total waste collected). The critical aspect of the plastics recovery system is the fact that different polymers, heterogeneous among themselves, belong to this category, which must be scrupulously separated in order to efficiently produce new products. Under the term '**metals**' are commonly included those wastes from separate collection that include aluminium packaging (cans) and tinplate packaging (steel cans and containers). Although representing a rather small share in the separate collection, the recovery of these fractions plays a key role in the market, replacing the use of virgin raw materials through recycling.

THE RESIDUAL DRY FRACTION

This is the mixed municipal waste that remains after having activated, in addition to the mandatory collections (i.e. those of the green and recoverable dry fractions), the separate collection of the organic waste fraction. If the latter is not carried out, the waste is called undifferentiated. The **main destination of the residual urban waste collected in Veneto is mechanical biological treatment (MBT)**, in plants that allow the stabilisation of the waste to be sent to landfill and, if necessary, the production of RDF (refuse derived fuel) to be sent for energy recovery. **The other destinations are incineration and landfilling[18].**

Street sweeping waste and bulky waste (furniture, mattresses, etc.), not being commodity fractions, are considered residual municipal waste. In recent years, such waste is no longer sent to landfills but increasingly to plants for the recovery of plastic, wood and metals (in the case of bulky waste) and

[17] Recovery of recoverable dry fractions. https://www.arpa.veneto.it/temi-ambientali/rifiuti/rifiuti-urbani/gestione/recupero-delle-frazioni-secche-recuperabili.
[18] Treatment of the residual dry fraction. https://www.arpa.veneto.it/temi-ambientali/rifiuti/rifiuti-urbani/trattamento-della-frazione-secca-residua

inerts and sand (in the case of street sweeping waste). Recently, some experiments have also been carried out to assess the possibility of material recovery from non-recyclable dry waste[19].

TRENDS IN URBAN WASTE PRODUCTION IN THE VENETO REGION[20]

The total production of urban waste can be considered almost stable in the years between 2000 and 2019, reaching **2.311 million tonnes** in 2019. Regional per capita production increased by 1% compared to the previous year, from 466 kg to 471 kg (1.29 kg/inhabitant). The percentage of separate waste collection (RD) in Veneto stands at 69.5% in 2019. In 2019, 502 municipalities, or 77% of the population, have exceeded the 65% separate collection target, while 223, or 36% of the population, have already reached the target set in the Regional Waste Plan (76%). One of the key components in achieving these results is the widespread organisation of separate waste collection that responds to the needs of the territory, informing and empowering all those involved.

As regards the trend of urban waste production in Veneto in 2020, the production of RU, equal to **2.229 million tonnes,** decreased by more than 3% compared to 2019, due to the effects of the pandemic, which caused the closure of the production and commercial sector, schools, travel restrictions, and the consequent reduction in tourist flows. The regional per capita production decreases by 3.2% compared to the previous year, from 471 kg to **456 kg**, despite the contraction of GDP and the halving of the tourist presence in Veneto, 32 million against 71 million in 2019. Differentiated waste collection in Veneto in 2020 will be 76.1% above the 65% target set by Legislative Decree 152/06 for 2012. At basin level all contexts exceed the national average (58.1% ISPRA 2018 data) except Verona City. Only Padua Centre and Venice have not yet reached the 65% target set by national legislation.

9 out of 12 basins also exceed the target of 76% set by the Regional Plan for 2020. Even considering the 2020 Covid-9 incidence, municipal waste management is still characterised by:

- a high amount of waste sent for material recovery (organic, recoverable dry fractions - paper, glass, plastic, wood, WEEE, sweeping and bulky waste)

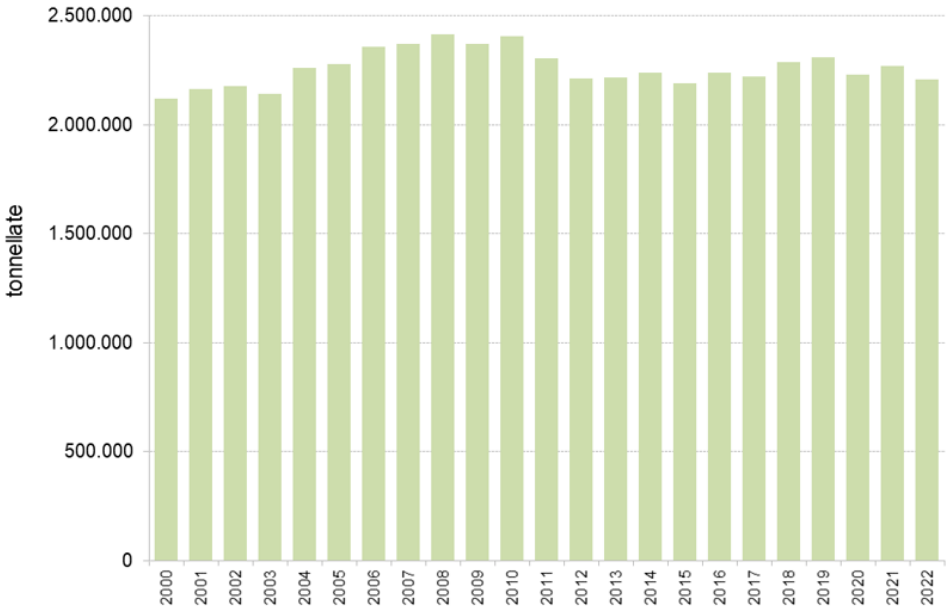
[19] The recovery of recyclable dry fractions in Veneto. https://www.arpa.veneto.it/temi-ambientali/rifiuti/file-e-allegati/recupero_frazioni.pdf

[20] ARPA Veneto, Urban Waste. https://www.arpa.veneto.it/temi-ambientali/rifiuti/rifiuti-urbani

- a significant amount of waste sent to mechanical and mechanical biological treatment for the production of CSS and biostabilised waste from landfills and to waste-to-energy;

- a reduced landfilling of residual waste. This is only 4% of the total waste and therefore well below the targets set by Directive 850/2019, which imposes 10% as a ceiling by 2035.

Applying the recovery percentages to the amount of waste produced in 2020 in Veneto allowed to derive the IR recovery index equal to 68.8% of the urban waste collected.
The index represents an estimate of the quantity of material, coming from urban waste treatment activities, reintroduced into an industrial production cycle, compared to the total amount of waste produced. The IR index is calculated by associating, to each individual waste fraction, the recovery percentages obtained from product analyses carried out over the years by the Regional Waste Observatory, the University of Padua - IMAGE Department, the CONAI system supply chain consortia, the plants themselves, specific studies carried out by bodies and institutions, and bibliographic information.
In 2021 RU production, amounting to 2.272 million t, had an increase compared to 2020 of 2% attributable to the economic recovery and the increase in tourism in Veneto, 50 million against 32 million in 2020. The regional per capita production increased by 1.7% compared to the previous year, from 456 kg to 464 kg (1.27 kg/inhab*day). Differentiated waste collection in Veneto in 2021, calculated according to the national method provided for by the Ministerial Decree 26/05/2016 and implemented in Veneto with DGRV no. 336/2021, stands at 76.2% above the 65% target set by Legislative Decree 152/06 for 2012. As far as the recycling rate is concerned, Veneto far exceeds the targets set by the regulations, reaching a rate of 68.9%.
The production of RU in 2022, equal to 2.207 million tonnes, had a decrease compared to 2021 of -3% attributable mainly to the rise in energy and raw material costs with evident effects on inflation rates due to the Russian-Ukrainian war. This was reflected in line with the contraction of consumption, particularly food. Also not to be underestimated is the decrease in green waste attributable to the very dry weather conditions. On the one hand, this trend was mitigated by a high tourist flow, which in 2022 was a particularly influential element in the waste production dynamics of certain areas of the region. Regional per capita production decreased by -2.4% compared to the previous year, from 464 kg to 453 kg (1.24 kg/inhab*day). Differentiated waste collection in Veneto in 2022 will be 76.3% above the 65% target set by Legislative Decree 152/06 for 2012. In 2022, 541 municipalities have exceeded the 65% target (83% of the population), while 192 (31% of the population) have already reached the 2030 target set by the Regional Waste Plan (84%).



T04 - Urban waste production in Veneto 2000-2022

In 2022 municipal waste management, in line with previous years, was characterised by:

- a high amount (76%) of waste sent for material recovery (organic, recoverable dry fractions - paper, glass, plastic, wood, WEEE, sweeping and bulky waste)
- 12% of RUR sent for mechanical and mechanical biological treatment to produce CSS and biostabilised landfill waste
- a 6% share sent to waste-to-energy;

only a small amount of residual waste sent directly to landfill (6%), which rises if we add the waste from surplus materials.

3.1.4. Illegal waste disposal sites or illegal landfills

Every year in Italy, huge quantities of waste are illegally dumped in the countryside or set on fire in uncontrolled fires, with major consequences on air pollution, contamination of the surrounding soil and, more generally, on the health of the population.

In some cases, the presence of waste and toxic substances can be linked quite directly to the presence of dangerous anthropic activities managed - especially in the past - with little or no environmental sensitivity, which have sometimes irreversibly compromised the state of environmental matrices (soil, subsoil, surface and underground water). These known situations are managed as part of **contaminated site remediation programmes**[21]. The reclamation of environmental matrices (soil, landfill materials, subsoil and groundwater) has been brought to the country's attention through the approval of targeted legislative measures, starting with Article 17 of Legislative Decree 22/97 (Ronchi Decree), which laid the foundations for addressing the issue of reclamation in a uniform manner at a national level, both from a technical and procedural point of view, a subject that was then implemented and articulated in Ministerial Decree 471/1999. Subsequently, from 2006 to the present, Legislative Decree 152/2006 'Regulations on environmental matters' - Part Four, Title V - reorganised the provisions on the subject, profoundly modifying the procedural process of reclamation interventions. To date, almost all proceedings refer to the regulatory regime of Legislative Decree 152/06, except for those proceedings that had a final reclamation project already approved when Legislative Decree 133/2014 ('Sblocca Italia' Decree) came into force. Legislative Decree 152/06 in Part Four, Title V 'Remediation of contaminated sites', regulates the remediation and environmental restoration of contaminated sites and defines the procedures, criteria and methods for carrying out the operations necessary for the elimination of the sources of pollution and in any case for the reduction of concentrations of pollutants, in harmony with the EU principles and standards, with particular reference to the 'polluter pays' principle. The main innovation introduced by Legislative Decree 152/06 with respect to the previous legislation is the introduction of the decision-making tool of the site-specific environmental health risk analysis, aimed at identifying whether a site requires remediation - as well as permanent safety enhancement (MISP) or operational safety enhancement (MISO) - and identifying the objectives of the remediation. For the failure to take action on illegal landfills, in its ruling of 2 December 2014, the EU Court asserts that Italy has breached its obligation to recover waste and to dispose of it without endangering

[21] https://www.mase.gov.it/pagina/programma-nazionale-di-bonifica-dei-siti-inquinati

human beings or the environment, which the obligation on the holder of the waste is to hand it over to a collector who carries out disposal or recovery operations in accordance with EU rules. Italy, the Court finds:

- did not ensure that the established permit regime was effectively implemented and complied with;
- did not ensure the effective cessation of operations carried out without authorisation;
- did not provide for an exhaustive cataloguing and identification of each of the hazardous wastes disposed of in the landfills;
- continues to breach the obligation to ensure that a conditioning plan or a final closure measure is adopted for certain landfills.

The Court, inter alia, points out in that regard that:

- the mere closure of a landfill or the covering of waste with soil and rubble is not sufficient to fulfil the obligations under the Waste Directive
- Member States are obliged to verify whether it is necessary to reclaim old illegal landfills and, if necessary, to remediate them;
- reminds Italy, the seizure of the landfill site to be reclaimed and the commencement of criminal proceedings against its operator do not constitute sufficient measures.

The conviction concerned 200 landfills:

- 198 landfills declared not in compliance with Directive 75/442 and Directive 91/689 for which clean-up operations are necessary to fully comply with the judgment
- 2 landfills declared not to be in compliance with Directive 1999/31, for which it is necessary to prove the approval of rehabilitation plans or the adoption of final closure decisions.

On 24 March 2017, the government decided to appoint a commissioner to bring the situation to a rapid resolution; 81 sites were thus commissioned with three different government measures. *From 2 December 2014, the date of the start of the penalty imposed by the EU Court of Justice, to March 2023*, Italy **has reclaimed 182 sites**, **out of the initial 200**, and **led to the exit from the procedure of 69 illegal landfills**. Over half a square kilometre of land has been reclaimed and redeveloped, and 85

per cent of the sites that once hosted illegal landfills have been removed from the European Commission's list of infringement procedures[22].

In order to make this process public, a dynamic map of the sites and their status was developed, containing a lot of data about each landfill site[23].

T05 - Map of Italy and commissioned sites

[22] Single Commissioner for the Remediation of Landfills and Contaminated Sites. https://www.commissariobonificadiscariche.governo.it/it/

[23] http://89.202.197.213/landfills/site/index.php/site/home

Although in terms of waste management, the process of remediation and standardisation of landfills is bearing fruit, according to data from ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale, the number of non-standard sites in Italy is around 22 thousand[24]. In 2019, Giuseppe Vadalà, the then Extraordinary Commissioner for the compliance of illegal landfills with the regulations in force, explained that when ISPRA talks about this incredible number of illegal landfills, it does not refer to hidden sites, but evidently to landfills in the light of day. Although for sure, there are also hidden storage sites.

THE IMPACT OF ENVIRONMENTAL CRIME

The impact of crimes against the environment is growing in 2023. Especially in the four regions with a traditional mafia presence (Campania, Sicily, Apulia and Calabria), where 43.5% of criminal offences are concentrated. The first region in the North is Lombardy, in eighth place, followed by Veneto, where criminal offences against the environment grow by +53.7% compared to 2022, with an increase in complaints of +137%. The first province in the North is Venice, with 662 offences, in ninth place in Italy[25].

THE REGIONAL CLASSIFICATION OF ENVIRONMENTAL ILLEGALITY IN 2023[26]

REGION	OFFENCES	PERSON CHARGED	ARRESTS	SEIZURES
CAMPANIA	4952	4643	49	1241
SICILIA	3922	3515	29	615
PUGLIA	3643	3404	38	1074
CALABRIA	2912	2758	15	669
TOSCANA	2318	2273	1	302

[24] Il Catasto dei Rifiuti. https://www.catasto-rifiuti.isprambiente.it/index.php

[25] Ecomafia 2024, Edizioni ambiente, Legambiente.

