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"Implementation of waste characterization research in target areas"

Project:

Zero Waste Strategy: Methods and Implementation in Black Sea Basin – ZeroWasteBSB

Implemented within the framework of the

Joint Operational Programme Black Sea Basin 2014-2020 is co-financed by the European Union through the

European Neighbourhood Instrument and by the participating countries: Armenia, Bulgaria, Georgia, Greece,

Republic of Moldova, Romania, Turkey and Ukraine.

Author: Christos Papalexiou

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Summary

The current report aims at the description of the current and future situation of the pollution caused by waste in the European Union and in Greece, under the framework of the implementation of the project entitled "Zero Waste Strategy: Methods and Implementation in Black Sea Basin" with acronym "ZeroWasteBSB ", which is implemented in the framework of the “Joint Operational Program" Black Sea Basin 2014-2020 ", which is co-financed by the European Union through the European Neighborhood Instrument (ENI).

The ZeroWasteBSB project is based on good cross-border cooperation between regional and local authorities, NGOs and one research institute from four different Black Sea Basin countries, Turkey, Greece, Ukraine and Bulgaria. The main goal of the project is to raise awareness of environmental challenges and good waste management practices related to river and seawater waste in the Black Sea basin to ensure the improvement of human well-being in the Mediterranean basin.

More specifically, the current research is structured in six chapters:

The **first chapter**, entitled "Updating Zero Waste Strategy", describes the Waste Situation in the World Earth, the European Union, Black Sea Basin and Greece. Also, the methods of waste management and organic waste are recorded. The Waste Management Strategies at all levels of governance are analysed: EU, regional and local.

The **second chapter**, entitled "Methodology for strategic management of zero waste", studies the waste categorization methodologies, the principles and techniques of the Zero Waste Management Strategy, as well as the conventional and alternative methods of waste management.

The **third chapter** entitled "Analysis of quantitative and structural indicators in the field of waste management in the Regions of Greece for the period 2017-2019". This chapter analyses the volume, structure of sources, distribution and disposal of municipal solid waste. More specifically, a record is made of the sources and quantities of waste produced in Greece from 2017 to 2019 as well as a record of the treatment methods applied in Greece. Special emphasis is given to the area of the Municipality of Thessaloniki, while there is a brief presentation of the results of in-depth interviews taken in the context of primary research by people who have an active role in waste collection and treatment processes.

"Projection of waste producers on infographics maps by waste type in the Regions of Greece" is the title of the **fourth chapter**, which lists waste producers, types of waste in the regions of Greece based on source of economic activity.

The title of the **fifth chapter** is "Forecasting the amounts of waste during 2022-2023 in Regions of Greece". In this chapter is made an analysis of waste in types based on the way of separation in the regions of Greece for the last decade (2010-2019) and three-year forecasts 2020-2023 for the volume and species in the respective regions.

The **sixth and last chapter** entitled "Information about waste management facilities at the beginning of 2020 and a forecast vision of waste transportation routes for the period 2020-2023 in the Regions of Greece" lists the existing infrastructure in Greece for the collection, management and transport of waste and forecasts for transport routes in the period 2020-2023.

Περίληψη

Η παρούσα έκθεση έχει ως σκοπό την αποτύπωση της υφιστάμενης και μελλοντικής κατάστασης της ρύπανσης από απόβλητα στην Ευρωπαϊκή Ένωση και στην Ελλάδα, στο πλαίσιο της υλοποίησης του έργου με τίτλο "Zero Waste Strategy: Methods and Implementation in Black Sea Basin" με ακρωνύμιο "ZeroWasteBSB", το οποίο υλοποιείται στο πλαίσιο του προγράμματος "Joint Operational Programme Black Sea Basin 2014-2020" που συγχρηματοδοτείται από την Ευρωπαϊκή Ένωση μέσω του Ευρωπαϊκού Μηχανισμού Γειτονίας (ENI -European Neighbourhood Instrument).

Το έργο ZeroWasteBSB βασίζεται στην καλή διασυνοριακή συνεργασία μεταξύ περιφερειακών και τοπικών αρχών, ΜΚΟ και ερευνητικού ιδρύματος από τέσσερις διαφορετικές χώρες της λεκάνης της Μαύρης Θάλασσας, την Τουρκία, την Ελλάδα, την Ουκρανία τη Βουλγαρία. Ο κύριος στόχος του έργου είναι η αύξηση της ευαισθητοποίησης σχετικά με περιβαλλοντικές προκλήσεις και ορθές πρακτικές διαχείρισης αποβλήτων που σχετίζονται με απορρίμματα ποταμών και θαλάσσιων υδάτων στη λεκάνη της Μαύρης Θάλασσας για τη διασφάλιση της βελτίωσης της ευημερίας των ανθρώπων στις περιοχές της Λεκάνης της Μαύρης Θάλασσας.

Πιο συγκεκριμένα, η παρούσα έρευνα διαρθρώνεται σε έξι κεφάλαια:

Στο **πρώτο κεφάλαιο** που τιτλοφορείται «Επικαιροποίηση της Στρατηγικής Μηδενικών Αποβλήτων», καταγράφεται η Κατάσταση των αποβλήτων στην στη Γη, στην Ευρωπαϊκή Ένωση, στη λεκάνη της Μαύρης Θάλασσας και στην Ελλάδα. Επίσης, καταγράφονται οι μέθοδοι διαχείρισης των αποβλήτων αλλά και των οργανικών αποβλήτων. Στη συνέχεια, αναλύονται οι Στρατηγικές Διαχείρισης Αποβλήτων σε όλα τα επίπεδα διακυβέρνησης: ΕΕ, περιφερειακό και τοπικό.

Στο **δεύτερο κεφάλαιο** με τίτλο «Μεθοδολογία στρατηγικής διαχείρισης μηδενικών αποβλήτων» μελετώνται οι μεθοδολογίες κατηγοριοποίησης των απορριμμάτων, οι αρχές και οι τεχνικές της Στρατηγικής Διαχείρισης Μηδενικών Αποβλήτων καθώς και οι συμβατικές και εναλλακτικές μέθοδοι διαχείρισης αποβλήτων.

Το **τρίτο κεφάλαιο** με τίτλο «Ανάλυση των ποσοτικών και δομικών δεικτών στο πεδίο της διαχείρισης αποβλήτων σε περιοχές της Ελλάδας για την περίοδο 2017-2019». Σε αυτό το κεφάλαιο αναλύεται ο όγκος, η δομή των πηγών, η κατανομή και απόθεση των αστικών στερεών αποβλήτων. Πιο συγκεκριμένα, γίνεται μία καταγραφή των πηγών και των ποσοτήτων αποβλήτων που έχουν παραχθεί στην Ελλάδα από το έτος 2017 μέχρι και το 2019 καθώς και μία αποτύπωση των μεθόδων επεξεργασίας που εφαρμόστηκαν στην Ελλάδα. Ιδιαίτερη έμφαση δίνεται στην περιοχή του Δήμου Θεσσαλονίκης, ενώ γίνεται και μία σύντομη παρουσίαση των αποτελεσμάτων των σε βάθος συνεντεύξεων που λήφθηκαν στο πλαίσιο της πρωτογενούς έρευνας από ανθρώπους που έχουν ενεργό ρόλο στις διαδικασίες συλλογής και επεξεργασίας αποβλήτων.

«Προβολή των παραγωγών αποβλήτων σε χάρτες infographics ανά τύπο αποβλήτων σε περιοχές της Ελλάδας» είναι ο τίτλος του **τέταρτου κεφαλαίου**, στο οποίο καταγράφονται οι παραγωγοί αποβλήτων, οι τύποι αποβλήτων στις περιφέρειες της Ελλάδας με βάση πηγή οικονομικής δραστηριότητας.

Ο τίτλος του **πέμπτου κεφαλαίου** είναι «Προβλέψεις ποσοτήτων από απόβλητα τα οποία παράγονται, συλλέγονται και εναποτίθενται ανά κατηγορία στο διάστημα 2022-2023 σε περιοχές της Ελλάδας». Στο συγκεκριμένο κεφάλαιο γίνεται μία ανάλυση των αποβλήτων σε τύπους με βάση τον τρόπο διαχωρισμού στις περιφέρειες της Ελλάδας για την τελευταία

δεκαετία (2010-2019) και προβλέψεις τριετίας 2020-2023 για τον όγκο και τα είδη στις αντίστοιχες περιφέρειες.

Στο **έκτο και τελευταίο κεφάλαιο** με τίτλο «Πληροφορίες για υποδομές αποβλήτων στις αρχές του 2020 και σχέδιο προβλέψεων μελλοντικών διαδρομών αποβλήτων για την περίοδο 2020-2023 σε περιοχές της Ελλάδας» γίνεται καταγραφή των υποδομών που υπάρχουν στην Ελλάδα για τη συλλογή, διαχείριση και μεταφορά των αποβλήτων και προβλέψεις για διαδρομές μεταφορών στην περίοδο 2020-2023.

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Introduction

The amount of rubbish is continuously increasing as the societies are becoming wealthier. People are consuming more goods. Consumers' tastes and preferences shift to disposable and short-life products. The modern way of life requires the possession and use of more and more electrical appliances that are constantly being replaced, improving the standard of living but also generate more waste than ever before. At the same time, there are many single-person households especially in the urban centres that tend to generate more waste per person than families or groups.

The average annual production of waste per person in the EU is approximately five tonnes and it is calculated that little more than a third of that is effectively recycled (European Commission, 2014). In 2016 the European Union produced 2.5 billion tonnes of waste; 0.8% of it is produced by agriculture, forestry and fisheries, 8.5% by the households, 10.3% by industry, 25.3% by mines and quarries, 36.4% by construction and 18.7% by other activities. From 2005 to 2018 the average amount of municipal waste per capita declined in the EU. Trends can vary by country. Municipal waste per capita increased in Denmark, Germany, Greece, Malta and the Czech Republic, while it decreased in Bulgaria, Spain, Hungary, Romania and the Netherlands (European Parliament: https://www.europarl.europa.eu/news/en/headlines/society/20180328STO00751/eu-waste-management-infographic-with-facts-and-figures).

All this waste has a harmful impact on the environment, causing pollution and greenhouse gas emissions that contribute to climate change. However, the nature of the produced waste is changing and it becomes more complicated that needs more organised management. The wide use of high-tech devices and the general modern consumption habits increases the variety of the materials that are wasted such as different kinds of plastics, precious metals and hazardous chemical products, which require special procedures to be handled safely.

The EU waste management policies aim to reduce the environmental and health impacts of waste and to promote the efficient use of resources in Europe. The general purpose is to increase the amount of materials that are being recycled and to minimize the extraction of additional natural resources. Proper waste management is a key element in ensuring resource efficiency and the sustainable development of the EU economy.

Chapter 1. Updating Zero Waste Strategy

1.1 State of waste in the World, Europe and the Black Sea Basin

1.1.1 State of Waste in the World

According to the World Bank (https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html) "The World generates 2.01 billion tonnes of municipal solid waste annually, with at least 33% of that—extremely conservatively—not managed in an environmentally safe manner. Worldwide, waste generated per person per day averages 0.74 kilogram but ranges widely, from 0.11 to 4.54 kilograms. Though they only account for 16% of the world's population, high-income countries generate about 34%, or 683 million tonnes, of the world's waste.

By 2050, global waste is expected to grow to 3.40 billion tonnes, more than double population growth over the same period. Overall, there is a positive correlation between waste generation and income level. Daily per capita waste generation in high-income countries is projected to increase by 19% by 2050, compared to low- and middle-income countries where it is expected to increase by approximately 40% or more. Waste generation initially decreases at the lowest income levels and then increases at a faster rate for incremental income changes at low income levels than at high income levels. The total quantity of waste generated in low-income countries is expected to increase by more than three times by 2050. The East Asia and Pacific region is generating most of the world's waste, at 23%, and the Middle East and North Africa region is producing the least in absolute terms, at 6%. However, the fastest growing regions are Sub-Saharan Africa, South Asia, and the Middle East and North Africa, where, by 2050, total waste generation is expected to more than triple, double, and double respectively. In these regions, more than half of waste is currently openly dumped, and the trajectories of waste growth will have vast implications for the environment, health, and prosperity, thus requiring urgent action.

Waste collection is a critical step in managing waste, yet rates vary largely by income levels, with upper-middle- and high-income countries providing nearly universal waste collection. Low-income countries collect about 48% of waste in cities, but this proportion drops drastically to 26% outside of urban areas. Across regions, Sub-Saharan Africa collects about 44% of waste while Europe, Central Asia and North America collect at least 90% of waste.

Waste composition differs across income levels, reflecting varied patterns of consumption. High-income countries generate relatively less food and green waste, at 32% of total waste, and generate more dry waste that could be recycled, including plastic, paper, cardboard, metal, and glass, which account for 51% of waste. Middle- and low-income countries generate 53% and 57% food and green waste, respectively, with the fraction of organic waste increasing as economic development levels decrease. In low-income countries, materials that could be recycled account for only 20% of the waste stream. Across regions, there is not much variety within waste streams beyond those aligned with income. All regions generate about 50% or more organic waste, on average, except for Europe, Central Asia and North America, which generate higher portions of dry waste.