[26] Source: Legambiente processing of police and harbourmaster's office data 2023

LAZIO	2200	2122	14	596
SARDEGNA	2076	1857	46	282
LOMBARDIA	1974	1907	49	554
VENETO	1761	2385	1	229
LIGURIA	1504	1423	3	170
EMILIA ROMAGNA	1422	1532	4	236
PIEMONTE	1359	1262	20	236
ABRUZZO	1235	1291	0	189
MARCHE	1177	1434	47	273
BASILICATA	805	611	3	93
TRENTINO ALTO ADIGE	574	368	0	130
UMBRIA	547	556	0	46
FRIULI VENEZIA GIULIA	541	644	0	179
MOLISE	492	426	0	35
VALLE D'AOSTA	73	69	0	3

T06 – Regional classification of environmental illegality in 2023

THE PROVINCIAL CLASSIFICATION OF ENVIRONMENTAL ILLEGALITY IN 2023[27]

	PROVINCE	OFFENCES
1	NAPOLI	1494
2	AVELLINO	1203
3	BARI	878
4	ROMA	867
5	SALERNO	815
6	PALERMO	710
7	FOGGIA	703
8	COSENZA	697
9	VENEZIA	662
10	LECCE	615

T07 – Provincial classification of environmental illegality in 2023

As regards the type of illegal activities, in the 2023 investigations, Ecomafie 2024 shows that the largest share, **45%,** concerns **waste management offences**, a category that includes illegal waste management, illegal dumping, illegal waste trafficking, etc.

INITIATIVES TO MONITOR AND REPORT OFFENCES IN WASTE MANAGEMENT

In recent years, in order to get more information and monitor the phenomenon of waste management malpractice, apps have been developed in which every single citizen, anonymously, can report and geolocate the 'hidden' site. One of these is TrashOut, developed by several NGOs, including Let's Do It!, a software that combines EuropeTrashOut and aims to map and uncover the network of illegal dumps in the country. To report an illegal site, simply take a photo of the illegal dump, geolocalise it, and indicate the type of waste present in the different locations. At the end of the process, simply upload the report, which immediately becomes visible to local authorities and environmental protection organisations. From January 2021 to August 2022, 2,080 reports were

[27] Source: Legambiente processing of police and harbourmaster's office data 2023

made on Italian territory: none of these, according to the findings of Let's Do It! Italy, were taken up and resolved by the local authority on duty. According to the data provided by the NGO Let's Do It!, 46% of the cases were plastic landfills, 19% inert and 18% urban waste.
A few years ago, Legambiente also promoted Gaia Observer[28], an app and related platform that allows the collection of georeferenced information on the environment to report, with photos, text and location, illegal dumps, but also fires or poaching activities[29].

ILLICIT WASTE TRAFFICKING ABROAD

A phenomenon that can certainly be linked to that of illegal landfills is the illicit traffic of waste abroad, mainly to Africa, a phenomenon that continues to increase despite seizures and complaints. According to the Customs Agency, waste seized for illegal trafficking abroad tripled in 2020: from 2,251 tonnes in 2019 to 7,313 tonnes last year. The profits for criminal organisations are high, the risks low: the waste is collected by companies that have to get rid of it, those who manage the traffic charge for disposal, and then ship it elsewhere, evading customs controls. A large flow of illegal waste continues to leave Italian ports, often mixed with other, legal waste in order to circumvent laws. In the containers there is everything: plastic, paper, car and motorbike parts, WEEE (Waste Electrical and Electronic Equipment) materials. But, also urban and so-called bulky waste. And hazardous waste containing mercury, arsenic, phosphorous, often handled by children and teenagers working in the huge dumps for the recovery of aluminium and copper. The countries of destination involved are Senegal, Gambia, Togo, Sierra Leone, Nigeria, but above all Ghana where, on the outskirts of Accra, there is the world's largest electronic waste dump, that of Agbogbloshie. It is estimated that more than 250 million tonnes of e-waste, at least 85% of which comes from Europe, ended up in the huge dump. Also, according to the Customs and Monopolies Agency[30], an analysis of data on waste seizures in 2023 shows, compared to the previous year, an increase in the number of seized items (+390%) and their estimated value (+57%). Regarding the types of waste, there was a significant decrease in seizures of plastics and metals and a sharp increase in waste from electrical and electronic equipment.

[28] https://www.gaiaobserver.it

[29] Discariche: ancora troppe in Italia. https://www.nonsprecare.it/numero-discariche-italia-regioni-meridionali-chiusura-entro-2020

[30] https://www.adm.gov.it

4. Measures and initiatives for the development and improvement of the waste management system at regional level

TECHNICAL TABLES

As part of the actions aimed at implementing the circular economy, the update of the regional plan for the management of urban and special waste proposes to incentivise and support the production sector for the valorisation of

- by-products and industrial symbiosis
- waste with specific characteristics, directly reusable as materials in production chains, according to the provisions of Article 216-septies of Legislative Decree 152/06
- materials from the recycling/recovery of waste that has ceased to be waste (End of Waste).

The **Regional Technical Coordination Table**[31] ha il compito di valutare le istanze provenienti dalle filiere produttive o da singole aziende e **definire buone pratiche tecniche e gestionali** che, nel rispetto della normativa vigente, possano consentire di individuare e "validare", caso per caso, determinati sottoprodotti nell'ambito di diversi cicli produttivi. Il Coordinamento, al termine dell'istruttoria svolta sul sottoprodotto oggetto dell'istanza, rilascia un documento di riconoscimento del sottoprodotto e tale sottoprodotto può essere iscritto all'Elenco Regionale dei Sottoprodotti gestito da ARPAV.

Il **Tavolo tecnico** di riferimento per gli **End of Waste**[32] has the task of developing and approving the technical reference documents for specific types of EoW products (starting with the most consolidated and recurring), containing the information deemed necessary to define the criteria for the cessation of waste status pursuant to Article 184-ter of Legislative Decree 152/2006 as amended. The documents that will be produced and validated according to a procedure approved by a special Decree of the Director of the Environment and Ecological Transition Directorate will define a reference for the Companies in the context of the case-by-case authorisation requests pursuant to Article 184-ter and by the competent authorities in the preliminary investigation for the release of these authorisations for the specific EoW.

With DGR no. 1257 of 17/10/2023 - BUR no. 146 of 03/11/2023[33] the 'Protocollo d'Intesa per la definizione di proposte operative per l'attuazione dell'economia circolare nei settori produttivi del Veneto' (Memorandum of Understanding for the definition of operational proposals for the implementation of the circular economy in the Veneto production sectors) was approved between

[31] https://elezioni.regione.veneto.it/web/ambiente-e-territorio/tavolo-tecnico-coordinamento-sottoprodotti

[32] https://elezioni.regione.veneto.it/web/ambiente-e-territorio/tavolo-tecnico-di-riferimento-end-of-waste

[33] https://bur.regione.veneto.it/BurvServices/pubblica/DettaglioDgr.aspx?id=514785

the Veneto Region, A.R.P.A.V., Ca' Foscari University, the University of Padua and the University of Verona, with the aim of activating shared and complementary strategies that favour the application of the circular economy in the various production sectors, in particular by promoting
- the reduction of the consumption of natural resources through more efficient production processes and the use of recovered materials to replace similar virgin materials
- the use of renewable natural resources;
- the development of a high quality and competitive recovery industry that steers the market towards a greater and more established confidence in the quality of recovered material;
- an analytical reading of the current regulatory framework in force, identifying the relative criticalities and possible initiatives aimed at overcoming them;
- the analysis of the design and implementation process of the production process, from design to product release, in different production sectors, to verify whether what is left over from one production sector can become a resource for a different sector, in a strategic vision based on process optimisation and circular economy;
- the promotion of technical operational tools to promote the achievement of circularity objectives, through an effective Life-Cycle Assessment;
- the possibility of developing a web platform, aimed at collecting and sharing the activities carried out by individual subscribers, to be eventually made available to operators in the sector;
- the promotion, development and support of circular business models based, inter alia, on circular design principles;
- the promotion, development and support of business models that envisage the affirmation and strengthening of value chains in a circular sense;
- the study and development of enabling technology tools with a view to making digitalisation and innovation an effective and efficient tool for overcoming the linear model and affirming the circular model.

In order to achieve the above-mentioned objective, the Memorandum of Understanding establishes the **Circular Economy Table**[34], coordinated by the Veneto Region, with the participation of the designated contact persons for each individual protocol signatory.

In the implementation of the **National Plan for Environmental Communication and Knowledge on Waste and Economy**[35] and of the Regional Waste Management Plan Update, the Veneto Region promotes communication and awareness initiatives in line with the implementation of regional waste management policies such as. An example for all: 'Veneto Green Cluster', the Veneto

[34] https://www.regione.veneto.it/web/ambiente-e-territorio/tavolo-per-l-economia-circolare

[35] https://www.mase.gov.it/pagina/il-piano-nazionale-di-comunicazione-e-conoscenza-ambientale

Innovative Network created to aggregate the best excellences in the field of waste valorisation[36]. It is possible to access the official websites of the initiatives proposed by public bodies and private subjects in the area through the links provided in the specific sections of the Veneto Region website[37].

[36] https://www.innoveneto.org/veneto-green-cluster/

[37] https://elezioni.regione.veneto.it/web/ambiente-e-territorio/piano-regionale-di-comunicazione

5. Conclusion

Based on the findings in the research report on the waste management system in the Veneto Region, Italy, key conclusions can be drawn:

1. **Advanced waste management framework**: Veneto is recognized as one of the leading regions in Italy for waste management efficiency. This success is attributed to its rigorous alignment with European and national regulations and its proactive approach in updating regional management plans to reflect emerging needs and regulatory changes.
2. **High rates of separate waste collection**: The Veneto Region has achieved high rates of separate waste collection, surpassing both national averages and regional targets set for 2020 and 2030. This achievement is facilitated by a robust collection system and strategic initiatives focusing on the separation of organic waste.
3. **Regional waste management plan**: The updated regional plan aims to reach ambitious targets, including 84% separate waste collection by 2030 and a significant reduction in residual urban waste production. Successful implementation of this plan is critical for minimizing landfill usage and avoiding the need for new disposal sites.
4. **Circular economy and sustainability**: Veneto is actively promoting circular economy principles through measures aimed at encouraging by-products and industrial symbiosis. The updates to the waste management plan include strategic actions to enhance sustainability and resource efficiency in the region's waste processing and recovery systems.
5. **Technological and organizational efficiency**: The region has developed a sophisticated network of waste management facilities, including composting and anaerobic digestion plants, that aid in the effective processing of organic and recoverable waste fractions. Moreover, the involvement of multi-service companies and inter-municipal collaborations further enhances organizational efficiency.
6. **Challenges and areas for improvement**: Despite its achievements, Veneto faces challenges like illegal waste disposal and environmental crime, which need ongoing monitoring and enforcement to ensure compliance and protection of the environment. Efforts such as community-based reporting apps and investigative initiatives are critical in addressing these issues.
7. **Economic and social influence**: The demographic and economic context of Veneto, characterized by high entrepreneurship and substantial tourist flows, impacts waste management dynamics. The region’s economic vitality supports infrastructural and service initiatives that further boost waste management success.

8. **Future outlook**: With its forward-thinking strategic plans and comprehensive waste management practices, Veneto sets a benchmark example for integrating environmental sustainability and waste management efficiency. Continued emphasis on technological advancements, community engagement, and policy updates will be essential to maintain and enhance these efforts.

Overall, the research highlights Veneto's effective strategies in waste management, the importance of adapting to regulatory landscapes, and the focus on sustainability and circular economy principles.

Tables of figures

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INTERREG ITALY-CROATIA
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AWASTER – Adopting WASTE as Resource

D.1.1.2 Regional waste management report – Apulia Region

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DISCLAIMER: The report reflects the project AWASTER views; the IT-HR Programme authorities are not liable for any use that may be made of the information contained therein.

Table of contents

1. Introduction

The present deliverable is one of the five regional reports foreseen by Activity 1.1 Regional background analysis, which is part of the WP1 Circular economy – current state analysis of the Interreg IT-HR AWASTER project.

The report assesses the primary analysis of waste management services in the partner's regions. Together with D.1.1.3 Secondary market report, the present deliverable represents a high-quality database on which stakeholders can base their requests for financing the measures provided for in the Joint Action Plan from European Union (EU) funds and other sources.

The report will assess the quantity and composition of collected waste, waste collection schemes, seasonality, and list existing waste prevention policies. Deliverable consists of 5 regional reports.

2. Apulia Region

The regional territory of Apulia region, situated in the easternmost part of the Italian peninsula (Southern Italy), is characterised by highly varied topography. In northern Apulia, there is a large alluvial plain, known as Tavoliere. In central Apulia, there is an extensive hilly region oriented toward NW-SE, referred to as the Murge. The southern part of Apulia, called Salento, is occupied by a large plain and a modest hilly system to the south. It exhibits significant territorial discontinuity and a prominent coastline (about 1035 km long inclusive of the Tremiti Islands), along the Adriatic and the Ionian Seas. Due to its peculiar geographical position and topography, Apulia presents highly varied climatic conditions, both within its different regional geographical areas and in relation to the broader Mediterranean macroclimate that exerts influence over it.[11]

The prevalence of calcareous soils and the scarcity of surface hydrography, the development along the whole coast, and the flatness of the territory are among the characteristics that highlight the physical-geographical individuality of the region in comparison with Italian territory. These landscapes have a strong rural character in which the agricultural spaces have been strongly conquered by humans, who extended the dry arable land area during the dominance of extensive capitalist agriculture based on a pastoral cereal economy. The signs of these complex transformation processes are present everywhere in the region. In the history of the region, therefore, the natural, historical, economic conditions, human activity, and the role of institutions have been decisive over time, often modifying land management, services, functions, demographic settlement, and resulting in abandoned farms and irreversible effects on landscapes.

Counting 258 municipalities, Apulia is distinguished by a markedly individual character and by a physical uniformity due to the specific lithological composition. Various geographical and historical factors have influenced the irregular population distribution, the type of economic structures, and transformation processes in the agricultural sector, especially around the 1950s. Lately, the region is facing a problem of demographic decline due to emigration: at the end of 2023 the Region counted about 3.890.250 inhabitants, 22.000 less than in 2022. Apulia has always experienced and still experiences a territorial, demographic and economic disparity which is concentrated above all in the smaller municipalities which are currently included in the National Strategy for Inner Areas.[1]

The current models of local development act mainly on a territorial aggregation of a political nature (agreements between neighbouring municipalities). This resulted in extensive fragmentation in micro cultural contexts, strongly linked to specific environmental conditions, to particular agricultural and productive traditions and diversified historical traditions that altogether helped to make the Apulia region prominent in the major tourist circuits in the Mediterranean. Tourism represents one of the most significant economic sectors in the Apulia region. In 2022, it contributed between 8.3% to 8.8% of the regional GDP. Coastal tourism plays a key role in the regional tourist framework, with coastal destinations recording the highest numbers of arrivals and tourist stay.[11]

Along the Apulia coastal region, another of the most developed economic sector is represented by aquaculture. Apulia plays a prominent role in the context of Italian shellfish farming with a production approximately of 5000 tons in 2020 and most plants located along the northernmost Adriatic Apulian coast and in the transitional water system Mar Piccolo. In the whole area, Apulia's economy is articulated into numerous sectors (aerospace, automotive, mechanics, furniture, food and beverage, agriculture, publishing, tourism, logistics, I.C.T) boasting several leading companies, but most of them produce materials or components, not finished goods.[11]

3. Waste management system

3.1. Waste management system in the Italian Republic

Italy has four administrative levels: national, regional, provincial and municipal. Administrative levels in charge for waste management are the national one, the regional one and the municipal one. The latter, also in a form of aggregation called AROs or ATOs, as it will be seen further in this report.
The Ministry of Environment outlines the overall waste management strategy by establishing the legislative framework, setting targets at national level and drawing up the National Waste Management Plan. In turn, regions prepare regional waste management plans based on criteria defined in the national legislation. The regions issue regulations in compliance with the national

legislation and define some optimal aggregation of municipalities called “Optimal Territorial Basins” (ATOs) or “Optimal Collection Basins” (AROs). The latter are responsible for meeting the targets on landfilling biodegradable municipal waste (BMW) and separate collection of municipal waste. Moreover, the ATOs or AROs are supposed to represent a geographical entity where waste management is economically feasible. Every region must formulate a plan for reducing landfilling of biodegradable waste. The regions define the waste streams to be collected separately and issue permits on constructing new treatment capacity and upgrading existing plants. The regions also coordinate the municipalities’ waste management and identify instruments for separate collection, enhancing implementation of the regional waste management plan. Aggregation of municipalities in the form of ATOs or AROs are in charge of municipal waste collection and disposal and collect charges for managing waste.[2]

The legislative decree 152 of April 3, 2006, Section IV (and subsequent updates), addresses the question of waste management outlining some priorities for the implementation of integrated solid waste management program. In particular, the legislative decree establishes two priorities: (1) prevention of waste production (Art. 180); and (2) Recovery of waste (Art 181). Therefore, if the first attention level is targeted to the prevention of waste and the reduction of its hazardousness (art. 180), the next step concerns the need of re-use of certain materials (e.g. returnable bottles) or recycling if they are not re-usable (e.g. paper recycling) (art. 181). Finally, only as regards the material that cannot be reused and then recycled (e.g., paper napkins), there are two solutions: (1) the energetic recovery through the bio-oxidation (aerobic or anaerobic), gasification, pyrolysis and incineration; or (2) the disposal in landfills. Therefore, even in an ideal world of complete recycling and recovery, there will be a percentage of residual waste to dispose of in landfills or to be oxidized for energy recovery. From an ideal viewpoint the use of incineration and undifferentiated landfills should be limited to a minimum.

The Legislative Decree No. 152 also set targets for separate waste collection, i.e., 35% by 2006; 45% by 2008; 65% by 2012. To meet those targets, a system of incentives and sanctions was adopted, in order to reduce or increase municipal waste tariffs where targets are met or not. Even if separate collection rates of municipal waste increased in all the Italian regions and Italy seems to be on the right path to reach the EU recycling target of 55% in 2025, it continues to suffer from huge cross-regional differences. The deeply heterogeneous design of ATOs/AROs and their organizational differences have determined dissimilar efficiency standards in waste management across Italy. Spatial pattern analysis highlights a clear degree of performance between regions, and Italy is a paradigmatic case study for stressing this issue.
Italy may be categorized under two waste management groups, according to its regional strategy of coping with environmental problems. The first group comprises Northern regions with high levels of waste management and relatively high levels of separate collection. The second group includes

Southern regions with low recovery rates, poor waste management infrastructures and relatively low dependence on separate collection.[3]

3.2. Waste management policies at the national and regional level

As in other European countries, waste management performance and policies in Italy are strictly related to EU recycling targets. Over the last two decades, European Union Directives have set waste policies and targets to deal with waste issues in a coordinated way. Those regulations have been moving municipal waste management in Europe up the waste hierarchy – laid down by the Waste Framework Directive 2008/98/EC – which prioritises waste prevention, followed by preparing for reuse, recycling, and other recovery, thus leaving disposal as the least desirable option. Waste management in the EU has improved considerably in recent decades. Furthermore, the EU is also making the requirements about separate waste collection more stringent, for instance, by specifying exemptions in further detail and requiring separate collection for textiles and hazardous waste from households by 2025. The most relevant pieces of Italian legislation date back to the Legislative Decree No. 22 of 1997 – the so-called Ronchi Law, after the name of the Minister of Environment, that aimed at introducing a number of remedies to salient environmental issues arising from waste management. Those issues included a remarkable increase in the amount and variety of waste; growing demand for waste disposal; increasing risk of negative environmental, health and social impacts of waste management practices. The Italian Decree of 1997 followed a few European directives of 1991 and 1994, which provided frameworks for waste management in the EU (see the directives 91/156/CEE, 91/157/CEE, 91/689/CEE, and 94/62/CE).[4] The Italian legislation promoted a model of aggregated waste management between several municipal administrations and a reduction of waste movement across Italian regions, according to principles of proximity and regional self-sufficiency in managing local waste. Therefore, regional governments hold the responsibility for drawing up waste management plans and strategies to promote waste reduction. Municipalities are included in so-called Optimal Territorial Basins (ARO - Ambiti di Raccolta Ottimali), to improve municipal waste management. The Ronchi Law set chronological targets for separate waste collection, to be achieved by ATOs, as percentages of total municipal waste generation: 15% by 1999, 25% by 2001, and 35% by 2003. In 2006, the Legislative Decree No. 152 repealed the Ronchi Law, but retained its main provisions and set new targets for separate waste collection, i.e., 35% by 2006; 45% by 2008; 65% by 2012.

Pressure from green and environmental groups, as well as the debate at the European level about the best possible strategy to reduce waste production, led the Italian government to issue a new piece of legislation introducing urgent measures to reduce waste production. This law consists of a number of measures representing a mediation by the Italian government, through its Ministry of the Environment, between green and environmental groups on one side and the industrial sector

(divided into several factions) on the other. Plastic was undoubtedly the target of an aggressive campaign on the part of other packaging producers. As a result of the technical innovations and radical changes in the trade sector during the 1980s, plastic packaging production rose at very high rates, worrying both the environmental groups and the other material packaging producers. The former felt uneasy with a material that encouraged wasteful attitudes on the part of the consumer (not reusable, not recyclable, difficult to dispose of, etc.), the latter (glass producers in particular) were faced with a situation where their share of their market was disappearing in favour of new materials (PVC and PET bottles, paper/plastic/aluminium composite containers, etc.). One of the measures introduced was a tax on nonbiodegradable plastic shopping bags amounting to 0,05 Euros per unit. The aim of this tax was to give an economic incentive to multi-use shopping bags. The results were miserable. The incentive was too low to encourage virtuous behaviour on the part of the citizen.[4]

More sophisticated, at least apparently, than a simple tax on unit product, was the constitution of the Obligatory Syndicates (Consortia) for the recycling of glass, metals and plastic containers for liquids. Municipalities were responsible for the separate collection of these materials, but the consortia were responsible for the reaching of the ambitious targets set by the law. Producers of packaging in the raw materials sector had been forced to subscribe to the Obligatory Syndicates. Packaging users and the distribution sector had no financial burden but were asked to elect a representative. The legislator, based on a restricted version of the polluter pays principle, chose to put the burden of packaging recovery entirely on the broad shoulders of packaging material producers. There is another important implication in giving the responsibility for the recycling of materials to producers of raw materials. The packaging material production sector is the most concentrated of the supply chains. The idea is that it would be easier for a few firms, with a tradition of cooperation, to find an agreement. The responsibility for the achievement of the EU directive on packaging waste targets is assigned to a new private compulsory consortium, CONAI, which, according to the shared responsibility principle, joins packaging producers, fillers and distributors (retailers).
The past history of Italian environmental policy warns us that the adherence of the legislative framework to EU parameters is not enough, and that close attention needs be devoted to the implementation phase.[4]

3.2.1. Origin, composition, categories and type of collected waste at national level

In 2022, the national production of municipal waste stands at about 29,1 million tonnes, down by 1,8% (544 thousand tonnes) compared to 2021. With reference to a longer time frame, production remained above 32 million tonnes between 2009 and 2010. After the sharp decline in the biennium 2011-2012 (concurrent with the contraction in the values of gross domestic product and household

consumption), production was below 30 million tonnes until 2015. Then, with the exception of 2017, the values increased again to above 30,1 million tonnes and then began to decrease, in a small way, in 2019 and more significantly, due to the pandemic, in 2020. In 2021, there is a reversal in trend, in line with the post-pandemic economic recovery, with production still below 30 million tonnes. Finally, in 2022, the production data indicates a contraction again. In 2022, the economic recovery recorded from the previous year continues, still recovering the sharp decline related to the health emergency that marked the socio-economic context of 2020. Italy starts recycling just over 30% of the urban waste treated, and composting and anaerobic digestion 26%, with a total share of waste started recycling operations of about 57%.[5]

The upward trend in waste production observed over the years can be related to several factors, even in combination with each other, including the introduction of new regulations that have, for example, changed the definition or accounting methods of urban waste collection and management, or health or socio-economic reasons, such as the pandemic of 2020 and the international crisis of 2022, which have affected consumption and, consequently, waste production. In general terms, the 2022 figure seems to reflect, in any case, the downward trend observed in the long term, with waste production resuming, from 2012, between 29 and 30 million tonnes. In relation to effects due to regulatory changes, the production data may be affected by the introduction, in Legislative Decree no. 152/2006, of Article 198, paragraph 2-bis, with Legislative Decree no. 116/2020. This paragraph provides for the possibility, for non-domestic utilities, to dispose of their municipal waste outside the public collection service, if they are able to demonstrate that they dispose of the said waste to persons who guarantee its recovery. The waste falling into such cases may therefore not be fully accounted for within the separate production and collection data of municipal waste and therefore fall within the special waste management pool. [5]

With regard to the individual merceological fractions, the collection of **organic waste** goes from about 7,4 million tonnes to just over 7,2 million tonnes, compared with a total amount of waste collected in a differentiated way that has remained almost unchanged in the last two years. The organic fraction consists of all the quantities of biodegradable waste produced by kitchens and canteens (wet fraction), by the maintenance of gardens and parks (green fraction), by the collection at markets and by biodegradable waste destined for the practice of household composting (the latter, essentially made up of wet fraction, is not assigned to the collection system). Overall, after the increase recorded in 2021, related to the reopening of commercial, industrial and craft activities and the resumption of travel and tourist flows, there is a decrease for this commodity fraction of 1,8%, corresponding to 136 thousand tons less. The decrease, also confirmed by a similar trend in management data at biological treatment plants, is linked to a reduction in the collection of biodegradable waste from the maintenance of gardens and parks, which makes a contraction of 139 thousand tons (-7,2%). With reference to the entire period 2011-2022, there is an average annual

increase in the organic fraction harvest of 4,5%, with a maximum value of 9,7% between 2013 and 2014, while the only negative values associated with the decline in the harvest are recorded for 2020 and 2022. 70,5% consists of the wet fraction from kitchens and canteens (5,1 million tons), 24,7% from biodegradable waste from the maintenance of gardens and parks (almost 1,8 million tons), 4,2% from domestic composting (almost 301 thousand tons) and 0,7% (about 48 thousand tons) from market waste. In the northern regions is intercepted almost 3,6 million tons of organic fraction (-3% compared to 2021), in the Centre about 1,4 million tons (-1,7%) and in the South, analogous to 2021, 2,2 million tons. In terms of per capita collection values are 131 kilograms per inhabitant in the North, 124 kilograms in the Centre and 112 kilograms in the South, with a national average of 123 kilograms.[5]

The differentiated collection of the **cellulosic fraction** exceeds 3,6 million tonnes, an increase of 1% compared to 2021. The amount harvested in the North is more than 1,8 million tons, the Central to 859 thousand tons and the South to 942 thousand tons. The northern and southern regions show percentage increases of 1,4% and 1% respectively, while the central regions show unchanged quantities. On the basis of the available data, the share of **packaging waste** is estimated to be on average 30% of the total cellulosic waste collected annually. The national per capita is 62 kilograms per capita per year, with values equal to 68 kilograms in the North, 73 kilograms in the Centre and 48 kilograms in the South. For this fraction, it is therefore confirmed that a per capita collection in central Italy is higher than that in the North. The cellulosic and organic fraction together accounted for 57,6% of the total differentiated harvest in 2022, with a slight decrease in incidence compared to 58% in the previous year. Separated glass collection exceeded 2. 3 million tonnes, up from 2021 (+3, 4%). In the North are collected almost 1,3 million tons, with a per capita value of 46 kilograms per inhabitant per year, in the Centre 438 thousand tons (over 37 kilograms per inhabitant) and in the South 635 thousand tons (32 kilograms per inhabitant). Between 2021 and 2022, there was a percentage growth in the Central and South, of 6,2% and 5,2% respectively, while in the North the percentage increase was more modest (+1,7%). For glass, it is estimated that packaging represents the predominant type of waste (92% of the total collection of this fraction). Plastic continues to show an increase in the quantities collected, although to a more moderate extent compared to the previous biennium, with a total quantity intercepted of 1,7 million tonnes (+1,5% compared to 2021). In particular, the regions of the South (484 thousand tonnes) show the highest percentage growth (+2,9%), followed by those of the Central (326 thousand tonnes, +2,7%) and those of the North (892 thousand tonnes, +0,4%). With a national per capita value of 29 kilograms per capita, the North collects 33 kilograms per capita, the Centre 28 kilograms and the South 24 kilograms. Based on available data, it is estimated that 95% of plastic waste collected in a differentiated manner consists of packaging. [5]