It is a frequent misconception that technology is the solution to the problem of unmanaged and increasing waste. Technology is not a panacea and is usually only one factor to consider when managing solid waste. Countries that advance from open dumping and other

rudimentary waste management methods are more likely to succeed when they select locally appropriate solutions. Globally, most waste is currently dumped or disposed of in some form of a landfill. Some 37% of waste is disposed of in some form of a landfill, 8% of which is disposed of in sanitary landfills with landfill gas collection systems. Open dumping accounts for about 31% of waste, 19% is recovered through recycling and composting, and 11% is incinerated for final disposal. Adequate waste disposal or treatment, such as controlled landfills or more stringently operated facilities, is almost exclusively the domain of high- and upper-middle-income countries. Lower-income countries generally rely on open dumping; 93% of waste is dumped in low-income countries and only 2% in high-income countries. Three regions openly dump more than half of their waste—the Middle East and North Africa, Sub-Saharan Africa, and South Asia. Upper-middle-income countries have the highest percentage of waste in landfills, at 54%. This rate decreases in high-income countries to 39%, with diversion of 36% of waste to recycling and composting and 22% to incineration. Incineration is used primarily in high-capacity, high-income, and land-constrained countries.

Based on the volume of waste generated, its composition, and how it is managed, it is estimated that 1.6 billion tonnes of carbon dioxide (CO2) equivalent greenhouse gas emissions were generated from solid waste treatment and disposal in 2016, or 5% of global emissions. This is driven primarily by disposing of waste in open dumps and landfills without landfill gas collection systems. Food waste accounts for nearly 50% of emissions. Solid waste–related emissions are anticipated to increase to 2.38 billion tonnes of CO2-equivalent per year by 2050 if no improvements are made in the sector.

In most countries, solid waste management operations are typically a local responsibility, and nearly 70% of countries have established institutions with responsibility for policy development and regulatory oversight in the waste sector. About two-thirds of countries have created targeted legislation and regulations for solid waste management, though enforcement varies drastically. Direct central government involvement in waste service provision, other than regulatory oversight or fiscal transfers, is uncommon, with about 70% of waste services being overseen directly by local public entities. At least half of services, from primary waste collection through treatment and disposal, are operated by public entities and about one-third involve a public-private partnership. However, successful partnerships with the private sector for financing and operations tend to succeed only under certain conditions with appropriate incentive structures and enforcement mechanisms, and therefore they are not always the ideal solution.

Financing solid waste management systems is a significant challenge, even more so for ongoing operational costs than for capital investments, and operational costs need to be taken into account upfront. In high-income countries, operating costs for integrated waste management, including col-lection, transport, treatment, and disposal, generally exceed $100 per tonne. Lower-income countries spend less on waste operations in absolute terms, with costs of about $35 per tonne and sometimes higher, but these countries experience much more difficulty in recovering costs. Waste management is labor intensive and costs of transportation alone are in the range of $20–$50 per tonne. Cost recovery for waste services differs drastically across income levels. User fees range from an average of $35 per year in low-income countries to $170 per year in high-income countries, with full or nearly full cost recovery being largely limited to high-income countries. User fee models may be fixed or variable based on the type of user being billed. Typically, local governments cover about 50% of investment costs for waste systems, and the remainder comes mainly from national government subsidies and the private sector.”

Meng-Chuen at al. (2020) found that the global share of organic waste declines from 47% to 39% from 2015 to 2050, while all other waste type shares increase, especially paper. The share of waste treated in dumps declines from 28% to 18%, and more sustainable recycling, composting, and energy recovery treatments increase. They estimated environmental loads to continue increasing in the future, although yearly plastic waste input into the oceans has reached a peak.

(Eurostat: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics&oldid=503336#Total_waste_generation)

1.1.2 State of Waste in the European Union

In 2018, the total waste generated in the EU-27 by all economic activities and households amounted to 2.317 million tonnes. Among the waste generated in the EU-27 in 2018, 101.4 million tonnes (4.3 % of the total) were classified as hazardous waste.

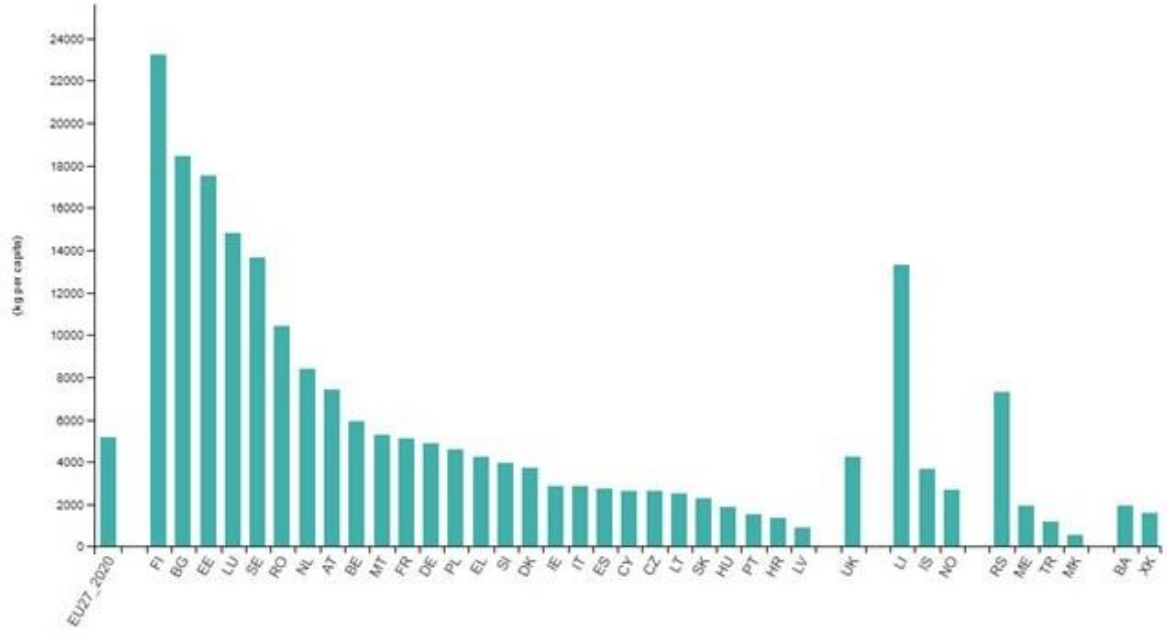


Figure 1: Waste generation in the EU-27 in 2018

Source: Eurostat (online data code: env_wasgen)

Figure 1 shows all the kg per capita of waste generated in each EU Member state in 2018. The EU-27 average waste generation was 5.190 kg per capita. Greece occupies the 14th position in the EU generating 4.248 kg per capita, while Bulgaria is in the second position with 18.470 kg per capita of waste. Turkey generated 1.195 kg of waste per capita in 2018.

The EU-27 waste generation excluding major mineral waste was 811,7 million tonnes. In 2018, the economic activity with the highest levels of waste generation in the EU was waste and water services (207,5 million tonnes) followed by households (184,4 million tonnes), manufacturing activities (180,2 million tonnes), other sectors (92,7 million tonnes), energy (78,4 million tonnes), construction (41,2 million tonnes), agriculture, forestry and fishing (19,3 million tonnes) and mining and quarrying (8.1 million tonnes).

Table 1: Waste generation by economic activities and households, 2018

(% share of total waste)

	Mining and quarrying	Manufacturing	Energy	Construction and demolition	Other economic activities	Households
EU-27	26.3	10.6	3.5	36.0	15.4	8.2
Belgium	0.1	24.9	1.2	33.5	33.1	7.2
Bulgaria	82.4	2.0	10.0	0.1	3.1	2.4
Czechia	0.3	18.2	1.8	41.6	24.8	13.3
Denmark	0.0	4.7	5.1	56.0	17.8	16.3
Germany	2.2	13.9	2.3	55.6	16.8	9.2
Estonia	29.5	18.8	32.3	9.5	7.6	2.4
Ireland	14.2	24.7	1.1	13.6	35.1	11.4
Greece	56.4	11.8	7.6	5.0	9.2	10.1
Spain	8.6	10.8	4.6	29.8	28.5	17.7
France	0.4	6.6	0.4	70.2	13.7	8.7
Croatia	12.0	8.9	1.3	22.7	31.7	23.3
Italy	0.8	16.5	1.3	35.3	28.7	17.5
Cyprus	6.6	16.3	0.1	45.8	14.5	16.8
Latvia	0.1	21.7	2.5	17.5	25.7	32.6
Lithuania	1.6	37.2	2.1	8.8	30.3	20.0
Luxembourg	0.0	6.9	0.1	81.2	9.7	2.1
Hungary	1.0	14.6	11.2	33.2	25.1	14.9
Malta	1.6	1.1	0.0	79.3	10.9	7.2
Netherlands	0.0	9.6	1.1	70.0	13.3	6.0
Austria	0.1	8.7	0.8	74.4	9.3	6.7
Poland	36.7	17.0	10.7	9.7	20.6	5.3
Portugal	0.2	19.0	1.1	8.8	38.1	32.8
Romania	87.9	4.0	3.4	0.3	2.4	2.1
Slovenia	0.2	20.2	11.8	8.1	51.9	7.8
Slovakia	2.2	27.5	7.9	4.4	39.8	18.2
Finland	74.9	6.7	1.0	12.3	3.5	1.6
Sweden	74.7	3.7	1.4	8.9	8.0	3.2
United Kingdom	5.2	4.0	0.2	48.8	32.4	9.4
Iceland	0.0	24.4	0.0	3.9	31.5	40.2
Liechtenstein (')	3.0	2.3	0.0	87.9	1.5	5.4
Norway	1.2	12.8	1.5	40.0	27.4	17.1
Montenegro	27.4	3.7	27.6	11.3	8.6	21.4
North Macedonia	14.2	46.6	0.5	3.1	35.6	0.0
Serbia	75.6	3.0	14.7	1.1	2.1	3.6
Turkey	22.3	:	32.6	0.0	8.9	36.1
Bosnia and Herzegovina	8.2	28.1	48.1	1.8	0.2	13.6
Kosovo*	93.5	2.0	3.4	0.1	0.0	1.0

(') 2016.

** This designation is without prejudice to positions on status, and is in line with UNSCR 1244/1999 and the ICJ Opinion on the Kosovo declaration of independence.*

Source: Eurostat (online data code: env_wasgen)

Several of the Member States with particularly high levels of waste generated per inhabitant reported very high shares of waste from mining and quarrying, while elsewhere construction and demolition often contributed to the high shares. More specifically, in the EU-27, construction contributed 36% of the total in 2018 and was followed by mining and quarrying (26,2%), manufacturing (10,6%), waste and water services (9,9%) and households (8,2%); the remaining 9,1% was waste generated from other economic activities, mainly services (4,2%) and energy (3,5%).

In Greece, mining and quarrying (56,4%) is the main waste generating sector followed by manufacturing (11,8%), households (10,1%), other economic activities (9,2%), energy (7,6%) and construction and demolition (5%).

In Bulgaria, the highest amount of waste is generated by mining and quarrying (82,4%), followed by energy (10%). Other economic activities contributed 3,1% in 2018, households 2,4%, manufacturing 2%, and construction and demolition 0,1%.

In 2018, 36,1% of the total waste generated in Turkey was from households, 32,6% from energy, 22,3% from mining and quarrying and 8,9% from other economic activities.

A lot of the waste from mining and quarrying and from construction and demolition is classified as major mineral waste. Almost two thirds (65 % or 3.4 tonnes per inhabitant) of the total waste generated in the EU-27 in 2018 was major mineral waste. The EU-27 Member States that had higher shares of major mineral waste were those that were characterised as having relatively sizeable mining and quarrying activities, such as Romania, Finland, Sweden and Bulgaria.

In 2018, the share of hazardous waste in total waste generation was below 10.0 % in all of the EU-27 Member States except for Estonia and Bulgaria, where it made up, respectively, a 46.9 % and a 10.4 % share of the total. The very high share for Estonia was principally due to energy production from oil shale. Turkey is was above the EU-27 average (15.3 %).

In the EU-27 in 2018, more than a half (54.2 %) of the waste was treated in recovery operations: recycling (38.1 % of the total treated waste), backfilling (10.1 %) or energy recovery (6.0 %). The remaining 45.8 % was either landfilled (38.7 %), incinerated without energy recovery (0.7 %) or disposed of otherwise (6.3 %). In total, 82.2 million tonnes of hazardous waste were treated in the EU-27 in 2018, with more than two thirds of this treated in just four EU-27 Member States, Germany (27.3 %), Bulgaria (16.5 %), Estonia (13.1 %) and France (11.6 %).

1.1.3 State of Waste in the Black Sea basin

The total population in the Black Sea area exceeds 160-170 million people. The daily activities of all these people contribute to marine litter problem in the environment of the Black Sea, which is mainly originated from the solid waste pollution problem. It originates from various land- and sea-based sources as a result of manifold human activities and causes multi-vectorial negative impact on the population, wild life, abiotic nature and some sectors of economy. This problem is directly linked to major problems of public health, conservation of the environment, and sustainable development in the Black Sea region as well.

Another serious problem in the Black Sea is the widespread distribution of illegal, unreported and unregulated fishing that is also a peculiar source of marine litter. Countless illegal nets and nets which were discarded or abandoned are causing the so-called “ghost fishing” phenomenon. “Ghost fishing” is a serious problem in the Black Sea. High concentrations of fixed and floating illegal, unreported and unregulated fishing gear in some areas result in the reduction of habitat space, formation of obstacles on migration ways and enhancement of incidental mortality (by-catch) of cetaceans, fishes and crustaceans (Birkun, 2009).

Since the 1980s and 1990s, the toll of various human pressures on the Mediterranean and Black Sea environment, ecosystems and living resources, and ultimately the impact of these pressures on the fishing sector, has been obvious. Collapses in stocks, large eutrophication events in both basins and the appearance of prodigious numbers of non-indigenous species were occurring across the region by the late 1990s and 2000s. Before long, other warning signs were added to the list of threats already evident: the extent of plastic pollution, ghost fishing and the various impacts of climate change, which include an overall warming of the sea, greater frequency of extreme warm or cold events in the upper layers of the ocean, increases in drought periods and decreases in river inflow (FAO, 2020).

1.1.4 State of Waste in Greece

The National Waste Management Plan 2020-2030 describes the current situation concerning the production and management of different types of waste in Greece in the reference year 2018.

Municipal Solid Waste

The total production of Municipal Solid Waste in Greece in 2018 was 5.523.809 tonnes and the production per capita 514 Kg / resident / year. The proportional composition of the Municipal Solid Waste was 44,30% organic, 22,20% paper / cardboard, 13,90% plastic, 4,30% glass, 3,90% metal and 11,40% other. Regarding the management of the produced Municipal Solid Waste, 31% of the recyclable paper, metal, plastic and glass was prepared for reuse and recycling. The proportion of the Municipal Solid Waste that was totally recycled was 20.1%. The proportion of the Municipal Solid Waste that was disposed in landfills was 78,4% and it is high in Greece. The sorting at the source is promoted by the EU. In Greece only 16,5% of the produced Municipal Solid Waste is collected in "sorting in source" management systems, 30,8% of the recyclable materials (paper, metal, plastic and glass) and 5,7% of the biowaste.

Biodegradable Municipal Waste

The total amount of Biodegradable Municipal Waste that produced in Greece in 2018 was 3.673.333 tonnes, 2.771.773 tonnes of it was buried in landfills.

Organic Waste – biowaste

The organic waste that produced in Greece in 2018 was 2.447.047 tonnes and 87% of it was kitchen waste, 10% garden / green waste and 3% edible fats and oils.

Recyclable Materials

2.447.047 tonnes of recyclable materials were produced in Greece in 2018. 759.620 tonnes of the produced recycled materials were prepared for reuse and recycling.

Packaging waste

810.900 tonnes of packaging waste were produced in 2018 in Greece. The production of the packaging waste per individual packaging material is presented in Table 2.

Table 2: Production of the packaging waste per individual packaging material in Greece in 2018

	Tonnes	**Percentage**
Glass	99.300	12,25%
Plastic	187.600	23,13%
Paper-Cardboard	369.700	45,59%
Metals	92.100	11,36%
Wood	54.900	6,77%
Other	7.300	0,90%
Total	**810.900**	**100**

Source: National Waste Management Plan 2020-2030

522.040 tonnes of the produced packaging waste were recycled in 2018, which is 64,4% of the total packaging waste produced in Greece. Especially, from the production of 187,600 tonnes of plastic packing in 2018, the recycling / recovery was 81,970 tons, quantity that corresponds to 43.7%.

Table 3: Recycling of the packaging waste per individual packaging material in Greece in 2018

	Recycled Packaging material (Tonnes)	Produced Packaging material (Tonnes)	Percentage of the recycled packaging material in relation to the produced
Glass	99.300	34.960	35,20%
Plastic	187.600	81.970	43,70%
Paper-Cardboard	369.700	327.610	88,60%
Metals	92.100	63.630	69,10%
Wood	54.900	13.870	25,30%
Other	7.300	-	-
Total	**810.900**	**522.040**	

Source: National Waste Management Plan 2020-2030

Disposable plastics

Until 2018, no targets have been set to limit the consumption of disposable plastics or conditions for their management. The issue of the disposable plastics was recently introduced by Directive 2019/904 / EU. Thus, there is no data on the quantities and no action has been taken on the disposable plastics. The new National Waste Management Plan 2020 introduces the establishment of a complete ban on the placing on the market from July 3, 2021 of plastic products such as cotton swabs, cutlery, plates, straws, drink mixers, etc. Also, some other measures are introduced, such as the separate collection for recycling of at least 77% by weight of plastic beverage bottles by 2025 and 90% by 2029 etc.

Table 4: Recycling targets until 2025 and until 2030 in Greece

RECYCLING TARGETS UNTIL 2025	RECYCLING TARGETS UNTIL 2030
Total Minimum Recycling: 65%	Total Minimum Recycling: 70%
Targets per material:	**Targets per material:**
i) 50% of plastic	i) 55% of plastic
ii) 25% of wood	ii) 30% of wood
iii) 70% of ferrous metals	iii) 80% of ferrous metals
iv) 50% of aluminum	iv) 60% of aluminum
v) 70% of glass	v) 75% of glass
vi) 75% of paper and cardboard	vi) 85% of paper and cardboard

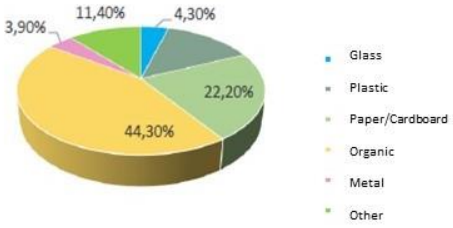
Source: National Waste Management Plan 2020-2030

Portable Batteries & Accumulators Waste

The amount of portable batteries and accumulators that wasted in 2018 in Greece were

1.646 tonnes and the quantity that collected was 553 tonnes, 33,6% of the production. There are no processing / recycling facilities in Greece for portable batteries and accumulators. The collected quantities are sent for further management (recycling) to processing units of other countries.

Table 5: Collective data of the current situation for Municipal Solid Waste

Municipal Solid Waste	
Current production (2018)	5.523.809 tonnes
Per capita production (2018)	514 Kg/ resident/year (according to Eurostat)
Quality composition (according to the National Waste Management Plan 2015)	
Current management (2018)	▪ Preparation for reuse and recycling for paper, metal, plastic and glass: 31% of the produced recycling ▪ Total recycling: 20.1% of the Municipal Solid Waste ▪ Total recovery (pre-shorting and through Municipal Solid Waste processing units): 21.6% of the Municipal Solid Waste ▪ Disposal at landfills
Sorting at source	▪ 16.5% of the Municipal Solid Waste ▪ 30.8% of the recyclable materials (paper, metal, plastic and glass) ▪ 5.7% of the biowaste

Source: National Waste Management Plan 2020-2030

1.2 Waste management methods

1.2.1 Waste management and disposal methods

According to Leblanc (2020), solid waste refers to the range of garbage materials—arising from animal and human activities—that are discarded as unwanted and useless. Solid waste is generated from industrial, residential, and commercial activities in a given area, and may be handled in a variety of ways. As such, landfills are typically classified as sanitary, municipal, construction and demolition, or industrial waste sites.

Solid waste management is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public health, conservation, economic, aesthetic, engineering, and other environmental considerations. Solid waste management includes planning, administrative, financial, engineering, and legal functions. The main purpose of solid waste management is reducing and eliminating adverse impacts of waste materials on human health and the environment to support economic development and superior quality of life (Leblanc, 2020).

Leblanc (2020) (https://www.thebalancesmb.com/an-introduction-to-solid-waste-management-2878102) defines the following six Functional Elements of the Waste

Management System:

1. **Waste generation**: This encompasses any activities involved in identifying materials that are no longer usable and are either gathered for systematic disposal or thrown away.
2. **Onsite handling, storage, and processing**: This relates to activities at the point of waste generation, which facilitate easier collection. For example, waste bins are placed at sites that generate sufficient waste.
3. **Waste collection**: A crucial phase of waste management, this includes activities such as placing waste collection bins, collecting waste from those bins, and accumulating trash in the location where the collection vehicles are emptied. Although the collection phase involves transportation, this is typically not the main stage of waste transportation.
4. **Waste transfer and transport**: These are the activities involved in moving waste from the local waste collection locations to the regional waste disposal site in large waste transport vehicles.
5. **Waste processing and recovery**: This refers to the facilities, equipment, and techniques employed to recover reusable or recyclable materials from the waste stream and to improve the effectiveness of other functional elements of waste management.
6. **Disposal**: The final stage of waste management. It involves the activities aimed at the systematic disposal of waste materials in locations such as landfills or waste-to-energy facilities.

Integrated Solid Waste Management (ISWM) is a contemporary and systematic approach to solid waste management. The U.S. Environmental Protection Agency (EPA) defines ISWM as a complete waste reduction, collection, composting, recycling, and disposal system. An efficient ISWM system considers how to reduce, reuse, recycle, and manage waste to protect human health and the natural environment. It involves evaluating local conditions and needs. Then choosing, mixing and applying the most suitable solid waste management activities according to the condition. A comprehensive waste management system for efficient waste collection, transportation, and systematic waste disposal—together with activities to reduce waste generation and increase waste recycling—can significantly reduce all problems caused by the wrong waste management approaches. An ISWM approach provides the opportunity to create a suitable combination of existing waste management practices to manage waste most efficiently. The four components or functional elements of ISWM include source reduction, recycling and composting, waste transportation and landfilling. These waste management activities can be undertaken either in interactively or hierarchically (Leblanc, 2019).

As mentioned above, disposal is the final stage of waste management but has been taking massive proportions. Though some advancement is being made in waste disposal methods, they are still not adequate. Seven effective Solid Waste Disposal and Management Methods are mentioned by the Compactor Management Company (https://www.norcalcompactors.net/waste-disposal-methods/):

1. Preventing or Reducing Waste Generation

The ideal waste management alternative is to prevent waste generation in the first place. Hence, waste prevention is a basic goal of all the waste management strategies (Lumen – Environmental Biology: https://courses.lumenlearning.com/suny-monroe-environmentalbiology/chapter/15-2-waste-management-strategies/). Extensive use of new

or unnecessary products is the root cause of unchecked waste formation. The rapid population growth makes it imperative to use second hand products or judiciously use the existing ones because if not, there is a potential risk of people succumbing to the ill effects of toxic wastes. Disposing of the wastes will also assume formidable shape. A conscious decision should be made at the personal and professional level to judiciously curb the menacing growth of wastes (https://www.norcalcompactors.net/waste-disposal-methods/). Numerous technologies can be employed throughout the manufacturing, use, or post-use portions of product life cycles to eliminate waste and, in turn, reduce or prevent pollution. Some representative strategies include environmentally conscious manufacturing methods that incorporate less hazardous or harmful materials, the use of modern leakage detection systems for material storage, innovative chemical neutralization techniques to reduce reactivity, or water saving technologies that reduce the need for fresh water inputs.

2. Recycling

Recycling refers to recovery of useful materials such as glass, paper, plastics, wood, and metals from the waste stream so they may be incorporated into the fabrication of new products (Lumen – Environmental Biology: https://courses.lumenlearning.com/suny-monroe-environmentalbiology/chapter/15-2-waste-management-strategies/). Recycling serves to transform the wastes into products of their own genre through industrial processing. Paper, glass, aluminum, and plastics are commonly recycled. It is environmentally friendly to reuse the wastes instead of adding them to nature. However, processing technologies are pretty expensive.

3. Incineration

Incineration features combustion of wastes to transform them into base components, with the generated heat being trapped for deriving energy. Assorted gases and inert ash are common by-products. Pollution is caused by varied degrees dependent on nature of waste combusted and incinerator design. Use of filters can check pollution. It is rather inexpensive to burn wastes and the waste volume is reduced by about 90%. The nutrient rich ash derived out of burning organic wastes can facilitate hydroponic solutions. Hazardous and toxic wastes can be easily be rid of by using this method. The energy extracted can be used for cooking, heating, and supplying power to turbines. However, strict vigilance and due diligence should be exercised to check the accidental leakage of micro level contaminants, such as dioxins from incinerator lines.

4. Composting

It involves decomposition of organic wastes by microbes by allowing the waste to stay accumulated in a pit for a long period of time. The nutrient rich compost can be used as plant manure. However, the process is slow and consumes a significant amount of land. Biological reprocessing tremendously improves the fertility of the soil.

5. Sanitary Landfill

This involves the dumping of wastes into a landfill. The base is prepared of a protective lining, which serves as a barrier between wastes and ground water, and prevents the separation of toxic chemicals into the water zone. Waste layers are subjected to compaction and subsequently coated with an earth layer. Soil that is non-porous is preferred to mitigate the vulnerability of accidental leakage of toxic chemicals. Landfills should be created in places with low groundwater level and far from sources of flooding. However, a sufficient number of skilled manpower is required to maintain sanitary landfills.

Sanitary landfills provide the most commonly used waste disposal solution. These landfills are desired to eliminate or reduce the risk of environmental or public health hazards due to waste disposal. These sites are situated where land features work as natural buffers between the environment and the landfill. For instance, the landfill area can be comprised of clay soil which is quite resistant to hazardous wastes or is characterized by an absence of surface water bodies or a low water table, preventing the risk of water pollution.
The use of sanitary landfills presents the least health and environmental risk, but the cost of establishing such landfills is comparatively higher than other waste disposal methods.

- Controlled dumps are more or less the same as sanitary landfills. These dumps comply with many of the requirements for being a sanitary landfill but may lack one or two. Such dumps may have a well-planned capacity but no cell-planning. There may be no or partial gas management, basic record keeping, or regular cover.
- Bioreactor landfills are the result of recent technological research. These landfills use superior microbiological processes to speed up waste decomposition. The controlling feature is the continuous addition of liquid to sustain optimal moisture for microbial digestion. The liquid is added by re-circulating the landfill leachate. When the amount of leachate is not adequate, liquid waste such as sewage sludge is used (Leblanc, 2019).