After the growth recorded in the previous two years, the **wood waste** shows a slight decline, however, at just over 1 million tonnes (-0,2%). Compared to 2021, the South and the Centre recorded an increase in intercepted quantities of 7,4% and 2,9% respectively, while the North recorded a decrease (-2%). Overall, it is estimated that about 16% is represented by packaging waste. At macro-area level, harvest values are 730 thousand tonnes for the North, 149 thousand tonnes for the Centre and 124 thousand tonnes for the South. In terms of per capita, 27 kilograms are collected per inhabitant in the northern regions, 13 kilograms per inhabitant in the central regions, while in the south the per capita collection is 6 kilograms, compared with a national value of 17 kilograms. [5]

The collection of **metal waste** is equal to 356,000 tons, down 4,2% compared to 2021, corresponding to a national per capita collection of 6 kilograms per capita. The northern regions show the most significant contraction (-6,4%), followed by the central regions (-2,7%), while the southern regions show a slight increase in intercepted quantities (+1,3%). For this fraction it is estimated that about 46% of the total harvest is represented by packaging. The data for macro geographical area show harvest values of 218 thousand tonnes for the North (8 kilograms per inhabitant per year), 64 thousand tonnes for the Centre (5,5 kilograms per inhabitant) and 75 thousand tonnes for the South (3,8 kilograms per inhabitant). Some of the fractions analysed above are, sometimes or largely, intercepted through the so-called multimaterial collection, whose modes of implementation differ from one territorial context to another. According to ISPRA's calculations, the total amount of urban waste intercepted through multi-material collections of various types is almost 2,1 million tonnes. These quantities are divided, net of waste, into the different merceological fractions and contribute to the total collection data. [5]

The amount of **waste from electrical and electronic equipment** collected in a differentiated way stands at 272 thousand tons, showing a decrease of 6,3% compared to 2021. The harvest falls in the northern and southern regions, where they are intercepted, respectively, 143 thousand tons (- 10,4%) and 66 thousand tons (-5,9%), with per capita values of 5,2 and 3,3 kilograms per inhabitant per year. In the Central regions alone, the harvest increased to 63 thousand tons (5,4 kilograms per inhabitant). With the exception of the Valle d'Aosta, whose production is increasing slightly, all Italian regions reported a decrease in waste produced. In particular, among the northern regions, the largest contractions are observed for Trentino-South Tyrol (-3,7%), Lombardy (-3,3%) and Veneto (-2,5%); in the centre, for Marche (-2,7%) and Tuscany (-2,1%) and in the south for Molise (-3,2%), Calabria and Sardinia (-2,5%) and Apulia (-1,9%). Regarding per capita values, the highest production, similar to previous years, is found in Emilia-Romagna, with 633 kilograms per inhabitant per year, although this is down by 7 kilograms compared to 2021. They are followed by the Aosta Valley with 616 kilograms, an increase of 14 kilograms compared to 2021, and Tuscany which, with a decrease of almost 9 kilograms, stands at 590 kilograms. [5]

The regions with a per capita urban waste rate higher than the national average (494 kilograms per inhabitant) are a total of 9: to the three mentioned above are added: Liguria, Umbria, Marche, Lazio, Piedmont and Friuli-Venezia Giulia. The lowest per capita production values are recorded for Basilicata (357 kilograms per capita), Molise (375 kilograms) and Calabria (401 kilograms). It should be noted that the per capita production figure is calculated in relation to the number of inhabitants residing in the reference territory and therefore does not take into account the so-called fluctuating population (linked, for example, to tourist flows), which can have a substantial impact on the absolute production figure of urban waste and therefore raise the per capita production value. The production of urban waste and, consequently, the value per capita is also influenced by the possible presence of so-called "similar" waste. Until the adoption of Legislative Decree no. 116/2020, these types of waste were part of the so-called assimilation, which led to the calculation, in the total amount of urban waste produced annually, also some quantities of waste resulting from craft, commercial and service activities that are part of the urban fabric. As a result of the aforementioned Legislative Decree No 116/2020 (which transposed Directive 2018/851/EU), the definition of municipal waste referred to in Article 183(1)(b) of Legislative Decree No 152/2006 has been amended to include, without quantitative limits, also undifferentiated and differentiated waste from other sources which are similar in nature and composition to the household waste listed in Annex L-quater produced from the activities listed in Annex L-quinquies to Part IV of Legislative Decree No 152/2006. These new provisions, which have resulted in the elimination of the quantitative limits provided for in the previous legislation, may result in a considerable variation in the types and quantities of waste produced by economic activities which may in all respects fall within urban waste. In addition, the total production figure, as already indicated, may be affected by the possibility, by non-domestic utilities, of using a collection service other than the public one, which is possible if such utilities are able to attest that their rejection is initiated at a recovery facility. Waste falling into such cases may therefore not be fully accounted for within the separate production and collection data of municipal waste.[5]

3.3. Waste management system in Apulia region

As known, each EU Member Country has to develop its local legislation by adopting the communitarian one but has the possibility to introduce changes specific to local situation, provided they are not in contrast with general requirements of EU normative. With specific reference to MSW, Italian national legislation fundamentally gives the Regions "planning, authorisation and control" responsibilities, and the Municipalities "service operations" duties. In addition, decisions and/or determinations on specific aspects by other institutional bodies are necessary to obtain all the necessary permits or authorisations. This fragmentation of competences has brought in some cases to administrative conflict between different public Institutions, so in some Regions an institutional body has been established which takes upon himself all responsibilities, by-passing and replacing

those of most institutional bodies. This is the case of Region Apulia (Puglia), located in south-east of Italy, where the territorial Apulia Region Agency for Waste Management (in the following, AGER) was established. AGER was instituted with the Regional Law nr. 20/2016, with the aim to put into action the Regional Plan for Waste Management, in turn based on the national and European Legislation. AGER is mainly responsible for the assignment of the construction and management of the plants as well as for the assignment of the sweeping, collection and transport of municipal solid waste. AGER, which is also guarantor of the quality of the services offered to the user and of the protection of the consumer itself, also carries out regulation and control of tariff aspects affecting the waste sector, i. e. in the validation of the costs (waste tax) that the user is required to pay for the use of the waste sweeping, collection and transport service. Some of the procedures relating to Ager's competences are actually still being implemented. Currently, it is the individual AROs or even the individual Municipalities that entrust the service of sweeping, collection and transport of waste following the legal procedures of the local authorities.

The Municipality of Casarano is main branch of the ARO called “9/LE”, to which 6 other neighbouring municipalities belong: Municipalities of Matino, Parabita, Ruffano, Specchia, Montesano Salentino and Miggiano. The waste management system in the ARO 9/Le provides for the differentiated collection of 6 waste fractions: food waste, plastic, paper, metals, glass and the undifferentiated residual waste. For these waste categories, the collection takes place daily using the door-to-door method using private containers (every family/user has his own set of containers for the separated waste). Other waste categories such as expired medicines, oils, batteries, clothing, or waste from electronic equipment are collected on call or by the road collection method, using public containers. In each of the municipalities there is also a "Municipal Collection Centre" (CCR - Municipal Collection Centre) where citizens can bring the most cumbersome waste such as wood, furniture, etc. Even the waste resulting from the sweeping activities is collected separately: thanks to some new plants on the territory, it is possible to recover the portion of inert material sucked from the road asphalt from everything else and reuse it in the construction field!

Thanks to the efficient design of the service, but also thanks to the awareness-raising and control activities carried out both towards the service provider and towards the users themselves, in the ARO 9/LE it was possible to achieve differentiated collection rates well above the Community targets but also the regional and national average.

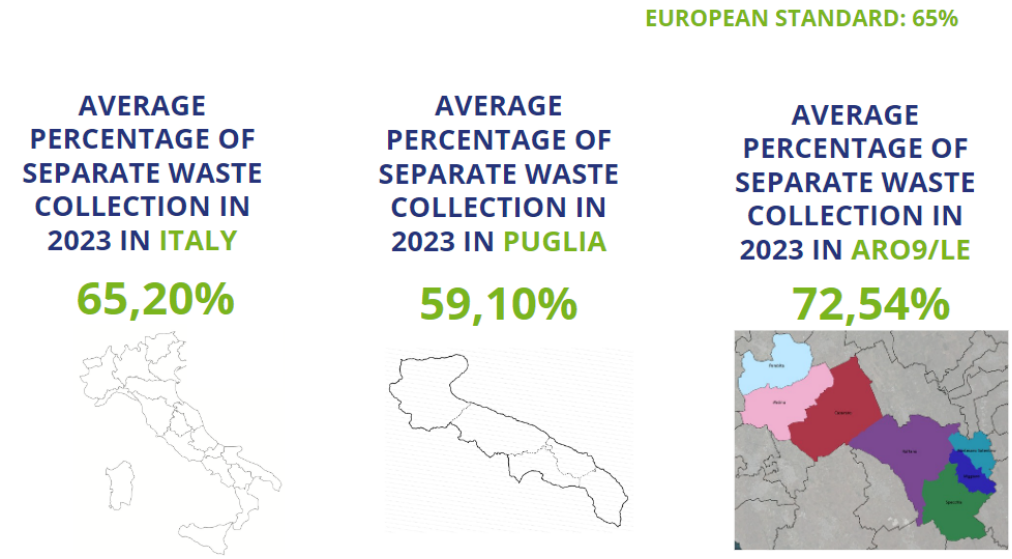

Figure 1 – Separated collection rates in Italy, Apulia Region (Puglia) and in the ARO9/LE leaded by the Municipality of Casarano and comparison to the European standard.

Figure 2 – ARO9/LE separate collection rate in 2023.

ARO/9 LECCE	Miggiano	Montesano	Specchia	Matino	Parabita	Ruffano	Casarano	Total (Kg) - ARO/9 LECCE
	Quantities	Quantities	Quantities	Quantities	Quantities	Quantities	Quantities	Quantities
MSW TOTAL (KG)	1 291 183,00	1 021 631,00	1 817 679,00	4 340 045,00	3 762 321,00	3 534 343,00	8 374 017,00	24 141 219,00
SEPARATE COLLECTION (KG)	915 383,00	750 651,00	1 400 499,00	3 028 145,00	2 492 821,00	2 385 463,00	5 251 477,00	16 224 439,00
UNINDIFFERENCIATED RESIDUAL WASTE	375 800,00	270 980,00	417 180,00	1 311 900,00	1 269 500,00	1 148 880,00	3 122 540,00	7 916 780,00
SEPARATED WASTE PERCENTAGE	70,89%	73,48%	77,05%	69,77%	66,26%	67,49%	62,71%	67,21%
POPULATION	41 112,00	31 752,00	56 664,00	135 348,00	106 272,00	115 500,00	237 624,00	724 272,00
PRO CAPITA PRODUCTION (KG)	31,41	32,18	32,08	32,07	35,40	30,60	35,24	49,61

Figure 3 – Quantitative details about separated collection rates in the 7 municipalities of the ARO9/LE

3.3.1. Waste management facilities, devices and collection systems in the Apulia region

The Regional Solid Waste Management Plan require the:

- development of "source separation" schemes with the target for 2012 of 65% of MSW separately collected to be subsequently handled for material recoveries;
- operation of Centres for the "qualification" of specific recyclable fractions deriving from above "source separation or separate collection";
- "biostabilisation" of urban waste remaining from separate collection prior to the separation of a treated wet fraction to be landfilled, or used for environmental purposes, and a dry fraction to be used for the production of refuse derived fuel. [4]

The Region is served by treatment plant for:

- "qualification" of specific recyclable fractions deriving from "source separation or separate collection" of urban waste;
- "pre-treatment" of residual urban waste deriving from conventional "not-separate collection"; "biostabilisation" of above pretreated waste;
- "mechanical separation" of biostabilised material into a "wet fraction" and a "dry fraction", being the former landfilled or submitted to further curing for the production of materials to be possibly reused for environmental purposes, the latter (FSC) processed for conversion into RDF;
- "landfilling" of process rejects or of untreated waste during shutdown periods for maintenance and/or emergency.
- "incineration" of the FSC fraction for energy recovery. [5]

3.3.2. Origin, composition, categories and type of collected waste at regional level

According to ISPRA, the Italian Institute for the Environmental Protection and Research, in 2022, in Apulia, the production of municipal waste decreased by 35.247 tons compared to the previous year; at the same time, the amount of differentiated waste increased by 5.103 tons and the amount of undifferentiated waste decreased by 39.547 tons. [5]

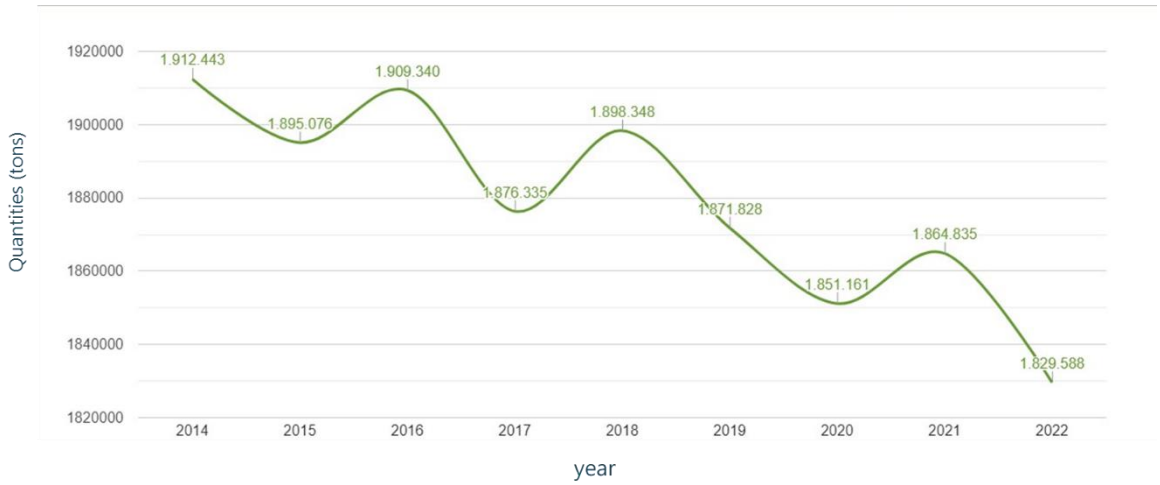

Figure 4 – Graph of total waste production in Apulia Region from 2014 to 2022

The following are some data on the Apulia Region, detailed by province, concerning the production of waste, the percentage of differentiated collection and the detail of the composition of the latter.[5]