6. Disposal in Ocean/Sea

Wastes generally of radioactive nature are dumped in the oceans far from active human habitats. However, environmentalists are challenging this method, as such an action is believed to spell doom for aquatic life by depriving the ocean waters of its inherent nutrients.

7. Plasma Gasification

Plasma gasification is an environment-friendly waste disposal method. It is used to convert commodity recyclables extracted from the municipal solid waste in the landfill into energy. The carbon-based materials are exposed to high temperatures and converted to syngas, a gas which can either be directly combusted or further refined into chemicals and higher-grade fuels. The non-organic part of the waste is converted to slag – cooled, tightly bound solid waste which can be used in construction as a raw material. Industries that strive to achieve zero waste prefer this waste disposal method.

1.2.2 The issue of organic waste

Organic waste is any part of the food production and consumption chain that is organic in nature (including crop residues, manure, food processing waste, restaurant food waste etc). It could be animal and vegetable waste (Valta, 2019). According to the Directive Directive 2008/98/EC amended by the Directive 2018/851/EC organic waste (or bio-waste) is defined as “biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants and other waste with similar biodegradability and compostability properties”.

On a global scale, bio-waste and other biodegradable waste are considered a major anthropogenic source of methane emissions from landfill sites. Bio-waste is about 32% by weight of the total municipal waste of the EU. Greece has a highest share of bio-waste in the total municipal waste, accounting for about 40% by weight. The annual bio-waste generation in the EU countries is about 118 – 138 million tonnes, of which only 25% is successfully

recycled to high quality compost. In Greece the annual bio-waste generation is 2.47 million tonnes, of which only 2% is composted (Vitoraki, 2017).

Composting is the controlled aerobic decomposition of organic waste by the action of small invertebrates and microorganisms. The most common composting techniques include static composting, pest composting, window composting, and in-house composting.

Anaerobic digestion also uses biological processes to decompose organic matter. Anaerobic digestion, however, uses an environment free of oxygen and bacteria to decompose waste where the compost must have air to allow microbes to grow (Leblanc, 2019).

On March 17th 2017, the European Parliament adopted the following waste legislative proposals regarding to bio-waste:

- 70% target for recycling of municipal waste with a 5% of that waste to be prepared for reuse by 2030
- Obligatory separate collection for the main waste streams, including bio-waste
- Separate collection at source of bio-waste and introduction of European waste codes for municipal bio-waste that has been separately collected at source
- Introduction of EU's food waste reduction target of 30% by 2025 and of 50% by 2030 compared to the 2014 baseline (Vitoraki, 2017).

At national level, the Greek Law 4042/2012 on waste (article 41) sets specific targets for bio-waste management:

- Separate collection of bio-waste at least 5% by weight of the total quantities produced until 2015
- Separate collection of bio-waste, at least 10% of the total quantities produced until 2020

Further, it imposes an additional landfill fee of 35 euros/tonne of untreated bio-waste, which increases annually to a maximum fee of 60 euros per tonne of landfilled bio-waste (article 43). The National Solid Waste Management Plan, issued by the Ministry of the Environment in June 2015, describes the main strategies and policies for the management of bio-waste and provides directions for the regional and local waste management plans. The main objectives to be achieved by the year 2020 were the following:

- Clear reduction in per capita waste generation compared to 2015 level
- Preparation of re-use and recycling of source separated materials, including bio-waste must cover 50% of the total waste generation.

More specifically, with regard to bio-waste, the National Plan set the following priorities:

- Prevention of bio-waste using informational campaigns, in combination with economic tools
- Creation of decentralized facilities for composting or anaerobic treatment of source separated bio-waste
- Maximization of source separation of bio-waste, to enhance high-quality recycling
- Separate collection of 40% of bio-waste by 2020 (Vitoraki, 2017).

These objectives were not achieved, as those of the National Waste Management Plan of 2018. The National Waste Management Plan 2020-2030 provides for the strengthening of Sorting at Source by expanding the collection network of recyclable materials and biowaste through the special brown bin for organic waste / biowaste and composting.

1.3 Waste management strategies

1.3.1 The EU waste management strategy

The EU waste management policy has evolved over the last 30 years through a series of environmental action plans and a legislative framework aimed at reducing the negative impact on the environment and public health and creating an energy and resource-efficient economy.

The Sixth Environment Action Program of the European Community entitled "Environment 2010: Our Future, Our Choice", which covers the period from 22 July 2002 to 21 July 2012, focuses on four priority areas for action:

1. Climate change
2. Biodiversity
3. Environment and health
4. Sustainable management of resources and wastes

Thus, it is clearly stated that the EU is concerned about the rational use of natural resources and the reduction of the produced waste. The objective was to ensure that the consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment and to achieve a decoupling of resource use from economic growth through significantly improved resource efficiency and the reduction of waste. With regard to waste, the specific target was to reduce the quantity going to final disposal by 20% by 2010 and 50% by 2050. The actions to be undertaken in order to achieve the objective are the following:

- development of a strategy for the sustainable management of resources by laying down priorities and reducing consumption;
- taxation of resource use;
- removal of subsidies that encourage the overuse of resources;
- integration of resource efficiency considerations into integrated product policy, eco-labelling schemes, environmental assessment schemes, etc.;
- establishment of a strategy for the recycling of waste;
- improvement of existing waste management schemes and investment in quantitative and qualitative prevention;
- integration of waste prevention into the integrated product policy and the Community strategy on chemicals.

(https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:l28027&from=EL)

The Sixth Environment Action Program of the European Community was the beginning for the development of a long-term integrated strategy on the viable management of natural resources and wastes. This Thematic Strategy on the prevention and recycling of waste set out guidelines and described measures aiming at reducing the environmental pressure caused by waste generation and management. The main directions of the Strategy were the amendment of the legislation in order to improve the implementation, the prevention of waste production and the promotion of efficient recycling. According to this approach, any waste is not only considered a source of pollution that must be reduced, but also a resource that can be exploited. The waste reduction continues to be a priority but the waste reuse, recycling and recovery are promoted as well, taking into consideration the environmental impacts and the life cycle of the resources.

The 2005 Thematic Strategy on Waste Prevention and Recycling has led to the revision of the Waste Framework Directive, the cornerstone of the EU waste policy. This review introduced a modernised approach to waste management, marking a shift from the perception that waste is an undesirable burden on seeing it as a valuable resource promoting recycling and reuse. The strategy simplifies the existing legislation by integrating the Waste Framework Directive with the Hazardous Waste Directive and the Waste Oils Directive by removing overlaps between the Waste Framework Directive and the Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (IPPC Directive) and by merging the three Titanium Dioxide industry waste directives. From that time, Member States are required to develop waste prevention programs and to promote the recycling sector in order to re-introduce waste into the economy in the form of quality products. Some substances are extremely dangerous and polluting and pose serious risks to the environment and health when removed from the economic circuit. (http://waste-prevention.gr/waste/wp-content/uploads/2015/10/2015_Strategy%20on%20the%20prevention%20and%20recycling%20of%20waste%201_GR.pdf)

The new Waste Framework Directive introduced the concept of life cycle in waste policies. All products and services have environmental impacts, from the extraction of raw materials to their production, distribution, use and disposal, including the use of energy and resources, soil, air and water pollution and greenhouse gas emissions. Life cycle approach involves the examination of all stages of a product's life to identify where improvements can be made to reduce environmental impact and resource use and to avoid actions that shift negative effects from one stage to another.

The revised Waste Framework Directive of 2008 introduced a five-step waste hierarchy where prevention is the best option, followed by re-use, recycling and other forms of recovery, with disposal such as landfill as the last resort. In line with this hierarchy, the 7th Environment Action Programme sets the following priority objectives for waste policy in the EU:

- reduce the amount of waste generated;
- maximise recycling and re-use;
- limit incineration to non-recyclable materials;
- phase out landfilling to non-recyclable and non-recoverable waste;
- ensure full implementation of the waste policy targets in all EU Member States.

(Eurostat: https://ec.europa.eu/eurostat/statistics-

explained/index.php?title=Waste_statistics&oldid=503336#Total_waste_generation)

1.3.2 The Greek National Waste Management Strategy

Concerning the National Greek legislation in the beginning of 2000s, the Joint Ministerial Decision 50910/2727/2003 on 'measures and conditions on solid waste management - National and Regional Management Plan' in 2003, aimed to coordinate waste management, setting specific rules and targets which should be met in waste management planning at the national and regional levels (Vitoraki, 2017).

According to the Article 28 of Directive 2008/98 / EC, Member States shall ensure that their competent authorities establish, one or more waste management plans that cover the entire geographical territory of the Member State concerned. In accordance to the Directive 2008/98 / EC and the articles 22 and 35 of National Law 4042/2012 (A' 24), Greece developed the National Waste Management Plan from 2015 until 2020. The ultimate goal is to reduce the negative effects of waste generation and management, reduce the overall impact of the use of resources and improve their efficiency, for the protection of the environment and human health.

The National Waste Management Plan sets out the waste management policy, strategies and objectives at the national level and sets out the general guidelines for waste management, indicating the appropriate measures and actions to achieve the objectives and principles set by Law 4042 / 2012 (A '24). The ECHR, as a political and strategic planning, is applied to all waste that fall within the scope of Directive 2008/98 / EC, in accordance with article 10 of Law 4042/2012 (AD 24).

Regional Waste Management Plans are developed in each Region, which specify the integrated management of all waste generated in their geographical unit according to the objectives and provisions of the National Waste Management Plan. Each Regional Waste Management Plan is designed and implemented by the relevant Regional Solid Waste Management Agency and, if it does not exist or does not operate, by the relevant Regional Authority. In the cases that there are more Solid Waste Management Agencies in one Region, the coordination is undertaken by the Regional Authority as well.

For certain categories of waste, the Ministry prepares Special National Waste Management Plans, which regulate in particular the management of these streams as a whole at national level and which take into account the regulations of the National Waste Management Plan.

The national waste policy was oriented towards the following goals - milestones until 2020:

- per capita waste has been drastically reduced
- the preparation for reuse and recycling with a separate collection of recyclable – organic waste to be applied to 50% of the total Municipal solid waste
- energy recovery is a complementary form of management when the margins of any other type of recovery have been exhausted
- landfilling is the last option and is limited to less than 30% of all Municipal

solid waste

According to the National Waste Management Plan, the strategies for implementing the new national waste management policy are the following:

1. **Development of an integrated framework for waste management planning:**

- Development of a national strategic plan for the prevention of waste generation, which sets out the priorities and national objectives regarding the way of prevention of waste generation, formulates the prevention strategy, which define the necessary measures and actions to be taken that are specialised in the Regional Waste Management Plans and local municipal management plans.
- Development of special national plans, at least for hazardous waste as well as in particular for hazardous waste of sanitary units, as operational plans for these streams.
- Revision of Regional Waste Management Plans, mainly non-hazardous waste, as operational plans for these streams and their specialisation at the level of municipality, organized community, group, activity and company.
- Harmonization of waste management planning frameworks with national and regional spatial planning.
- Defining the obligation of Municipalities to plan and implement local decentralised waste management plans, in the context of national and regional plans. The specifications, objectives and schedule of the local plans are included in the form of a model in the annex to the National Waste Management Plan. In this context, all those necessary arrangements will be identified that will ensure the ability of the Local Government to undertake all the activities required for the implementation of a local decentralized management plan.

2. **Ensuring protection of the environment and human health:**

- Enhance the development of the central mechanism for recording and processing production and waste management data, in order to ensure traceability from production to their final destination. Development of an appropriate network of waste recovery and disposal infrastructure.
- Rehabilitation of contaminated waste disposal areas.
- Creating the conditions for the reduction of waste exports, as this implies a significant loss of potential resources and at the same time recycling and recovery opportunities in the country, unless there is no corresponding infrastructure in the country.
- Elimination of illegal waste transport within the country, for the development of healthy and environmentally sound entrepreneurship in the field of waste management.
- Strengthen inspections of controls and enforcement mechanisms to ensure compliance with legislation.

3. **Application of Sorting at Source, as the most appropriate collection method in order to achieve high quality recycling. By taking the following measures:**

- Establishment of a separate collection of waste structure nationwide, in order to achieve the necessary quality standards in the respective recycling sectors. Separate

collection is established at least for glass, paper, metal and plastic, in order to ensure recycling of at least 60% of total weight from the pre-qualification stage until 2020.

- Establishment of separate collection of organic waste, as a primary step of the new management system, to facilitate the separate collection and recycling of selected organic waste to achieve the goal of separate collection, ie 40% of the total weight of organic, by 2020. Treatment of separately collected organic waste in order to produce compost that meets quality standards for its further use in accordance with international and / or national standards.
- Adoption of measures and creation of a new network of Green Points and Recycling Training Centers for Sorting at Source, with spatial and demographic criteria at least one per municipality.
- Adoption of measures in order to achieve at least the objectives of the National Law 4042/2012 (A' 24) by 2020 regarding the preparation for reuse, recycling and recovery of constructions and demolition materials.
- Radical review of the operation of Alternative Management Systems and their redesign, within a single central coordinating body for solid waste management. Review of the institutional framework with a view to optimizing the operation, transparency and control of alternative management systems in other materials, within a framework of a single central coordinating body.
- Additional use of energy recovery methods, provided that they do not alter the objectives of material prescribing and recovery
- Priority in the further recovery of materials, over the production of secondary fuels, in waste processing industries.
- Limiting the disposal of non-recoverable waste on landfills (especially biodegradable municipal waste).