Production and separated waste by Province in Apulia Region - 2022 (ISPRA)						
Provinces	**Population (nr. inhabitants)**	**Separated Waste tons**	**Undifferentiated Waste tons**	**Separated Waste Rate (%)**	**Pro capita Separated Waste (kg/inhab.*year)**	**Pro capita Undifferentiated Waste (kg/inhab.*year)**
Foggia	594.007	116.827,369	265.427,019	44,01%	196,68	446,84
Bari	1.223.102	341.214,607	555.950,547	61,37%	278,97	454,54
Taranto	555.999	148.512,346	272.643,256	54,47%	267,11	490,37
Brindisi	378.898	114.726,364	189.334,574	60,59%	302,79	499,7
Lecce	770.078	239.466,682	375.068,152	63,85%	310,96	487,05
Barletta-Andria-Trani	378.768	110.669,163	171.164,813	64,66%	292,18	451,9

Table 1 - Production and separated waste by Province in Apulia Region - 2022 (ISPRA)

Detail of the composition of the separated waste by categories in Apulia Region Provinces - 2022 (ISPRA)

Provinces	Food Waste (tons)	Paper (tons)	Plastic (tons)	Metals (tons)	Glass (tons)	Wood (tons)	Furnitures, etc. (tons)	Electrical Equipment (tons)	Clothing (tons)	Waste from construction and demolitions (tons)	Street Sweeping to recover (tons)	Others (separated waste) (tons)
Foggia	44.175,440	16.401,745	9.397,897	1.246,677	11.904,172	3.246,030	7.466,120	987,89	1.442,100	968,985	18.095,610	1.351,580
Bari	130.382,920	73.604,938	31.730,313	3.247,422	38.379,003	13.794,530	23.975,250	4.125,520	3.937,390	6.165,775	4.953,500	6.250,255
Taranto	58.469,565	24.182,728	12.837,013	1.459,514	16.273,403	3.912,630	14.509,940	1.666,480	1.071,170	3.125,650	7.338,540	3.494,503
Brindisi	50.768,830	20.206,195	13.476,759	1.296,934	8.453,386	4.216,180	7.026,540	1.437,790	1.246,620	3.278,250	387,16	2.721,291
Lecce	99.187,740	46.857,472	24.323,699	3.834,412	28.147,525	7.343,890	9.116,060	4.385,680	1.320,256	6.140,955	5.109,070	3.191,222
Barletta-Andria-Trani	49.491,320	18.061,000	9.077,943	679,728	11.220,239	6.183,230	7.045,080	935,87	1.611,460	2.894,240	1.774,600	1.568,750

Table 2 – Detail of the composition of the separated waste by categories in Apulia Region Provinces - 2022 (ISPRA)

Data are provided by ISPRA and related to 2022 waste production, originated both from domestic users (families) and non-domestic users (restaurants, supermarkets, cinemas, shops, museums, hotels, etc.).[5]

3.3.3. Illegal waste disposal sites or illegal landfills

Waste collection and disposal have met unprecedented challenges in Italy, especially in the southern area. Illegal dumping is widespread, and waste trafficking is a key activity of organised crime. In the Italian legal system, the criminal protection of the environment is almost entirely limited to a series of misdemeanors, which fall outside the Penal Code. As far as the illegal trafficking of waste is concerned, it was firstly introduced in Article 259 of the Environmental Code (D.Lgs. 152/2006) on the "Illegal shipment of waste", which punishes *"whoever carries out a shipment of waste constituting illicit traffic according to Article 26 of the Regulation (European Economic Community) 1 February 1993, no. 259 or carries out a shipment of waste listed in the Annex II of the above-mentioned Regulation in violation of article 1, par. 3, a), b), c) and d), of the Regulation itself shall be punished with a fine from € 1550 to € 26000 and with arrest of up to two years. The penalty is increased in case of shipment of dangerous waste".* Amongst the few cases that do include the felony, there is the case of organized activities for the illegal trafficking of waste. Firstly introduced in 2001 when art. 22 of the Law 93/2001 implemented the art. 53-bis of the d.lgs. 22/1997 (the so-called decreto Ronchi), in 2006 organized activities for the illegal trafficking of waste became a definitive part of the Environmental Code. In particular, art. 260 of the Environmental Code punishes by imprisonment from one to six years *any person who, in order to gain unfair profit through operations and preparation of means and organized continuing activities, sells, receives, transports, exports, imports or otherwise improperly handles large quantities of waste. If the*

waste is highly radioactive, the sanction is harsher, punishing violators with imprisonment from three to eight years. It should be noted that before the approval of this law, nobody had been seriously punished for the crime of illegal trafficking of waste. Since then, criminal enforcement has made an important step forward and has enabled disbanding some of the most active national and transnational criminal organizations.[6]

Illegal trafficking of waste arises when higher profits are expected compared to legal options of recycling or disposal, combined with institutional or enforcement failure. From an economic point of view, this environmental crime is mainly motivated by cost-saving decisions driven by the attempt: i) to reduce the relatively high costs of treatment and disposal of waste and ii) to take advantage of regional differences in environmental taxation (i.e., landfill and incineration taxes).[6]

Another economic factor that can induce the illegal shipment of waste is the potential economic returns of waste as an export. In fact, several waste streams are shipped to countries outside the EU as 'second-hand goods' (i.e., primarily waste electrical and electronic equipment, end-of-life vehicles, but also car tires and other types of waste). The wide difference in prices between used and new products in these countries is one of the most important factors encouraging illegal shipments. The illegal trafficking of waste may also be driven by other factors that have an institutional nature and are concerned with regulatory or enforcement failures. Firstly, in Italy, waste treatment and disposal plants are insufficient and are somewhat unevenly distributed at regional level.[6]

Illegal disposal of toxic waste, mostly from industries and hospitals, was concentrated in five regions in southern Italy (Campania, Basilicata, Apulia, Calabria and Sicily) due to the local prominence of organised crime. As emerged during investigations, a collusion existed between politicians, industrial entrepreneurs and organised crime that rewarded each actor: politicians received votes and resources from organised crime for their authorisation to dispose of toxic waste illegally, while northern entrepreneurs slashed their production costs. In Campania, the Camorra disposes of toxic waste in the countryside, generating a myriad of micro-landfills in a strip of land north of Naples nicknamed the Land of Fires. It also digs the waste underground in farmland and utilises building foundations in the informal construction sector as readily available hiding places. In Sicily, toxic waste was disposed primarily in two types of sites: in abandoned mines, some of which were in public hands, and in caves, which were excavated to extract materials for construction on the black market and then were filled back with garbage. In 2008, the European Union (EU) Commissioner to the

Environment warned that waste disposal was a problem far from limited to Campania: the Court of Justice charged Italy for the existence of 4,866 illegal or unmonitored landfills in 15 regions: Abruzzo (361), Basilicata (152), Calabria (447), Campania (225), Emilia Romagna (380), Lazio (426), Liguria (305), Lombardy (541), Marche (244), Molise (84), Piedmont (335), Apulia (599), Toscana (436), Umbria (157), Veneto (174) (Ansa News Agency 2007). On March 21st, 2019 the Court of Justice of the European Union has issued a sentence for Italy, charging the Italian Government for the existence of 44 abusive landfills located in Abruzzo, Basilicata, Campania, Friuli-Venezia Giulia and Apulia. In the April 2022 infringement package, the European Commission found that Italy, despite having regularly closed 32 landfill sites, has not yet been able to ensure the definitive closure and/or remediation of the remaining 12.[7]

The presence of unauthorised or non-compliant landfills creates serious risks of soil, water and air pollution, with potential harm to citizens' health. The illegal landfills and uncontrolled waste combustion affect negatively the groundwater quality: the soluble pollutants leach freely into the ground and accumulate in the aquifer. The surrounding environment can be harmed by eutrophication and acidification. Moreover, some pollutants are toxic to living beings and can be accumulated into the food chain. On a larger scale, pollutants released by illegal landfilling and burning increase the global warming and may lead to photochemical smog formation. It appears clear that the pollution generated by these illicit actions affects the air, the bodies of water, the groundwater the soil the flora and the fauna. Landfill pollutants have also harmful effects on human beings raising the risk of illness such as: acute intoxication, cancer, infectious disease, respiratory and cardiovascular problems. The local communities are also affected by discomfort and change in habits, economical issues and aesthetic degradation of the landscape. The tangible environmental damage due to the illegal landfill raises awareness among the population. This awareness takes the form of social mobilizations and collective actions.[7]

The implementation of an effective system of control in Italy it's necessary. This is sometimes quite difficult for several reasons. First, the waste management cycle is characterized by many steps whose traceability is ensured by self-certifications (the so-called formulary FIR), and so it is easily eluded and counterfeited. Second, since monitoring and inspection activities are officially delegated to some regional environmental agencies (ARPA) without a sufficient financial budget and often lacking the necessary technical equipment, the challenge is therefore entirely left to the police force that, however, may investigate only when in possession of a notitia criminis. In addition, multiple police

forces enact law enforcement at, both, national (Arma dei Carabinieri, Polizia di Stato, Guardia di Finanza) and local levels (Polizia Provinciale and Polizia Municipale), which quite often do not communicate and cooperate among each other.[6]

4. Measures and initiatives for the development and improvement of the waste management system at regional level

4.1.1. Waste management improvements in the Italian framework

In the Italian framework in waste management is characterised by some technological, structural an economic barriers. There are two types of economic barriers: barriers to market entry by new firms and the structure of small and family Italian firms which, having small access to capital, don't manage to invest. As regards technological barriers, the Italian innovation capacity is less than that of the other European countries. Italy imports a lot of energy resources from abroad, yet, and green procedures seems not to be completely adopted by the firms. In this framework the regulatory and policy drivers may be important for the adoption of waste related innovation. Different policy measures with the aim to promote new funding schemes for waste and circular economy were adopted during the last years. Incentives and subsidies have been introduced to improve energy efficiency in buildings and support the eco-innovation and organizational innovations (ISO and Ecolabel among others). Law No. 221 of 2015, December 28th deserves a special mention. Article 21 tried to increase the demand for green products, sustaining competitiveness. Through the Article 23, the Ministry of Economic development furnished financial incentives to the business activities that produce goods using recycled materials and dismantled resources. Article 32 introduced measures to increase separated collection and recycling, setting a top-down increase of 20% in the local landfill tax for those municipalities that do not respect the national targets for the separated collection of waste while articles 36–7 announced a decreasing scheme of waste tariffs for households and activities. As regards the small islands, article 33 gave the possibility of charging a maximum 2.5 € fee to tourist – the underlying idea is that tourist flow increases waste and makes necessary environmental recovery projects. [8]

4.1.2. Waste management improvements in Apulia region

As already mentioned before, the Italian framework is also characterized by a solid fragmentation. This situation makes regional and provincial policies decisive for achieving concrete results.

In the first half of the 1990s, there was a major crisis related to municipal solid waste disposal in the Apulia region. To cope with this emergency, the Regional Government approved the plan for

municipal solid waste (MSW) management that was implemented by regional law nos. 17/1993 and 13/1996. The plan aimed to significantly improve the sorted waste collection rate to 65% and reduce the quantity of produced waste. A Deputy Commissioner was appointed to manage the environmental crisis by reorganizing municipal waste disposal services. In 2007, after the declaration of the end of the crisis, the rate of sorted waste was only approximately 9%, while the rate of landfilled waste was slightly less than 80% ([9] ISPRA, 2008). The achievement of an unsatisfactory rate of sorted waste collection, together with the failure to meet the planned targets, on the one hand, and the changes in waste management regulations that occurred over the years, on the other hand, led the regional government to start on the reorganization of the management of the municipal waste cycle. Such reorganization included the adoption of a new governance model and the development of a new regional waste cycle management plan that was approved in 2012, giving greater attention to the need for the facilities necessary for waste material treatment. Regional law nos. 24/2012 and 42/2012 initiated the reforming process of the governance of the municipal waste cycle, which provided for the management of treatment, recovery, recycling, and disposal services in some preliminarily delimited optimal territorial areas (abbreviated as ATOs, at this point there were 6 of them, fundamentally coinciding with the 6 provinces), including several municipalities, and the provision of sweeping, collection, and transportation services in a greater number of smaller sized optimal collection territorial areas (AROs in short). Accordingly, the upstream phase of the sweeping, collection and transportation of waste and the downstream phase of waste treatment and disposal were separated because of their different economic characteristics. The managing body of each ATO was given the responsibility to plan the MSW service and set targets and goals that should be achieved to provide it according to criteria of effectiveness, efficiency, and transparency. Under the principle of self-sufficiency and proximity set by Legislative Decree 205/2010, the operations for waste disposal and recovery of unsorted municipal waste must be implemented using an integrated network of facilities allowing the single ATO to achieve self-sufficiency, avoiding or limiting the movement of waste streams from the ATO where they have been produced to any other ATO to be treated. At least one facility equipped with complex technology for the treatment of waste, including a service landfill, had to be located inside the ATO area. [10]

A recent study conducted by Corrado lo Storto[10] on the Apulia Region MSW system (Cleaner Waste Systems, 2024) has shown in data the limitations of a multilevel and heterogeneous governance for the management of waste. To exploit economies of scale, reduce the administrative burden, and obtain efficiency gains, starting in 2012, the number of regional ATOs was reduced to 6, one for every province (Law nr. 14/2011).

Since 2016 to nowadays, the principle of self-sufficiency is operated within the whole Region (as if there's one only ATO). This switch to a homogeneous and central policy of management made it easier to exploit the economies of scale in the operation of the waste treatment facilities, with consequent advantages in costs. Moreover, organizing the collection of waste within optimal collection areas (AROs) much smaller than the ATOs has provided citizens with a more effective service, even though the delay in their formal establishment had a negative impact on industry efficiency. Thanks to initiatives of private companies, in a few years the region became self-sufficient regarding the treatment of the food waste, whose separate collection is essential for achieving the community target of 65% separate waste collection. For the treatment of the organic fraction used to produce compost, though, the price paid to the facilities owners is generally higher than the average in the rest of Italy as a result of the monopolistic power locally enjoyed by the company, although this economic activity was carried out in a free market regime.

Often what makes a decisive change in performances in the single AROs, but also in the single municipalities, is the management operated by the local institutions which can lead an improvement in the users sensibility towards the whole recycling process. Good performance strengthens and expands when the joint action of citizens and local governments is considered, i.e., the waste management process is optimised when each actor plays his/her part. In order to set up and run separate collection properly, after allocating the necessary resources, the administration requires that its citizens make a minimal effort to separate their refuse. Separate waste operations cost the individual citizen time and effort and can also be unpleasant (think of the smell of organic waste, the lack of time for recycling, the difficulty of moving the recycling bin to the kerbside and the unusual locations of composting sites), whereas the economic and ecological benefits accrue to the entire community. Intrinsic motivation would occur when individuals believe recycling to be a personal undertaking (impure altruism) or intention to carry out specific behaviour to maximise social welfare (pure altruism). Recyclers feel a sense of intrinsic personal satisfaction in doing the right thing and in nourishing the approval of the neighbourhood and friends thanks to their virtuous behavioural conduct, or both. The level of citizen efforts required to recycle can depend on the type of programme operated by local institutions. [8]

Furthermore, the economics literature show that desirable behaviour can be promoted by making monetary reward. By contrast, nonmonetary interventions (e.g. public information and awareness campaigns) can preserve intrinsic motivation or increase it (crowding-in effect). The most effective and cheapest way to reduce waste and to improve separate collection is to encourage households to take into account the benefits that separate collection confers upon the whole of society by means of public information and awareness campaigns. People are motivated to recycle by pressure that they receive from the surrounding environment, family and friends. The more people see recycling as effective, the more likely they are to participate. If people perceive that their neighbours are recycling, they are more likely to do so as well i.e. a belief could be defined as the subjective probability that the behaviour will be stimulated. [8]

5. Conclusion

The report asseses the primary analysis of waste management services in Italy, with a focus on the Apulia Region partner. In detail, it provides a brief report on quantity and composition of collected waste, waste collection schemes and existing waste prevention policies.
From a historical and geographical point of view, Italy can be divided into three macro-areas: the North, the Centre and the South. In general, the macro-area is an aggregate of regions, each with decision-making autonomy in the planning of the waste management process. In fact, Italy has four administrative levels: national, regional, provincial and municipal. Administrative levels in charge for waste management are the national, regional and municipal one. The Ministry of Environment outlines the overall waste management strategy by establishing the legislative framework, setting targets at national level and drawing up the National Waste Management Plan. Then, with specific reference to MSW, Italian national legislation fundamentally gives the Regions "planning, authorisation and control" responsibilities, and the Municipalities "service operations" duties. Macro-areas are characterized by deep socio-economic disparities, which shows effects also on the waste management performances, in terms of cost-efficiency but also in terms of achievement of separate waste collection targets.

In Italy, it's the legislative decree 152 of April 3, 2006 (and further updates), Section IV, which addresses the question of waste management. It outlines some priorities for the implementation of integrated solid waste management program (prevention of waste production and recovery of waste) and also set targets for separate waste collection according to the communitarian targets (currently, 65% of separate collection and 50% of recycling). To meet those targets, a system of incentives and sanctions was adopted.
Even if separate collection rates of municipal waste increased in all the Italian regions and Italy seems to be on the right path to reach the EU targets it continues to suffer from huge cross-regional

differences. This is essentially due to the high fragmentated management scheme typically adopted in Italy, to which the one for managing the MSW is no exception.
Spatial pattern analysis highlights a clear degree of performance between regions, and Italy is a paradigmatic case study for stressing this issue. Italy may be categorized under two waste management groups, according to its regional strategy of coping with environmental problems. The first group comprises Northern regions with high levels of waste management and relatively high levels of separate collection. The second group includes Southern regions with low recovery rates, poor waste management infrastructures and relatively low dependence on separate collection.

Apulia Region, part of the Southern Italy regions has improved a lot in the past few years.
According to ISPRA, the Italian Institute for the Environmental Protection and Research, in 2022, in Apulia, the production of municipal waste decreased by 35.247 tons compared to the previous year; at the same time, the amount of differentiated waste increased by 5.103,86 tons and the amount of undifferentiated waste decreased by 39.547 tons.
Apulia Region comes from a framework of major crises related to municipal solid waste disposal in the first half of the 1990s. To cope with this emergency, strong local policies were adopted and then adapted to the results and the changing framework. Currently, the management scheme which brought greater results it's a more homogeneous and central approach to the management that makes the whole region responsible for the downstream phase of waste treatment and disposal and the AROs (medium dimension areas sized for the "optimal collection rate") responsible for the upstream phase of the sweeping, collection and transportation of waste.
This is mostly the management scheme also adopted in the rest of Italy, with some differences in the local approach to the management. In 2022, the national production of municipal waste stands at about 29,1 million tonnes, down by 1,8% (544 thousand tonnes) compared to 2021. More details about the composition analysis of the collected waste are provided in chapters 3.1.2 (national level) and 3.2.2 (regional level, Apulia Region).

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7. List of Figures and Tables

Interreg

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AWASTER

INTERREG ITALY-CROATIA
PROGRAMME 2021 – 2027

AWASTER – Adopting WASTE as Resource

D.1.1.2 Regional waste management report – Dubrovnik-Neretva County

Version: Final

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AWASTER

INTERREG ITALY-CROATIA PROGRAMME 2021 – 2027
Standard Call for Proposals
Programme priority: Green and resilient shared environment
Specific objective: 2.2: Enhancing protection and preservation of nature, biodiversity and green infrastructure, including in urban areas, and reducing all forms of pollution
Project: AWASTER – Adopting WASTE as Resource

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Project website: https://www.italy-croatia.eu/web/awaster

Table of contents

1. Introduction

The purpose of Regional waste management report is analysing and addressing environmental issues in the context of waste production and waste management in Dubrovnik-Neretva County. The impact of increased waste, particularly plastic waste, has significant negative ecological and socioeconomic implications. Report aims to provide a comprehensive analysis of the current state of municipal waste management in Dubrovnik-Neretva County, focusing on the trends in waste generation as a base for minimizing waste generation. By achieving these objectives, Report will provide insights and recommendations that will help reduce the environmental impact of waste production, support sustainable development, and improve the quality of life for Dubrovnik-Neretva County and beyond.

Main topics covered in the Report are detailed socio-economic, topography and demographic description of Dubrovnik-Neretva County, waste management system in the Republic of Croatia, analysis of the composition, categories and type of collected waste at national and regional level, description of the existing waste management infrastructure, including facilities, devices, and collection systems in Dubrovnik-Neretva County, detailed analysis of the types and sources of collected waste collected within the region, illegal waste disposal sites or illegal landfills, and policies, technologies, and practices for improving waste management system in Dubrovnik-Neretva County.

Historically, the increase in waste production can be attributed to factors such as population growth, urbanization, and changes in consumption patterns. Despite efforts to enhance waste management infrastructure and policies, challenges persist. Prompted by the need to address these challenges, this report aims to provide a comprehensive analysis of municipal waste management in Dubrovnik-Neretva County. It seeks to offer data-driven insights and actionable recommendations that will aid in mitigating negative ecological impacts, reducing pollution and associated health risks, and reducing waste generation.

2. Dubrovnik-Neretva County

Socioeconomic description

Dubrovnik-Neretva County, located in the southernmost part of Croatia, is renowned for its picturesque coastline along the Adriatic Sea and the historical city of Dubrovnik. This region includes the fertile Neretva River delta, numerous islands such as Korčula, Mljet, and the Elaphiti Islands, and the Pelješac Peninsula. The county covers an area of 1,782 square kilometers, featuring a diverse landscape that includes the Adriatic coastline, the Neretva River delta, and numerous islands.

The economy of Dubrovnik-Neretva County is primarily driven by tourism, agriculture, and maritime activities.

Tourism is the cornerstone of the county's economy, significantly boosted by Dubrovnik, an UNESCO World Heritage site. The city attracts millions of tourists annually, contributing to a vibrant hospitality sector. Other tourist attractions include the scenic islands, pristine beaches, and historical sites, promoting a strong service industry with numerous hotels, restaurants, and recreational facilities.

The Neretva River delta is a vital ***agricultural*** area known for its production of citrus fruits, particularly mandarins, olives, and vegetables. Viticulture is also prominent, with the Pelješac Peninsula being famous for its high-quality wines, especially the Plavac Mali grape variety.

The county's extensive coastline and numerous islands facilitate a thriving maritime industry, including fishing, shipbuilding, and maritime transport. Dubrovnik Port and several smaller ports support both commercial and passenger maritime traffic, contributing to regional trade and connectivity.

Regarding the ***transportation and connectivity*** Dubrovnik-Neretva County is connected by road, sea, and air. The Dubrovnik Airport serves international and domestic flights. The Adriatic Highway (D8) runs along the coast, while the Pelješac Bridge, completed in 2022, connects the Pelješac peninsula with the mainland, improving accessibility. The Port of Dubrovnik accommodates numerous cruise ships, enhancing tourism, often bringing negative environmental impacts. The Port of Ploče is a critical hub for cargo traffic, linking Bosnia and Herzegovina with the Adriatic Sea.

In conclusion, Dubrovnik-Neretva County is a region with a dynamic economy primarily driven by tourism, complemented by agriculture, fisheries, and trade. Its rich cultural heritage and natural

beauty make it a prominent destination, while ongoing infrastructure developments and sustainable practices are crucial for its future growth and stability.

Demographic indicators

The population density of the County is relatively low, compared to more urbanized areas of Croatia, with significant variation between densely populated urban centers like Dubrovnik and sparsely populated rural areas.

The county has a population of approximately 115.564 residents. The population density is relatively low, with significant variations between urban centers like Dubrovnik and rural or island areas. Dubrovnik with 41.562 inhabitants is the largest city and administrative center, is a key driver of the county's demographic trends. Metković is second largest City in the county and it is also entirely located in the inland without direct connection with sea.

City	Population
Dubrovnik	41.562
Metković	15.235
Korčula	5.415
Ploče	8.220
Opuzen	2.838
Municipalities	
Župa dubrovačka	8.705
Konavle	8.607
Vela Luka	3.772
Orebić	3.705
Blato	3.330

Largest municipalities are Župa dubrovačka (8.705 inh.) and Konavle (8.607 inh.), while smallest municipalities are Zažablje with 553 inhabitants and Janjina with 522 inhabitants.

Importance of tourism is also visible from touristic statistics which reveal that total of 2.06 million tourists visited the County and produced 8.38 million overnight stays. When calculating the waste management indicators, we account those as additional 22.958 inhabitants/equivalent daily. However, this number can also be divided by monthly visits where pressure is put in summer season

months with peak months like July with 1 844 082 overnight stays which account for 59.486,51 additional inhabitants/equivalent daily.

3. Waste management system

This chapter provides a comprehensive description of the waste management system in the Republic of Croatia and Dubrovnik-Neretva County.

3.1. Waste management system in the Republic of Croatia

The last published report on waste management in Republic of Croatia is the one prepared for the year 2022, published in July 2023 and revised in September 2023, by the Croatian Ministry of Economy and Sustainable Development. When we are talking about the waste management in general, we analyse the municipal waste management streams and partially specific waste types that are similar to municipal waste (excluding the waste from various types of production, agriculture, forestry, wastewater treatment, vehicles and construction and demolition waste). Methodologically, all the municipal waste providers and other operators report quantities through the electronic system called ROO (register for waste polluters).

3.1.1. Waste management policies at the national and regional level

Croatian legislation is aligned with the EU directives. The Waste Management Act (NN 84/2021) prescribes measures to achieve the goals of the European Green Deal, particularly a 65% recycling rate for municipal waste and a reduction of waste disposal to 10% of the total amount of waste generated by 2035.

According to the Waste Management Act (2021), waste is any substance or object that the holder discards, intends to discard, or is required to discard. Waste management, therefore, is the process of conducting and directing activities to achieve set goals and relates to activities such as the collection, transportation, recovery including sorting, and disposal of waste, the supervision of these activities, as well as the monitoring and measures implemented at locations where waste has been disposed of (Republic of Croatia, 2021).

As the overarching planning document that aligned the waste management system in Croatia with new goals and policies, the Waste Management Plan of the Republic of Croatia for the period 2023-2028 has been developed, based on the goals set for 2035.

In addition to the National Plan, other planning documents for waste management include the Waste Management Plan of regional self-government units and the Waste Management Plan of the City of

Zagreb, which are proposed by the executive body and adopted by the representative body of the regional self-government unit or the City of Zagreb.

The goals of national waste management plan summarized all the obligations and goals set in primary and secondary national legislation and following table presents major waste stream goals:

Br.	Waste type	Objective
1.	Municipal waste	Recover through recycling and preparation for reuse at least: • 55% of the mass of municipal waste by 2025, • 60% of the mass of municipal waste by 2030, and • 65% of the mass of municipal waste by 2035. To landfill less than 264.661 tonnes of biodegradable waste; To landfill less than 10% of total waste mass produced by 2035; Increase the collection and treatment of biowaste.
2.	Packaging waste	Separately collect and recover, materially or energetically, at least 60% of the total mass waste packaging produced in the territory of the Republic of Croatia. Recycle at least 70% of the mass of total waste packaging by December 31, 2030, at least the following mass of material in the recycling process: • 55% plastic • 30% wood • 80% of unpainted metals • 60% aluminium • 75% glass • 85% paper and cardboard

Besides the Waste law, the waste acquis in Croatia consists of 19 secondary bylaws and 8 ministerial decisions.