4. Rationalize of the cost of waste management services and promote economically and environmentally sustainable investments in the waste sector, with the aim of institutionalizing a reciprocal benefit to the citizen from recycling:

- Support of environmental technologies, and innovation, which are considered important for both developing and emerging economies, where there are significant growth trends, to promote the hierarchy in waste management.
- Providing incentives for the implementation of the Green Points nationwide by the Municipalities for the reuse and recycling of waste.
- Providing incentives for the implementation of nationwide Green Points and Centers for Recycling, Education, Sorting at the source only for education and sorting at the source of waste only in the framework of a program contract with municipalities, within the administrative boundaries of municipalities.
- Promoting voluntary action on green procurement agreements and the supply of sustainable / green products.
- Improving working conditions and eliminating hazardous and unhealthy conditions in the field of waste management.
- Upgrading waste management services to citizens and waste producers, raising awareness and encouraging the active participation of citizens through extensive

consultation and implementation of management actions (recycling, reuse, composting, residue) during waste generation.

- Development of a national communication strategy, aiming at informing and raising awareness in the field of waste, for the general population and selected target groups.
- Development of an effective mechanism for transparency, systematic information, support and training of those involved in the production and management of waste.
- Improving access to information of stakeholders through e-government.
- Institutionalize the responsibilities of municipalities, so that they can implement the full range of actions of local management plans, including the smooth disposal of recyclable materials and enhance their technical competence as well as other waste management bodies
- Encourage initiatives and participation of social economy actions in the framework of local decentralized management plans.
- Development of collaborations between local communities and stakeholders in waste management, with the aim of achieving social consensus. In particular, per waste stream, the strategies adopted are:

  Municipal solid waste

  - Establishment of separate collection and recovery of organic waste.
  - Establishment of separate collection of paper, glass, metals and plastics.
  - Organising of the separate collection in other streams of Municipal solid waste with targeted collection for further preparation for reuse and recycling.
  - Consider home composting as recycling and not as prevention.
  - Institutionalization of measures to prevent waste production and in particular for food waste and packaging. Development of a Special Waste Management Zone for island and tourist areas.
  - Upgrading the quality of city equipment (bins, vehicles, sidewalk cuttings, public cleaning symbols, street sweepers, etc.).
  - Institutionalization of local government regulations that will organise local communities and reward the environmental management of Municipal solid waste.

  Municipal type sludge

  Treatment of sludge as a resource - source of organic matter for agricultural use or energy recovery.

  Waste of sanitary units

  Ensuring the separate collection of the individual categories of sanitary units waste and their legal management, inside or outside sanitary units.

  Industrial waste

  - Priority, reuse and recovery, if it is not possible to use the waste as resources during the production process.
  - Strengthen cooperation between industries, so that the waste of one industry is channeled as raw materials to other industries or used in other industrial sectors.

Promotion of sectoral voluntary agreements.

- Ensure the prohibition of mixing hazardous industrial waste with other hazardous or non-hazardous waste / materials.
- Creation of the necessary hazardous waste management infrastructures, designed by the state and implementing the "polluter pays" principle in order to ensure on the one hand the best environmental and social practice and on the other hand the safe use of waste as resources in the production process.

5. Waste of utility facilities, public services, etc.

Promoting the implementation of separate collection systems of at least paper, glass, metals and plastics with the best economically and environmentally sound method and by maximizing efficiency under the responsibility of the operators of the facilities.

6. Livestock waste

- Pursuit of full recovery of agricultural waste, with priority given to its recovery in agriculture and the establishment of cooperation with the biodegradable waste recycling industry.
- Optimal utilization of the energy content of agricultural waste.
- Promotion of organic methods in agricultural production, in order to increase the absorption of soil-improving material produced from agricultural waste.
- Establishment of the necessary hazardous waste management infrastructure, designed by the state and in application of the "polluter pays" principle in order to ensure on the one hand the best environmental and social practice and on the other hand the safe use of waste as resources in the production process.
- Ensure the environmentally sound management of agricultural and livestock production waste (greenhouse plastics, pesticide packaging, etc.).
- Informing and sensitizing the producers of agricultural and livestock products, regarding the benefits (financial and other) that can bring the legal management of this waste.

7. Alternative management flows

- Review of the role and Radical review of the operation of the citizen service points, upgrade of the role of the local authorities, especially with regard to the municipal waste included in the alternative management, review of the business plans of the citizen service points and in this context redefining of the financial contributions.
- Nationwide expansion of recycling.
- Full implementation of alternative management in the public administration and in the sectors of the tourism market, science and social collectives.
- Establishment of a separate collection of packaging waste per material.
- Quality upgrade of recycling.
- Enhance the collection of packaging waste / other products.
- Enhance recycling recovery.
- Fight against contribution evasion.
- Development of markets for recovered materials.

- Integration of new currents in alternative management.
- Registration of managers / producers of packaging / other products.
- Awareness raising of the general population / institutions.
- Involvement of Civil Society

8. Small amounts of hazardous waste in Municipal areas

- Separate collection of small amounts of hazardous waste in Municipal areas from the stream of Municipal solid waste and their further appropriate management.

9. Waste containing mercury

- Gradual abolition of uses and emissions of mercury, excluding uses for research and development, medical or chemical analysis purposes.
- Development of a mercury waste management system by recording the sources of origin and development of the transmission and storage collection network.

10. Waste containing asbestos

Reduction of cross-border shipments of asbestos waste and, as a matter of priority, its disposal within the country.

1.3.3 The Greek National Waste Management Plan 2020 -2030

The National Waste Management Plan 2020-2030 has been prepared in accordance with the provisions of articles 22 and 35 of the National Law 4042/2012 (A' 24), as amended by article 83 of Law 4685/2020 (A' 92). It includes all the provisions of Article 28 of Directive 2008/98 / EC, covering at the same time all the new obligations and all the new elements introduced in this Article through Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018, as well as the EU guideline "The role of Waste-to-Energy in the circular economy" COM (2017) 34 final / 26.01.2017. It also includes a special chapter on the management of packaging and packaging waste, in full compliance with the provisions of Article 14 of Directive 94/62 / EC of the European Parliament and of the Council on packaging and packaging waste. This National Waste Management Plan contains the necessary measures provided in Article 5 of Directive 1999/31 / EC (L 182) on landfill as amended, as well as the basic guidelines to be applied to Disposable Plastics, in accordance with Article 11 of Directive (EU) 2019/904. In addition, hazardous waste is considered as a separate stream under the National Waste Management Plan.

The main changes brought by the National Waste Management Plan 2020-2030

- It sets as a main target the reduction of the municipal solid waste landfill, which is the lowest level of management in the waste hierarchy pyramid, to less than 10% in 2030, bringing this target five years earlier than the European burial rate 10% in the year 2035.
- The above goal will be achieved by promoting reuse, enhancing recycling rates,

promoting the secondary materials market, informing and raising public awareness, the rapid development of organic waste and recyclable collection networks, the creation of modern infrastructure for waste and organic waste management, the upgrade of the Diagnostic Assessment and Support Centres and increase of their number and the energy utilization of alternative (secondary / waste) fuels and processing residues.

- It attaches great importance to recycling and sorting at source. In particular, it promotes the universal separate collection of organic waste for the whole country at the end of 2022, one year earlier than the European directive. At the same time, it promotes the separate collection of 4 streams in recycling, and the creation of a network for the amplification of the collection of recyclable materials.

- The National Waste Management Plan 2020-2030 set the target of recycling, according to the requirements of the relevant EU legislation and more specifically the Directive 2018/851 and 2018/852 (L 150) and the Directive on the Disposable Plastics 2019/904 (EU, L 155).

- The national planning aims to maximize the recovery and utilization of Industrial Non-Hazardous Waste from waste processing units. Promotes the adoption of the principles of the circular economy and industrial coexistence for the utilization of their waste as secondary raw materials or alternative fuels.

- Proposes actions for the proper and integrated management of the agricultural waste of the country, which constitute the largest category of waste (approximately 40%) and whose management to date, with few exceptions, is done in a non-acceptable manner, such as incineration, during which significant amounts of gaseous pollutants are emitted.

- Includes planning for the collection and recovery of biodegradable agricultural waste and its utilization in the production of by-products (such as fertilizers) and / or alternative fuels.

- It places particular emphasis on the responsibilities of producers in the context of extended producer responsibility. It thus explicitly provides for, among other things, the allocation of responsibilities for the collection of waste to the Alternative Management Systems that operate now and the creation of new systems of extended producer responsibility for waste such as furniture, mattresses, greenhouse waste, textiles, textile waste and packaging.

In addition, the new national plan:

✓ enables and encourages the cooperation between the public and the private sector for waste management. This applies to all levels of waste management such as collection, sorting, processing.

✓ includes a detailed plan for the operation of the necessary infrastructure for the whole country, namely the Waste Treatment Units and the Bio-Waste (organic) Treatment Units.

✓ envisages a specific plan for the development of new, and the strengthening of existing networks for the collection of recyclable materials and organic waste.

✓ follows the best practices from the EU in the context of the circular economy, for the utilization of secondary alternative fuels for energy production, contributing to the reduction

of waste landfill.

✓ takes into account tourism and in particular the intensity it brings to waste production and management. It is estimated that approximately 3.3% of the Municipal solid waste produced (reference year 2018) is a result of external tourist flows in the country, a percentage that is expected to reach the years 2025 and 2030, 5.4% and 7.5% of the total Municipal solid waste respectively.

The National Waste Management Plan 2020 – 2023 proposes the following key measures:

- Modernization of the "environmental contribution" (landfill fee) in the waste that leaded to landfill, in order to prevent landfill.
- Application in practice of the principle "pay as much as you throw", so that they can measure the production of waste either in total or in some of the streams, especially at the level of housing, building, Municipal unit, selected producers.
- Enhancement of Sorting at Source by expanding the collection network of recyclable materials and organic waste.
- Reinforcement and upgrade of Recycling Materials Sorting Centers.
- Establishment of an adequate national network of waste treatment units throughout the country. Today only 5 units are operating. Another 30-38 units are projected by the end of 2023.
- Promoting the production of alternative secondary fuels from waste treatment units and from the waste of the Recycling Materials Recycling Centers.
- Creation of power generation units (at least 3-4 units) from the residues of the Waste Treatment Units of Recyclable Material Sorting Centers, so that the country can achieve the reduction of landfill waste, below 10%.
- Creation of a special electronic platform, on the basis of which the Regional Waste Management Plans and the National Waste Management Plan will be monitored.
- Publication of the Decisions of Approval of Environmental Conditions of the industrial facilities based on the provisions of the new environmental law (4685/2020), aiming at the smallest possible production of industrial waste.
- Development of a special electronic waste platform in order to promote synergy between industries for the recovery of industrial waste.
- Definition of streams of industrial waste that can be a secondary raw material or alternative fuel from industrial facilities all over the country as well as definition of technical specifications for the use of inorganic waste of industrial origin as secondary materials.
- Development of a network for the collection of biodegradable waste from agricultural and livestock origin and their reuse either in the primary sector or in other productive activities.
- Promotion of the separate collection and recovery of plastics of agricultural origin with emphasis on greenhouse plastics and plant protection packages and especially the packaging plastics that are in contact with them.
- Establishment of a program for monitoring the management of livestock waste.
- Creation and organization of landfills for hazardous waste (landfill) by 2022-23. There is a special need in the country for the safe disposal of asbestos waste.
- Coverage of the country, with priority on the islands, with management systems for Excavation, Construction and Demolition Waste. Simultaneously promoting the simplification

of bureaucratic procedures for the regeneration of inactive quarries.

- Collection of medical waste of small units of health interest (medical clinics, veterinary clinics and dental clinics).
- Installation of collection bins at all points of production of industrial vehicle batteries, such as petrol stations, workshops, industries / handicrafts, end-of-life vehicles, power units and others, in order to achieve the goal of recycling 100% of waste vehicles accumulators and industry.
- Promotion of the use of recovered materials from the processing of used tires by public bodies.
- Raising public awareness - boosting confidence in recycling with a holistic approach to the environmental and economic importance of recycling and diversion of landfill waste, with the ultimate goal of adopting the principles of the Circular Economy. Particular emphasis will be placed on special campaigns at younger ages, such as schools.

Chapter 2. Methodology for strategic management of zero waste

2.1 Research methods and waste classification

The framework for waste management in the EU Member States is set out with the Directive (EU) 2018/851, which also includes the "extended producer responsibility". It prioritizes waste prevention as the best solution, followed by preparation for reuse, recycling, recovery and disposal. The hierarchy of waste is defined in Article 4 of Directive 2008/98 / EC (Valta, 2019).