Article 111 of the Waste Management Act prescribes the obligations of regional self-government units regarding the development, adoption, and evaluation of the Waste Management Plan of the regional self-government unit. The content of the regional Plan is specified in Appendix VI of the Waste Management Act. Unfortunately, the Dubrovnik-Neretva County did not prepare the regional waste

management plan, however the public procurement for development of the plan has been started in April of 2024.

3.1.2. Origin, composition, categories and type of collected waste at national level

Since 2011, the amounts of municipal waste generated have been continuously increasing, ranging between 1.6 million and 1.8 million tons. In 2020, because of the COVID-19 pandemic, which led to a significant reduction in the service sector (closure of hospitality establishments, a decrease in the number of tourist overnight stays), the amounts of municipal waste fell to the levels of 2014. With the increase in service sector activities (hospitality establishments, a significant increase in the number of tourist overnight stays, etc.) from 2021, the amount of municipal waste rose again, and in 2022, the total amount of municipal waste reached 1,844,382 tons, which is the highest value in the observed period from 1995 to 2022. (Ministry of Economy and Sustainable Development, 2023)

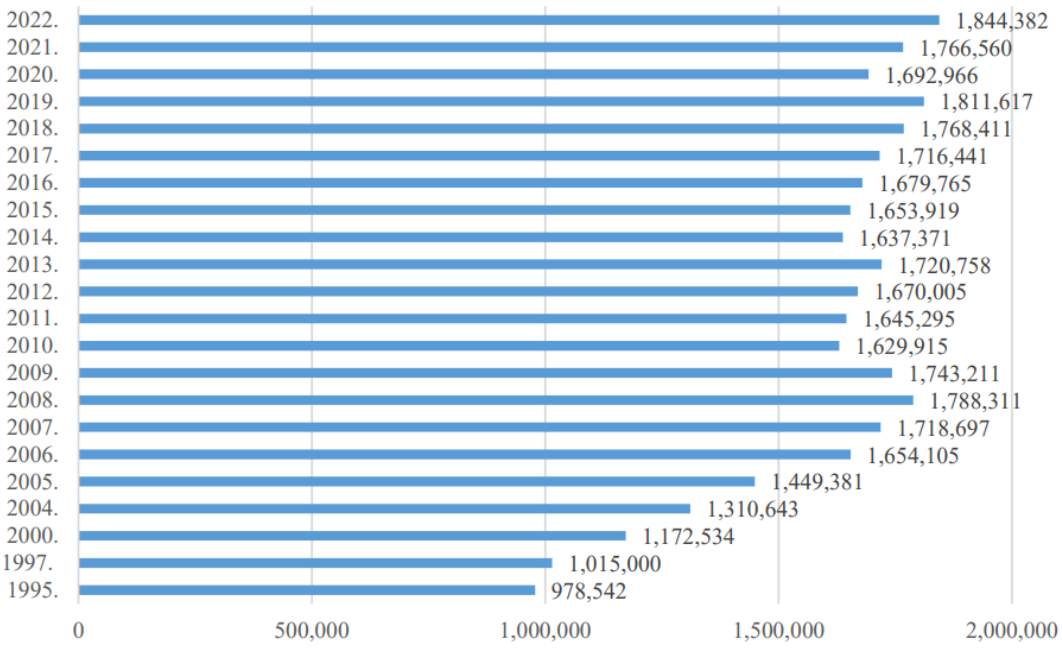

Figure 1. overall waste production in Croatia (year/tonne)

When observing the annual amount of municipal waste generated per capita, it amounted to 474 kg, which is the highest value in the observed period from 1995 to 2022. This can be attributed to the use of the 2021 census, which resulted in significantly lower values compared to the Eurostat population estimates used in previous years.

3.2. Waste management system in the Dubrovnik-Neretva County

Unfortunately, no official regional document has been prepared recently in order to summarize the data for the County, and we will use other national sources to summarize the description of current state of play in the waste management sector in the region. The regional waste management plan is in preparation, and it is currently undergoing the procedure of preparing the Strategic Environmetal Impact Assesmet. The plan aims to cover the period between 2024 and 2029.

3.2.1. Waste management facilities, devices and collection systems in the Dubrovnik-Neretva County

According to the national waste management plan, in the Dubrovnik-Neretva County region 6 landfills still operated in 2022 with estimated remaining landfilling capacities of 95.645 t of waste. Following table presents last 19 landfills and status of sanitation and closure prediction:

Landfill name	Operator	Operation status	Date of closure / if available	Status of sanitation	Waste landfilled in 2022 / tonnes	Remaining capacities
Dubravica	Čistoća Metković d.o.o.	Active		Finalized	6.094,46	11.739
Dubravica 2	Općina Mljet	Closed		Finalized	0	0
Grabovica	Čistoća d.o.o. Dubrovnik	Active		Ongoing	28.155,695	39.604
Kokojevica	KTD MINDEL d.o.o.	Active		Ongoing	4.996,07	51.159
Lovornik	Komunalno održavanje d.o.o.	Active		Ongoing	6.568,204	22.377
Ljubalj	Općina Pojezerje	Closed ex-situ		Finalized	0	0
Mokošica 1	Grad Dubrovnik	Closed ex-situ		Finalized	0	0
Mokošica 2	Grad Dubrovnik	Closed ex-situ		Finalized	0	0
Osičine	Općina Orebić	Closed ex-situ		Finalized	0	0
Podvlaštice	Općina Orebić	Closed		In preparation	0	0
Prapatno	Općina Ston	Closed ex-situ	31.12.2007	Finalized	0	0
Put za Osoj	Grad Dubrovnik	Closed ex-situ		Finalized	0	0

Sitnica	Komunalne djelatnosti d.o.o. Vela Luka	Active		Finalized	2595	8.926
Smrijek	Dubrovačko primorje d.o.o.	Closed ex-situ	31.12.2008	Finalized	0	0
Sozanj	Komunalac d.o.o. Lastovo	Active		Finalized	340	1.444
Sutvara	Općina Župa dubrovačka	Closed		Finalized	0	0
Ugrinovica	Krublić d.o.o.	Closed	31.05.2019	In preparation	0	0
Vardište	Općina Janjina	Closed ex-situ		Finalized	0	0
Vinošte	Komunalno d.o.o. Trpanj	Closed ex-situ	23.12.2019	Finalized	0	0

The largest operating landfill in Dubrovnik-Neretva County is Landfill Grabovica located near the City of Dubrovnik and currently accepts waste from the City of Dubrovnik and Municipalities of Župa Dubrovačka, Dubrovačko Primorje and Konavle, where in 2022 28.155,695 tonnes of waste were landfilled. In July 2019 the landfill sanitation has begun with phase 1 and the completion of works is expected in 2025. Just like majority of landfills on Karst surface, direct impact on soil, water and air were associated.

Figure 2. Grabovica landfill (source: City of Dubrovnik)

The future of WM facilities in Dubrovnik-Neretva County predominantly depends on the development of the waste management centre Lučino Razdolje which will replace all the existing landfills and introduce mechanical-biological treatment (MBT) for the mixed residual waste. The MBT plant is expected to processing approx. 40,000 t/year of waste, while Construction waste processing plant is planned for processing approx. 7,520 t/year of construction waste.

The new centre has planned municipal waste disposal site for 578,000 m3 of processed waste during the expected lifetime (25 years). The project also envisage the storage for small amounts of separately collected waste which will be collected and temporarily stored in the area.

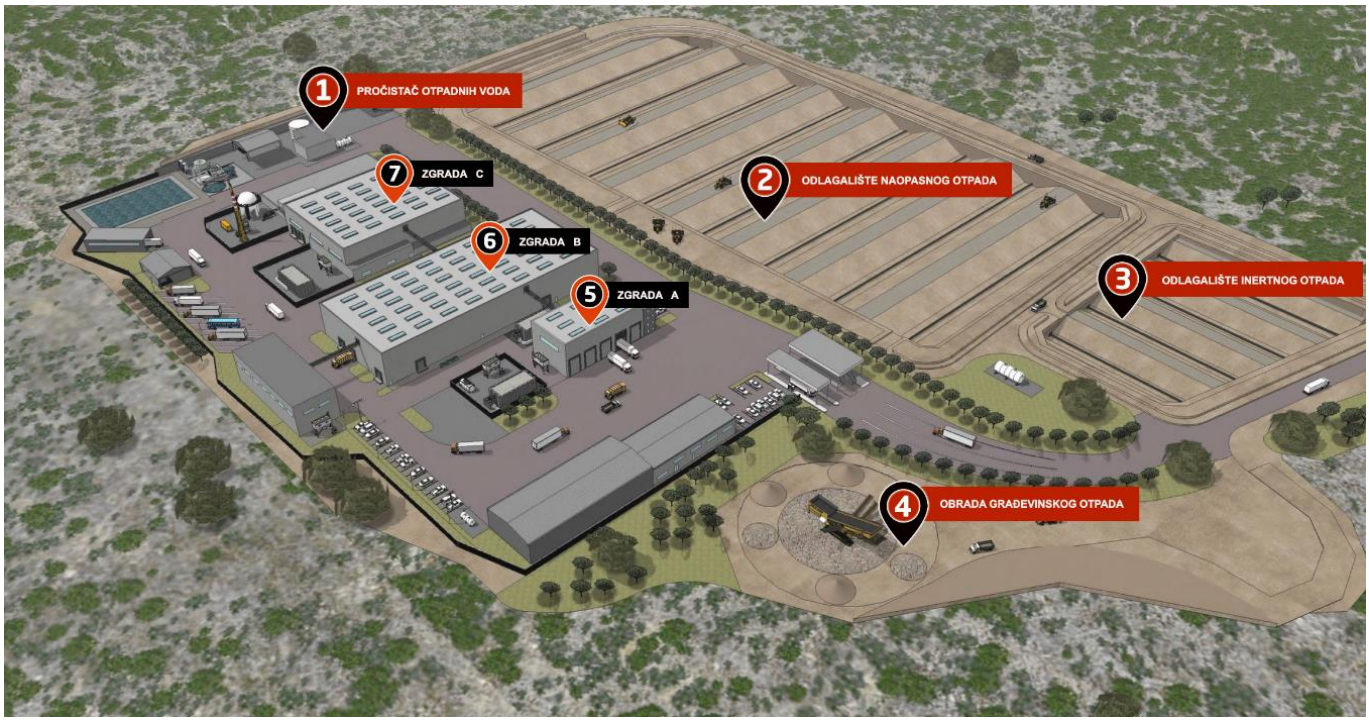

Figure 3. scheme of the Lučino Razdolje Waste management centre (source: https://ago-dnz.hr/o-projektu)

Like many waste management projects, Lučino Razdolje has faced opposition from some local residents concerned about potential environmental and health impacts, since different research show connection with potable water sources for the region. Despite advanced lining and leachate collection systems, there is always a risk of leachate leaking into the groundwater. This can lead to contamination of local water sources, affecting both human health and ecosystems.

According to national waste management plan, the County currently has 2.900 tonnes per year capacity installed for separately collected waste while total needed capacity is around 29.775 tonnes per year. Investment needed to satisfy the capacities are approximately 12,48 M EUR, and it should sort additional 24.076 tonnes of separately collected waste.

Regarding biowaste treatment facilities such as composting plants and anaerobic digestion plants, the County currently has 1 plant in operation with 5.720 tonnes capacity in the city of Metković. Additional 11.759 tonnes capacities shall be constructed with total investment predicted to be set at 7.80 M EUR. The composting facility in Metković has been financed by EU with 1.6 M EUR (50%), and it has been opened in late 2023, and in full operation since April 2024 which means it is the first significant composting project in Dalmatian region.

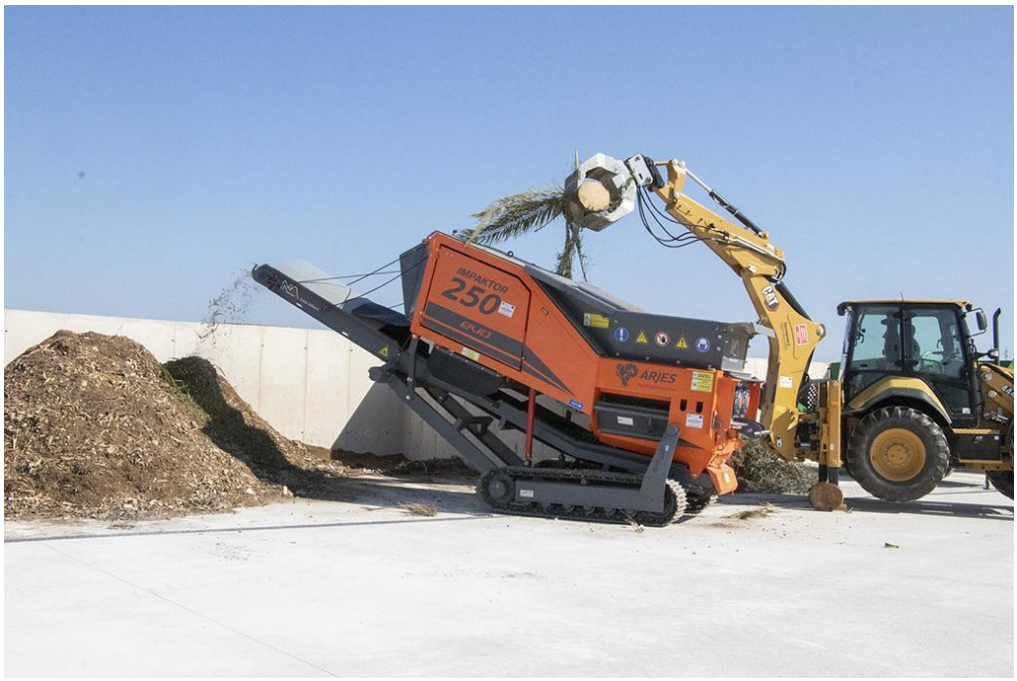

Figure 4. shredding operation on Metković composting facility (source: www.metkovic.hr)

Besides the municipal solid waste, capacities are not needed in the construction and demolition waste sector where 898.090 tonnes of capacities have been installed.

Regarding the post sorting phase, National plan envisages also development of recycling capacities for plastic recycling (9.278 tonnes/year plant), glass recycling (2.333 tonnes/year plant) and paper recycling (12.254 tonnes/year plant).

3.2.2. Origin, composition, categories and type of collected waste at regional level

In 2022 the amount of municipal waste collected was 55.283 tonnes, out of which 48.901 t were collected from households, 6.381 tonnes from business sector (mostly mixed waste).