Directive 2008/98/EC sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odours, and without adversely affecting the countryside or places of special interest. Waste legislation and policy of the EU Member States shall apply as a priority order the following waste management hierarchy:

Figure 2: Waste Management Hierarchy

Source: European Commission (https://ec.europa.eu/environment/waste/framework/)

Simon (2019) describes in another more extended way the “new” Zero Waste Hierarchy in The Zero Waste Europe in cooperation with the Zero Waste International Alliance, which introduces the concept of the Circular Economy (https://zerowasteeurope.eu/2019/05/a-zero-waste-hierarchy-for-europe/). This “new” Zero Waste hierarchy has seven levels, two related to products and 5 related to waste:

1. REFUSE, RETHINK, REDESIGN (stopping waste from being produced)
2. REDUCE AND REUSE
3. PREPARATION FOR REUSE
4. RECYCLING, COMPOSTING, ANAEROBIC DIGESTION
5. MATERIAL AND CHEMICAL RECOVERY

6. RESIDUALS MANAGEMENT

7. UNACCEPTABLE

Figure 3 depicts this “new” Zero Waste Hierarchy model:

Figure 3: Zero Waste Hierarchy

Source: Zero Waste Europe (https://zerowasteeurope.eu/2019/05/a-zero-waste-hierarchy-for-europe/)

In 2018, after 4 years of negotiations, the Circular Economy Package presented a new legislation which aims at recycling 65% of total municipal waste by 2035. Although the targets could have been more ambitious, the legislation contains the relevant elements to move towards a Zero Waste Circular Economy, such as separate collection of organic bio-waste and textiles that become compulsory by 2023 and 2025, respectively, and the call on the Commission to propose targets on waste prevention and food waste reduction (Zero Waste Europe, 2020).

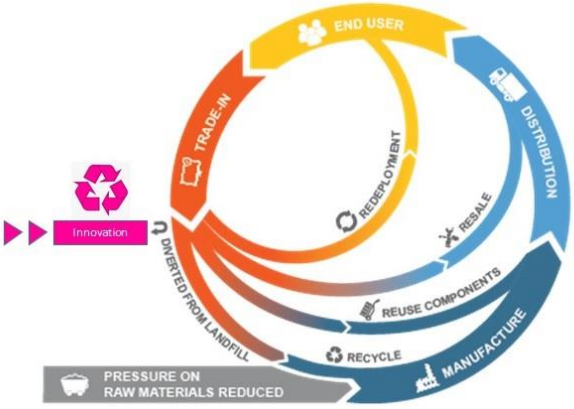


Figure 4: Circular Economy for Zero Waste model

Source: SIMS Lifecycle Services https://www.simslifecycle.com/press-releases/surfsara/

The circular economy in waste management integrates the processes of reuse, repair, renovation, exchange, rental, source sorting and product recycling to achieve the following objectives:

- Prolongation of the life cycle of raw materials and goods
- Waste reduction
- Environmental Protection
- Saving raw materials
- Stimulation of innovation
- Job creation

(Scheiner Gabriela, Hellenic-German Assembly - Thessaloniki Office, www.grde.eu, presentation at a conference: https://gr.boell.org/el/2019/04/15/dimioyrgia-kentroy-epanahrisis-sto-dimo-thessalonikis).

The main categories of waste

The categories of non-hazardous and hazardous waste are the following:

1. MUNICIPAL TYPE WASTE

- Municipal Solid Waste
- Municipal Sludges

2. INDUSTRIAL WASTE (excluding those included in alternative management or other categories):

- Industrial non-hazardous waste
- Industrial hazardous Waste

3. AGRICULTURAL WASTE

(from both agricultural and livestock activities)

4. OTHER DANGEROUS WASTE

- Waste containing asbestos
- Waste packaging of hazardous substances
- Waste containing polychlorinated biphenyls / triphenyls (PCB / PCT)

5. WASTE OF EXCAVATIONS, CONSTRUCTIONS AND DEMOLITIONS

6. OTHER WASTE CURRENTS SUBJECT TO ALTERNATIVE MANAGEMENT

- Waste of (Lubricant) Oils
- End-of-Life Vehicles
- Waste of Accumulators for Vehicles and Industry
- Waste of Electrical Equipment
- Used Vehicle Tires

7. HAZARDOUS WASTE OF HEALTH UNITS

- Purely Infectious Hazardous Waste
- Mixed Hazardous Waste
- Other Hazardous Waste

Concerning the waste produced by the citizens, organic waste from the garden, kitchen and food consumption accounts for about one third of the household waste. On average, 40% of the organic waste of the EU Member States is transported to landfills. The impermeable conditions of the landfills do not allow the materials, especially the biodegradable waste, to decompose completely and due to the lack of oxygen they give off methane, which is one of the dangerous greenhouse gases. However, organic waste can alternatively be used for energy production or compost.

The safe collection and management of electronic waste is also of great importance because it contains hazardous substances, such as heavy metals, which can cause environmental pollution and significant health problems. Electronic waste also contains significant amounts of valuable raw materials, such as gold, silver and platinum. The EU legislation places restrictions on the amount of dangerous substances in electrical and electronic equipment. At the same time, it sets targets for the amount of electrical and electronic equipment waste that the Member States must collect and recycle. The EU rules for the management of electrical and electronic equipment waste promote producer responsibility. Manufacturers are financially responsible for the reuse, recovery or disposal of the products they produce. The producers pay a fee for the collection and recycling of an amount of waste relevant to the goods they sell in the market. This forces them to look at the whole life cycle of the goods they produce and motivates them to develop products that avoid waste and can be used in recycling and recovery procedures.

2.2 Principles for Strategic Management of Zero Waste

The Zero Waste International Alliance (http://zwia.org/zero-waste-community-principles/) set some basic practical steps for communities in order to design and implement a successful zero waste strategy:

- **Adopt the Zero Waste definition of the Zero Waste International Alliance**: “Zero Waste: The conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without

burning and with no discharges to land, water, or air that threaten the environment or human health."

- **Establish benchmarks and a timeline** to meet goals for measuring success and monitoring accomplishments. Communities should aim to make significant strides within five years and to invest local resources and leadership in achieving tangible and visible accomplishments that demonstrate to the public this new direction as quickly as possible.
- **Engage the whole community**. Citizens or communities need to take the leadership role in organizing meetings to engage all sectors of the community. All organizations (nongovernmental organizations, grassroots movements, business and governmental) that provide waste reduction, takeback, reuse, recycling and composting services should be involved in order to achieve Zero Waste at home, at school, at university, at work and at play, while their communities develop longer term policies and programs for the entire community.
- **Demand decision makers manage resources not waste**. Landfill practices must be reformed to prevent all pollution of air and water including pre-processing all residues at landfills before burial to stabilize the organic fraction and prevent methane generation and the use of Residual Separation and Research Facilities. Landfills are a major source of greenhouse gases. More energy can be saved, and global warming impacts decreased, by reducing waste, reusing products, recycling and composting than can be produced from burning discards or recovering landfill gases.
- **Use economic stimulus funds and fees levied on tons of waste hauled or landfilled** to fund programs to educate and train Resource Managers to use a Zero Waste approach, to develop programs for handling community discards, and to create green jobs and to enforce environmental rules.
- **Educate residents, businesses and visitors**. Communities must establish programs to educate and train residents, school children, college students, businesses, and visitors about new rules and programs on Zero Waste.
- **Perform Zero Waste Assessments**. Communities should conduct a waste audit to find out the amount and type of waste being produced in their community. Data can be collected. These audits should be used as a baseline to identify recovery and employment opportunities, cost savings and measure the success of the reduction and recovery program.
- **Build Residual Separation and Research Facilities**. In the interim phase, residuals should be sent to Residual Separation and Research Facilities before the remaining inerts are allowed to be buried in a landfill designed to have no air or water emissions.
- **Develop New Rules and Incentives to move towards Zero Waste**. Communities can significantly change what is "economic" in the local marketplace with new policies, new rules and new incentives. Communities should restructure contracts and policies to make the avoided costs of collection and disposal a key engine for moving towards Zero Waste.
- **Enact Extended Producer Responsibility (EPR) Rules**. Communities need to help and encourage local businesses to take back products and packaging at their stores and factories from consumers. They should also advocate for state and national EPR

policies and programs for brand-owners and producers. This gives producers the financial incentive to redesign products to make them less toxic and easier to reuse and recycle. Products and packages that cannot be reused, recycled or composted locally or are toxic should be required to be taken back at the point of sale or facilities set up by producers to conveniently receive those products at no cost from the public.

- **Remove government subsidies for wasting.** Governments, particularly in the US, have adopted many tax incentives to encourage mining and timber harvesting, which are no longer needed and subsidize the wasting of resources. Governments have also subsidized incinerators under the guise of "Energy from Waste" when in fact such facilities waste energy. Government regulations of landfills have also inadequately addressed leachate, methane generation and perpetual long-term care, which is an indirect subsidy for wasting. Community adopted garbage rate structures have also made it cheaper to waste than recycle, rather than adopting Pay As You Throw incentives. Communities should remove the subsidies for wasting in its control, and call for the removal of all these other subsidies.
- **Support Zero Waste Procurement**. Local governments should adopt the Precautionary Principle for municipal purchasing to eliminate toxic products and services; purchase Zero Waste products and services; avoid single use products and packaging; return to vendors any wasteful packaging; reduce packaging and buy in larger units; use reusable shipping containers; purchase reused, recycled and compost products; buy remanufactured equipment; lease, rent and share equipment; buy durables (using life-cycle cost analyses); and encourage businesses and institutions to follow these practices as well.
- **Expand Zero Waste Infrastructure**
    - Zero Waste Infrastructure (developing locations for reuse, recycling and composting businesses to collect and process materials, manufacture products, and sell products to the public, including Resource Recovery Parks)
    - Support Reuse Businesses, NGOs and citizens groups
    - Get Compostable Organics out of Landfills and back to the soil
    - Support Zero Waste practices at businesses and institutions
    - Construction, Demolition, Landclearing and Remodeling (C&D) – Adopt deconstruction, reuse and recycling policies citywide (Green Building programs to prioritize deconstruction and reuse, and to require all new buildings to provide space for recycling containers)
    - Locally owned and operated local enterprises. Wherever possible communities should support locally owned and operated community enterprises, to manage and use local discards sustainably and create jobs and training opportunities in the local community.
- **Challenge Businesses to lead the way to Zero Waste**. Zero Waste Businesses are reducing their costs of managing resources and discards, increasing their operating efficiency, decreasing their carbon footprint (including energy use) and decreasing their long-term liability (http://zwia.org/zero-waste-community-principles/).

2.3 Strategic Zero Waste Management Techniques

2.3.1 Landfill

Landfills are very important. Even in the cases of integrated management systems, the products of management end up in landfills. According to Panagos and Sandalakis (2015), in most cases, a landfill can be used for 20 to 30 years. The duration of decomposition of solid waste inside the landfill reaches or exceeds 100 years. Landfills have revenue only during their operation and must be monitored for at least 30 years after their closure. The equipment and materials of a landfill, after the end of its post-care period, can not be used, so in addition to the environmental costs, the next generations are also charged with its financial costs.

2.3.2 Mechanical - Biological Treatment & Heat Treatment

The Greek Joint Ministerial Decision 29407/3508/2002 on Landfill sets a new framework for the design of Landfills in order to improve the chemical composition of waste that eventually ends up in landfills. The Mechanical - Biological Treatment can be used either individually or before the Thermal Treatment for the production of energy and the reduction of the waste that is buried in the Landfills. The methods of biological waste treatment are applied to wastes that can be treated in this way, ie organic, biodegradable waste including some agricultural waste and residues, solid waste and sludge from food industries, sludge of biological treatment of municipal sewage and municipal waste. Biological treatment methods are based on the controlled growth and activity of microorganisms that treat biodegradable waste. The basic forms of biological treatment of organic biodegradable waste are aerobic treatment (composting or biological drying) and anaerobic digestion. Composting leads to the production of a stabilized material (high quality compost or compost -type material), biological drying to the production of secondary fuel enriched in biodegradable materials and high calorific value, while anaerobic digestion to the production of energy (biogas) and a relatively hydrogenated residue. Before entering the biological treatment, the municipal solid waste must be subjected to pre-treatment based mainly on mechanical methods. The method of pre-treatment of incoming waste depends on the type and purity of the waste.

2.3.3 Composting

Composting is based on the natural process that results in the degradation of organic matter by microorganisms. Degradation takes place if the organic mass is supplied with moisture and a sufficient amount of air. The process is the same as the degradation that takes place in nature, for example in forest soils or fields. The fact that the process takes place under controlled conditions differentiates composting from the natural degradation that takes place in nature and is responsible for recycling nutrients. Composting is a method of managing the organic part of solid waste and aims at the optimal degradation of the organic fraction and the creation of a final product, stable, ideal for storage and use in the soil, without compromising the environment. The term composting includes the aerobic process, which leads to an increase in the temperature of organic matter as carbonaceous compounds are consumed as energy sources by microorganisms. In this process, significant physical, chemical and microbial changes take place making the final product completely

different from the original. The composting process is carried out under controlled conditions of ventilation and humidity, carbon / nitrogen ratio, pH and temperature. The products of composting are water, carbon dioxide and compost which is a humic content, rich in organic ingredients.

In any case, the most desirable way for the viable waste management is summarised in three “r” words: Reduce, Reuse and Recycle.

Chapter 3. Analysis of quantitative and structural indicators in the field of waste management in the Regions of Greece for the period 2017 – 2019

3.1 Waste sources

In a the total of 30.943.819 tonnes of waste produced in Greece in 2018, 40,3% was agricultural waste, 24% industrial non-hazardous waste, 17,9% municipal solid waste and 16% excavation, construction and demolition waste . The quantities, categories and waste flows in the reference year 2018 in Greece are presented in Table 6.

Table 6: Waste production in Greece in 2018

Waste category	Production in 2018 (tonnes)	Percentage
1. MUNICIPAL WASTE		
Municipal Solid Waste	5.523.809	17,9%
Urban Sludges	114.021	0,4%
2. INDUSTRIAL WASTE (not including those in alternative management or other categories)		
Industrial non-hazardous waste*	7.469.790	24%
Industrial hazardous waste	99.655	0,3%
3. AGRICULTURAL WASTE		
Agricultural waste	12.469.086	40,3%
4. OTHER HAZARDOUS WASTE		
Waste containing asbestos **, Hazardous packaging waste Waste containing polychlorinated biphenyls / triphenyls	2.994	~ 0%
5. EXCAVATION, CONSTRUCTION AND DEMOLITION WASTE		
Excavation, Construction and Demolition Waste	4.943.092	16%
6. OTHER WASTE ELEMENTS BELONGING TO ALTERNATIVE MANAGEMENT		
Waste (Lubricants) Oils, End of Life Vehicles, Waste Batteries for Vehicles and Industry, Waste Electrical - Electronic Equipment, Used Vehicle Tires	303.602	1%
7. HAZARDOUS WASTE OF HEALTH UNITS		
Hazardous Waste Purely Infectious, Mixed Hazardous Waste & Other Hazardous Waste	17.770	0,1%
TOTAL WASTE PRODUCTION	**30.943.819**	**100%**

Source: National Waste Management Plan 2020 - 2030

According to the National Waste Management Plan 2020 – 2030, in 2018, 5.523.809 tonnes of Municipal Solid Waste were produced in Greece. The production of the per capita Municipal Solid Waste was 514 kg / inhabitant / year according to Eurostat. At national level, 4,30% of the Municipal Solid waste produced in 2018 was glass, 13,90% plastic, 22,20% paper and cardboard, 43,30% organic waste, 3,90% metal and 11,40% other.

Concerning the Municipal Solid Waste management in 2018 in Greece:

- 31% was prepared for reuse and recycling for paper, metal, plastic and glass
- 20,1% was totally recycled
- 21.6% was totally recovered
- 78,4% was disposed in landfills.

3.2 Waste volumes

The most reliable data regarding the waste volumes at national level are provided by the Hellenic Statistical Authority (www.statistics.gr), which is publishing data every two years. The last report was published in 2020 including data from 2018.

3.2.1 Waste volumes 2017 -2019 in Greece

The Hellenic Statistical Authority announced data on the generation and treatment of waste for the year 2018, which are collected from administrative sources. During the year 2018 the following were noticed:

- Waste generation for the year 2018 amounted to 45,592,603 tons and decreased by 37.0% compared to 2016. Respectively, waste treatment amounted to 42,651,993 tons while it decreased by 39.0% compared to 2016
- Regarding the categories of waste generated, in 2018, "Mining and other waste activities" account for 79.5% of total waste generated and "Municipal solid waste" account for 11.8%
- Concerning the generation of waste by sections of the statistical classification of economic activities (NACE Rev. 2) and households for 2018, "Mining and quarrying" account for 56.4% of the total generated waste, "Manufacturing" accounts for 11.8% and "Households" for 10.1%
- Regarding waste treatment by type of treatment for 2018, "Deposit onto or into land" accounted for 81.6% of the total, while "Recovery other than energy recovery – except backfilling" accounted for 10.7%
- Regarding waste treatment by category of waste in 2018, "Mining and other waste activities" amounted to 34,470,963 tons and account for 80.8% of the total, while "Municipal waste" amount to 5,306,869 tons and 12.4% of the total.

(Hellenic Statistical Authority: https://www.statistics.gr/en/statistics?p_p_id=documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN&p_p_lifecycle=2&p_p_state=normal&p_p_mode=view&p_p

_cacheability=cacheLevelPage&p_p_col_id=column-2&p_p_col_count=4&p_p_col_pos=1&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_javax.faces.resource=document&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_ln=downloadResources&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_documentID=430336&_documents_WAR_publicationsportlet_INSTANCE_qDQ8fBKKo4lN_locale=en)

The quantities and the percentages of the solid waste generated in Greece in years 2014, 2016 and 2018 are presented in Table 7.

Table 7: Generation of Solid waste by main waste category in Greece 2014, 2016 & 2018

Year	2014		2016		2018	
	Quantity (tonnes)	Percentage (%)	Quantity (tonnes)	Percentage (%)	Quantity (tonnes)	Percentage (%)
Chemical & Medical waste	251.623	0,4	474.508	0,7	859.709	1,9
Recyclable waste	1.313.524	1,9	2.329.179	3,2	3.018.205	6,6
Municipal waste	7.495.065	10,7	5.483.633	7,6	5.361.148	11,8
Sludge	138.035	0,2	116.977	0,2	120.663	0,3
Mining & other waste activities	60.560.621	86,8	63.928.056	88,4	36.232.878	79,5
Total	69.758.868	100	72.332.353	100	45.592.603	100

Source: Hellenic Statistical Authority

3.2.2 Local waste volumes 2017 – 2019 in the Municipality of Thessaloniki, Greece

Thessaloniki, since its creation, has played a historically important role at national and international level as it is a focal point, to the north, east and west. It is a hub of road, rail and air transport that connects Greece with the Balkans, Black Sea and European countries.

The basic infrastructure of the city is the Egnatia Motorway, the Port of Thessaloniki, Thessaloniki Airport Macedonia, three railway axes and two railway stations. The city port is the second port in the country and one of the largest in the Mediterranean.

In Thessaloniki there are three public higher education institutions (Aristotle University of Thessaloniki, University of Macedonia and International Hellenic University) and a number of private colleges and Universities. There are nine (9) public hospitals, more than twenty (20) private clinics, while about 40% of the hotels in the Municipal Unit are located within the city of Thessaloniki.

The total permanent population of the Municipality of Thessaloniki is 325.182 inhabitants (Census of 2011), showing a significant decrease compared to the 2001 census, when the population was 397.156 inhabitants.

Table 8: Main waste production spots in the Municipality of Thessaloniki

Waste production spots	No	Waste production spots	No	Waste production spots	No	Waste production spots	No
Hospitals	8	Universities	3	Marine sports infrastructure	3	Private conservatory	32
Clinics	20	Municipal Football field	3	Elderly Protection Open Centre	14	Theatres	9
Municipal kindergardens	17	Municipal gym	6	Citizen Service Centre	6	Private cinemas and theatres	31
Kindergardens of the Nursery Organization Child and Family Care of the Municipality of Thessaloniki	10	Municipal swimming pool	1	Archaeological sites	15	Municipal buildings (services)	115
Kindergarden of "Agios Stilianos"	1	Municipal indoor gym	2	Byzantine&Post-Byzantine monuments	28	Public services	65
Private kindergardens	2	Municipal sport centre	3	Ottoman monuments	11	Thessaloniki International Fair Centre	1
Kindergardens of charity organisations	6	Municipal Free Outdoor Sports Areas	24	Traditional markets	5	Hotels	47
Family Care Centre	2	School gym	9	Museums	22	Embassies - Consulates	25
Kindergarden schools	83	National stadium	1	Modern culture monuments	32	Thessaloniki port	1
Primary schools	77	Football field	4	Cultural Centres	6	Commercial Railway Station	1
High schools (Gymnasium)	37	Swimming pool	2	Municipal libraries	24	Passenger Railway Station	1
High schools (Lyceum)	30	Sports centre	5	Music Hall	2	Macedonia International Airport	1
Professional High schools	9	Indoor gym	3	Municipal conservatory	1	Bus Station	1
Vocational Training Centres	1	Outdoor Basketball court	1	Music Centre	1		

Source: Local Decentralized Waste Management Plan of the Municipality of Thessaloniki, 2016

The quantities of the categories of waste produced in the Municipality of Thessaloniki in 2018 and 2019 are presented in Table 9.

Table 9: Waste categories in the Municipality of Thessaloniki in 2018 and 2019

No	Waste category	2018 (tn)	2019(tn)**	Electronic Waste Register 2019 (tn)***
1	MUNICIPAL WASTE	130.582,63	138.497,11	137.473,02
2	PACKAGING MATERIALS (blue bucket): Diversion, Sorting	19.555,32	20.174,33	20.093,86
3	PACKAGING MATERIALS (blue bucket): Residue *	7.881,87	8.069,73	6.971,18
4	ELECTRICAL & ELECTRONIC EQUIPMENT WASTE	107,33	106,70	113,79
5	CLOTHING	417,30	556,00	556,00
6	GLASS (packaging)	362,26	419,29	419,30
7	MASSIVE WASTE *	9.075,33	8.353,20	10.358,73
8	MASSIVE WASTE *			978,47
9	EXCAVATION, CONSTRUCTION AND DEMOLITION WASTE (recovered)			918,20
10	ABANDONED VEHICLES (end-of-life vehicles)	96,50	163,00	200,67
11	TIRES	19,14		10,80
12	LEAD BATTERIES (vehicles)	11,79		1,52
13	USED VEHICLE LUBRICANTS (OILS)	4,67		1,47
14	PLASTIC CAPS			5,77
15	ASBESTOS EXCAVATION, CONSTRUCTION AND DEMOLITION WASTE			5,40

*Included in No 1

****Source**: Municipality of Thessaloniki (data provided by a member of the Municipal Council of Thessaloniki)

*****Source**: Electronic Waste Register

3.3 Distribution and disposal of mainly municipal waste

3.3.1 Distribution and disposal of mainly municipal waste in Greece

The most reliable data regarding the waste disposal at national level are provided by the Hellenic Statistical Authority (www.statistics.gr), which is publishing data every two years. The last report was published in 2020 including data from 2018. According to this report, the waste treatment by treatment category and waste type is presented in Table 10.

Table 10: Waste treatment by treatment category and type of waste in Greece in 2018

	Incineration	Recovery other than energy recovery	Disposal	Total	Percentage (%) Distribution
Chemical & Medical waste	8.104	384.569	119.431	512.103	1,2
Recyclable waste	22.258	2.218.644	3.746	2.244.648	5,3
Municipal waste	142.543	119.835	5.044.492	5.306.869	12,4
Sludge	38.113	51.225	28.072	117.410	0,3
Mining & other waste activities	94.894	3.275.147	31.100.921	34.470.963	80,8
Total	305.911	6.049.420	36.296.661	42.651.993	100

Source: Hellenic Statistical Authority

The waste treatment by type of treatment and hazardousness all over Greece in 2018 is presented in Table 11.

Table 11: Waste treatment by type of treatment and hazardousness in Greece in 2018 (quantities and percentages)

	Incineration				Recovery other than energy recovery				Disposal				Total	
	Energy recovery		Disposal		Except backfilling		Backfilling		Deposit onto or into land		Land treatment & release into water bodies			
	tonnes	%	tonnes	%	tonnes	%	tonnes	%	tonnes	%	tonnes	%	tonnes	%
Non-hazardous	272.811	0,6	3.165	0,0	4.101.053	9,7	1.494.700	3,5	34.800.502	82,6	1.479.819	3,5	42.152.050	100
Hazardous	26.091	5,2	3.845	0,8	453.667	90,7	0	0,0	16.340	3,3	0	0,0	499.943	100
Total	298.902	0,7	7.010	0,0	4.554.720	10,7	1.494.700	3,5	34.816.842	81,6	1.479.819	3,5	42.651.993	100

Source: Hellenic Statistical Authority

3.3.2 Distribution and disposal of mainly municipal waste in the Municipality of Thessaloniki - Greece

In the Local Decentralized Waste Management Plan of the Municipality of Thessaloniki, submitted in 2016, there are projections for the Municipal Solid Waste production for the years 2017, 2018, 2019 and 2020. As it is shown in Table 12, the quantities are continuously increasing.

Table 12: Projections of the Municipal Solid Waste production in the Municipality of Thessaloniki

	2017	2018	2019	2020
Organic Fraction	58.809,77	60.647,58	62.359,05	63.869,39
Paper-Cardboard	29.471,26	30.392,24	31.249,91	32.006,78
Plastic	18.452,73	19.029,38	19.566,38	20.040,28
Metals	5.177,38	5.339,18	5.489,85	5.622,81
Glass	5.708,40	5.886,79	6.052,91	6.199,51
Wood	6.106,66	6.297,49	6.475,21	6.632,04
Other recoverable	2.124,05	2.190,43	2.252,25	2.306,80
Other	6.903,18	7.118,90	7.319,80	7.497,08
Total	**132.753,43**	**136.901,98**	**140.765,35**	**144.174,69**

Source: Local Decentralized Waste Management Plan of the Municipality of Thessaloniki, 2016

3.3.3 In-depth interviews

In order to achieve a better and integrated perception of the current situation a qualitative primary research was conducted. Four stakeholders involved in the Municipal Waste Management were in-depth interviewed in separated teleconferences that lasted from 45 to 60 minutes each. The interviewees were carefully selected. In order to achieve a more integrated approach, they are all coming from different organisations: a member of the Municipal Council of the Municipality of Thessaloniki, a representative of a Civil Society Organisation that is involved in Ecology issues, an employee of the Municipality of Thessaloniki in the Cleaning Department and an owner of a recycling private company.
They all believe that the most important problem of Waste Management in Greece is the fact that a high percentage of the produced Municipal Solid Waste goes to landfills. There is a need for the development of modern structures and facilities for alternative and more "eco-friendly" management systems. Another crucial problem is the lack of "recycling & reuse culture" in the Greek society. Civil Society Organisations and individual citizens should be informed and be made aware of more viable and eco-friendly waste management approaches and systems. Non-formal educational workshops organised by teachers or ecological NGOs could inform pupils using experiential approaches and help them to adopt more eco-friendly and viable daily habits for waste management in their lives. The existing recyclable materials management "system" is not profitable for the potential investors, who are interested in running a business for the collection of non-functional old electronic and electrical devices for instance or materials such as glass or paper. There are also people, who are illegally collecting metals or electronic and electric devices and this this causes unfair competition with the legitimate companies in the sector. The system should be organized and functioning properly. Many steps should be done and many bureaucratic obstacles should be overcome for the smooth and effective operation of the "Green Spots" that are promoted by the EU for "sorting at the source" of the recyclable materials.