Waste stream	Quantity/tonne	Share
Mixed municipal waste	48.901	93%
Biodegradable waste	85	0%
Wood	0	0%
Metal	138	0%
Textile	7	0%
WEEE	0	0%
Paper	392	1%
Plastics	249	0%
Glass	79	0%
Other	2.638	5%
Total	52.489	100%

Figure 5. quantities of collected MSW in 2022. (source: ROO public database)

From statistical data, it is visible that majority of waste is still landfilled or treated with other recovery option as 93% of collected waste is mixed municipal waste.

Total amount of waste generated as part of public service in DN County is 52.489 t of waste, out of which 48.901 t have been landfilled, which leaves the capacities for further landfilling for less than 3 years of operation. The total amount of separately collected waste through collection service was 3588 tonnes which is pitifully low. Since none of the cities or municipalities have reached the recycling targets set by legislation (50% by 2020), all of them have to pay the national fee for landfilling for total of 20.759 tonnes resulting in damages in taxes worth approximately 551.038,55 EUR.

Outside of municipal waste streams (public service stream) additional t was collected by the economic operators, where 3.186,52 were recovered or recycled.

Companies outside of public service-related waste streams are:

Number.	Operator	Quantities/tonne
1.	RESPEKT d.o.o.	792,52

2.	Signalizacija Dubrovnik d.o.o.	376,00
3.	Strabag d.o.o.	2000

Figure 6. waste producer/collector in Dubrovnik Neretva County

These small quantities definitely leave DN county at the very bottom of national statistics per region, and major efforts will be needed in order to reach European and national targets.

Waste composition analyses in DN County has not been conducted in last few years, so in order to further analyse the effectiveness of the waste management system, we will enclose the analyses presented in Elaborate for Environmental Protection for Waste Management Centre in Dubrovnik Neretva County on the location Lučino Razdolje. (IPZ Uniprojekt, 2014)

Waste type	Share (%)
Kitchen biowaste with Garden biowaste	41,2%
Paper	12.2%
Wood	3,20%
Textiles	4,9%
Bones and leathers	0,1%
Glass	1%
Plastic	19,80%
Metal	2,30%
Rubber and leather	2,1%
Other	13,2%
Total	**100**

Figure 7. waste composition in Dubrovnik-Neretva County (source: Environment protection Elaborate for Lučino Razdolje)

3.2.3. Illegal waste disposal sites or illegal landfills

Croatia has been struggling with the problem of illegal waste disposal sites for decades. Their exact number is impossible to determine, and it is about locations with a few bags of garbage on the one hand and locations of large illegal landfills on the other. From time to time, the competent services or volunteers in their voluntary actions succeed in remediating them by taking waste to official

landfills, but due to irresponsible behaviour and insufficiently developed environmental awareness of people (whom we will call "Someone" for the purposes of this text), they are created again, in the same or nearby place.

Environmental awareness also strengthens citizens, individuals have the opportunity to report illegal landfills in their surroundings. According to the report of the Green Telephone Association, the largest number of reports from citizens, over 30%, refers to the Waste category. Namely, as early as 1992, the first service for citizens was established, where information could be obtained and problems related to the environment, nature and their protection could be reported - the Green Phone. Additionally, since 1st of January 2020, the state has implemented electronic system for evidencing and reporting illegal landfills and fly tipping locations called Records of the locations of discarded waste (Croatian - Evidencija lokacija odbačenog otpada ELOO). The locations are marked with geolocation pins and also contain pictures of waste found on the site.

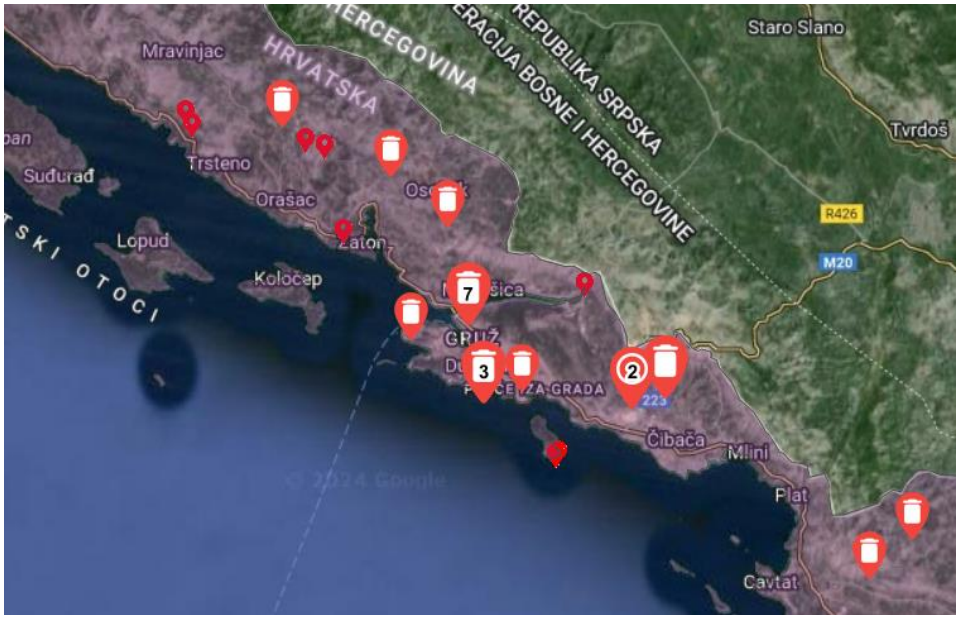

Figure 8. screenshot of waste locations in Dubrovnik-Neretva County (source:eloo.haop.hr)

Since the implementation of the ELOO system, the illegal landfills were reported on 87 occasions on officially recognized 43 spots, and local authorities have resolved 45 cases (51,7%) and permanently closed fly tipping 2 spots.

Naziv lokacije: Ulica od Nuncijate, Dubrovnik

Opis lokacije:
čestica zemlje 200/2 k.o. Gruž

Naselje: Dubrovnik

Grad/Općina: DUBROVNIK

Vrsta otpada:
Komunalni otpad, glomazni otpad, građevinski otpad

Ukupna količina otpada: 200 kg, 5 m3

Procijenjena površina otpada: 15 m2

Status lokacije otpada: Otpad na lokaciji

Datum uklanjanja otpada: 15.11.2021.

Koordinate (HTRS96/TM): (630344.41, 4725976.49)

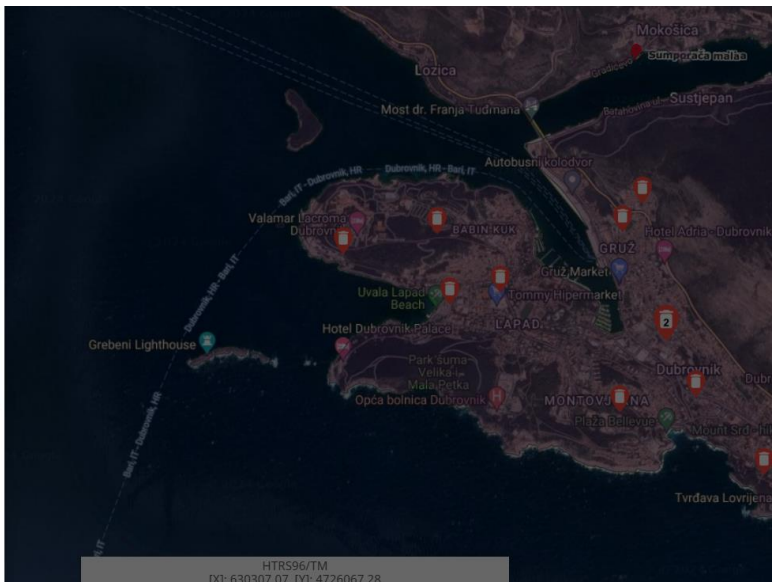

Figure 9. screenshot of publicly available ELOO inteface

4. Measures and initiatives for the development and improvement of the waste management system at regional level

The problematic measures and initiatives is at this moment rather unknown due to the fact that national waste management plan relieved the local planning obligation and shift it to operational planning on regional level. Since the planning still has only started, we will analyse historically most important initiatives in the municipal solid waste management sector.

Regional project of the waste management centre Lučino Razdolje is currently in the high stage of preparation, however the details of the construction timeline seem to be rather scarce, as even official webpage shows little or no information on current progress.

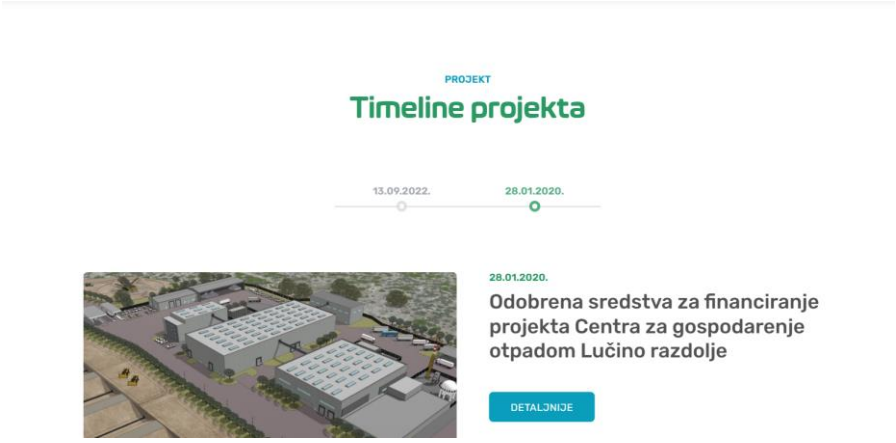

Figure 10. screenshot of project progress webpage - ending at 2020. (source: ago-dnz.hr)

However, this project is only an "end of pipe" solution as serious investments and organizational changes need to happen on higher hierarchy levels, such as waste prevention, waste collection and transportation of waste.

One of the pioneers of separate waste collection based on ***door to door*** methodology in Dalmatia is the City of Metković, with its municipal company Čistoća Metković d.o.o. that removed street collection system and put in place the system that allows collection from each household already in 2016. Even that change did not go without citizens' protests. The public resistance and unwillingness to give up messy street container system was rather short as it was visible from first days of the project implementation that the new collection system is serving them perfectly. Another important project run by this City is the ***composting plant*** project which was also pioneering in the region and will hopefully lead towards the first target achieving municipality in Dubrovnik-Neretva County.

In May 2020, the City of Dubrovnik became the first Croatian coastal city to join the ***Plastic free initiative***, implementing project activities that reduced the plastic footprint in various segments of social life and the local community, while promoting alternative solutions for plastic waste. Part of the awareness campaign targeted both foreign and domestic tourists, as tourism is a key contributor to pollution. The city adopted the "Action Plan to Reduce Plastic Pollution in the City of Dubrovnik for the Period 2021-2026." On August 30th, 2021, the Dubrovnik City Council decided to limit the use of single-use plastics for the City of Dubrovnik and its institutions and businesses. Two public events free of single-use plastics were held in 2021. Since its launch, the Dubrovnik Plastic Free Initiative has made significant strides in reducing plastic waste within the city. The visible reduction in plastic litter, improved recycling rates, and increased public awareness are early indicators of success. The project itself was successfully implemented by association Sunce from Split in cooperation with WWF mediterranean office.
Another positive initiative by the Sunce association is the project concerning island of Lastovo and marine litter. Marine litter represents one of the fastest growing global marine environmental problems. Although in Croatia there is a lack of data on the impact of marine debris on seabirds, it is expected that birds will be exposed to this problem and more research is needed on this threat.

Figure 11. Plastic waste analyses on Lastovo Island (source:www.sunce-st.org).

During the monitoring of the amount and composition of solid waste washed up on the coast, it was recorded, sorted and a total of 42,047 different pieces of waste were removed. The total mass of

collected waste was 745.70 kg, where the category Artificial polymer materials accounted for the largest share of mass with 55.54% (414.23 kg), and after it, processed wood with 33.17% (251.43 kg). The remaining 12% are the rest of the marine categories waste. (BIOM, SUNCE, BirdLife and Lastovsko otočje, 2021)

In the 2024. the City of Korčula finished the process of transitioning to a new, individualized way of managing waste that was based mainly on a door-to-door methodology. Common containers on public areas are kept only in those locations where it is not possible to have an individual tank in front of the house, such as in the Old Town. Those parts of the city dispose their mixed waste in common containers using a waste meter.

Last but not the least step towards sound waste management practice is the change of collection methodology in the City of Dubrovnik which is the largest producer of waste in the County. The pilot project for the introduction of pay as you throw system will be introduced in the city parts called Mokošica and Lapad. “Underground containers will be equipped with waste meters. Once people get used to it, we will begin implementing the new waste management system, which we will then expand to the entire area of Dubrovnik. I believe that by the end of the year, we will start with the waste management system," said Mayor Mato Franković.” (Metković, N., 2024).
In the new waste management system, it is planned that waste collection will be charged based on the actual amount of waste disposed.

5. Conclusion

Dubrovnik-Neretva County faces significant waste management challenges driven by factors such as tourism, population growth, and urbanization. Despite existing efforts and infrastructure, there is a need for further improvements to mitigate the environmental and health impacts of waste. The introduction of innovative systems like "pay as you throw" and the promotion of recycling and waste separation are crucial steps towards sustainable waste management. By implementing these measures and continuing to develop and refine waste management policies, Dubrovnik-Neretva County can reduce its environmental footprint, promote sustainable development, and enhance the quality of life for its residents and visitors. The report underscores the importance of ongoing efforts and the need for a comprehensive approach to waste management that includes both technological solutions and community engagement.

The waste management system in Croatia and specifically in Dubrovnik-Neretva County is detailed, including policies, infrastructure, and types of waste. The report outlines the current state of waste generation, emphasizing the negative ecological and socioeconomic impacts of increased waste production, especially plastic waste. Key data on waste composition and sources are provided, showing that artificial polymer materials constitute a large portion of the waste collected.

The report also discusses the illegal waste disposal sites and the need for improved waste management practices. Various initiatives and measures aimed at enhancing waste management in the region are examined, including a pilot project for a "pay as you throw" system in Dubrovnik. This system aims to charge for waste collection based on the actual amount of waste disposed of, thereby encouraging recycling and waste separation.

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List of figures