Chapter 4. Projection of waste producers on infographic maps by waste type in the Regions of Greece

4.1 Recording waste production

The projections for the production of Municipal Solid Waste in every Region of Greece are presented in Table 13.

Table 13: Projections of the Municipal Solid Waste produced in the Greek Regions in 2020

	Municipal Solid Waste produced in 2020 (tonnes)
Region of East Macedonia and Thrace	251.403
Region of Central Macedonia	837.273
Region of West Macedonia	117.775
Region of Thessaly	316.121
Region of Epirus	142.914
Region of Ionian Islands	131.548
Region of West Hellas	304.429
Region of Sterea Hellas	269.785
Region of Peloponnisos	253.069
Region of Attica	1.826.494
Region of North Aegean	81.709
Region of South Aegean	258.699
Region of Crete	367.995

Source: National Waste Management Plan 2020 - 2030

The largest quantities of Municipal Solid Waste (1.826.494 tonnes) are produced in the Region of Attica as it was expected, because almost half of the Greece's total population lives there. Apart from the households, many economic and industrial activities are taking place in this Region. The Region of Attica is also the biggest trade centre in Greece and the International port of Piraeus, which is located in the Region of Attica, is the largest port of the Country.

The Region of Central Macedonia is the second largest Municipal Solid Waste producing Region (837.273 tonnes), where the second biggest city – Thessaloniki – and its port is located. Both primary and secondary sector activities are developed in Central Macedonia. There is an industrial area in the metropolitan Centre of Thessaloniki but there are also many

agricultural enterprises in the countryside of the Region.

The third Municipal Solid Waste producing Region is Crete (367.995 tonnes). It is the largest island of Greece with very intense tourism and agricultural activity. Thessaly is the forth Region concerning the production of Municipal Solid Waste. The main economic activity of the Region of Tessaly is agriculture. It is followed by the Regions of Western Greece and the Peloponnese and the last in the production of Municipal Solid Waste are the island Regions of the Aegean and the Ionian. The regions of the Ionian Islands, the North Aegean and the South Aegean have as their main economic activity summer tourism and small-scale agriculture.

Based on the Regional Waste Management Plans, the quantities and percentages of each type of waste are shown in the following table 14:

Table 14: Quantities and percentages of Municipal Solid Waste produced in Greece in 2019

	Quantities (tonnes)	**Percentage (%)**
Organic fraction	2.397.803	42,6%
Paper-Cardboard	1.361.139	24,2%
Plastic	782.847	13,9%
Metals	210.366	3,7%
Glass	231.241	4,1%
Wood	201.528	3,6%
Other	442.233	7,9%
Total	5.627.158	100,0%

Source: National Waste Management Plan 2020 - 2030

The largest percentage of the Municipal Solid Waste produced in Greece (42,6%) is organic. Different processing methods such as composting can transform this kind of waste into useful materials such as ground reinforcements for agricultural holdings or as raw material for the production of power. Greece should develop an integrated system for organic waste management, in order to reduce the total material wasted in landfills and get the benefits of utilising the useful products of the organic waste processing. Paper-Cardboard is 24,2% of the total quantities of Municipal Solid Waste produced in Greece in 2019, followed by plastic (13,9%). 4,1% of the Municipal Solid Waste in Greece is glass, 3,7% metals and 3,6% wood.

4.2 Types of waste in Greek Regions

The highest percentage of the Municipal Solid Waste produced in all Greek Regions is organic waste. The materials that can be recycled or reused are paper and cardboard, plastic, metals, glass and wood. In Greece paper is recycled in larger quantities and this is due to the fact that it was the first material that began to be recycled in the country (Kamzola, 2014).

Household waste varies in composition and quantity. The factors that affect these variables are the standard of living, consumption patterns, the mobility of the urban population and the seasons of the year (Katsigiannis, 2009). For instance tourism is a factor that significantly influences the quantities of the produced waste, especially in the summer in the Regions where tourism is the main economic activity such as the Regions of Ionian Islands, North Aegean and South Aegean.

Commercial waste is mainly packaging materials. The largest amount of Municipal Solid Waste is produced in the Attica region, while a significant quantity is also produced in the Region of Central Macedonia. In 1997, the average production was 0.97 kg / inhabitant / day and in 2001 it was 1.14 ^ / inhabitant / day. This quantity is constantly increasing in recent years, according to the estimates of the competent bodies that operate the landfills. The most significant changes in waste composition from the 1980s to the present are the reduction of fermentable materials and the increase of plastics and paper (Katsigiannis, 2009).

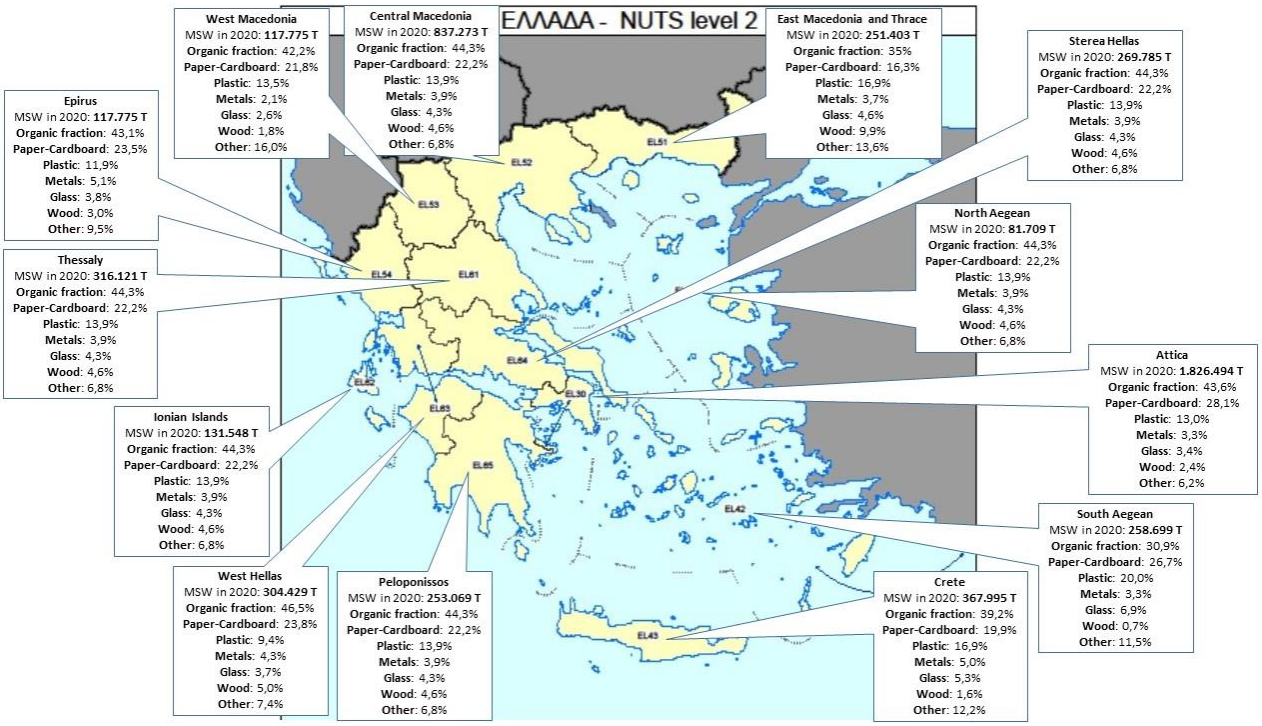
The following table 15 presents the percentages of each type of Municipal Solid Waste in the Greek Regions according to their Regional Waste Management Plans.

Table 15: Percentages of Municipal Solid Waste produced in the Greek Regions

Regions	Organic fraction	Paper-Cardboard	Plastic	Metals	Glass	Wood	Other
East Macedonia and Thrace	35%	16,3%	16,9%	3,7%	4,6%	9,9%	13,6%
Central Macedonia	44,3%	22,2%	13,9%	3,9%	4,3%	4,6%	6,8%
West Macedonia	42,2%	21,8%	13,5%	2,1%	2,6%	1,8%	16,0%
Thessaly	44,3%	22,2%	13,9%	3,9%	4,3%	4,6%	6,8%
Epirus	43,1%	23,5%	11,9%	5,1%	3,8%	3,0%	9,5%
Ionian Islands	44,3%	22,2%	13,9%	3,9%	4,3%	4,6%	6,8%
West Hellas	46,5%	23,8%	9,4%	4,3%	3,7%	5,0%	7,4%
Sterea Hellas	44,3%	22,2%	13,9%	3,9%	4,3%	4,6%	6,8%
Peloponnisos	44,3%	22,2%	13,9%	3,9%	4,3%	4,6%	6,8%
Attica	43,6%	28,1%	13,0%	3,3%	3,4%	2,4%	6,2%
North Aegean	44,3%	22,2%	13,9%	3,9%	4,3%	4,6%	6,8%
South Aegean	30,9%	26,7%	20,0%	3,3%	6,9%	0,7%	11,5%
Crete	39,2%	19,9%	16,9%	5,0%	5,3%	1,6%	12,2%

Source: National Waste Management Plan 2020 - 2030

Map 1 depicts the projections of the quantities and percentages of the Municipal Solid Waste produced in the Greek Regions in 2020.



Map 1: Projections quantities and percentages of the Municipal Solid Waste produced in the Greek Regions in 2020

Source: Data from the National Waste Management Plan 2020 – 2030, Map from Eurostat (https://ec.europa.eu/eurostat/documents/345175/7451602/2021-NUTS-2-map-EL.pdf)

4.3 Distinction of waste based on the source of economic activity

Table 16 presents the waste generated by each economic activity in Greece in 2018 according to the Hellenic Statistical Authority. This is the most relevant data. Mining and quarrying is the most waste producing economic activity (56,4%), followed by Manufacturing (11,8%), Households (10,1%), Energy (7,6%), Water supply & waste management (6%), Construction (5%), Services (1,8%), Agriculture, forestry and fishing (1,1%) and Wholesale of waste and scrap (0,2%).

Table 16: Waste generation by sections of the Statistical Classification of Economic Activities and households in Greece, 2018

Economic Activities	Total waste in tonnes	Percentage (%) distribution
Agriculture, forestry and fishing	485.143	1,1%
Mining and quarrying	25.704.903	56,4%
Manufacturing	5.360.940	11,8%
Electricity, gas, steam and air conditioning supply	3.459.811	7,6%
Water supply, sewerage, waste management and remediation activities	2.748.761	6,0%
Construction	2.286.467	5,0%
Services (except wholesale of waste and scrap)	843.055	1,8%
Wholesale of waste and scrap	96.146	0,2%
Households	4.607.377	10,1%
Total	45.592.603	100,0%

Source: Hellenic Statistical Authority

Chapter 5. Forecasting the amounts of waste during 2022 – 2023 in the Regions of Greece

5.1 Analysis of waste in types based on the way of separation in areas of Greece for the last decade 2010-2019

The first National Waste Management Plan for Greece dates back to June 2015. It records the current situation with data from 2011 and aims to reduce waste in the five years 2015-2020. For the needs of this section, the available reference data are used (see Table 17) for the year 2011 by the National Waste Management Plan 2015-2020 for the whole of Greece.

Data from the Hellenic Recycling Organization and the Hellenic Recycling Utilization Company were used for the Commercial Packaging Waste. More specifically, data were received on the total Packaging Materials produced by the Hellenic Recycling Organization (2018), which include Household and Commercial Packaging Waste.

Table 17: Waste categories in Greece in 2011

Waste category	Non-hazardous waste (thousand tonnes)	Hazardous waste (thousand tonnes)	Total waste (thousand tonnes)
I- MUNICIPAL TYPE WASTE	**5.743**	**6,5**	**5.749**
[1] Municipal solid waste	5.569	6,5	5.575
Bio-waste	2.470		2.470
Packaging waste	866		866
Other recyclable materials	1.860		1.860
Households electrical and electronic equipment waste	66	1,1	67
Waste of portable batteries and accumulators		1,1	1,1
Other Municipal Solid Waste	307	4,3	311
[2] Municipal type sludge	174		174
II- INDUSTRIAL WASTE AND WASTE FROM OTHER ACTIVITIES	**17.186**	**272**	**17.459**
[1] Industrial waste	17.034	136	17.171
[2] Waste from common interest infrastructure, public services etc	2,9	16	19
[3] Oil waste		56	56
[4] Waste batteries for vehicles and industry		47	47
[5] End-of-life vehicles	104	1,0	105
[6] Used vehicle tires	38		38
[7] Industrial electrical electronic equipment waste	7,4		7,4
[8] Waste of sanitary units		16	16
III- EXCAVATION, CONSTRUCTION AND DEMOLITION WASTE	**1.306**	**0,6**	**1.307**
IV- AGRICULTURE AND LIVESTOCK WASTE	**10.781**		**10.781**

Source: National Waste Management Plan 2015 - 2020

As can be seen from the data for 2011, the data concerning packaging waste generated, which the section focuses on - for comparison purposes - was 866.000 tons.

From the study "Waste Management" published in 2018 for waste management by the

National Centre for Environment and Sustainable Development and the Ministry of Environment and Energy, the data of waste production from the category of packaging recycling led to the recovery of materials for 2014-2016 are shown in the following table 18.

Table 18: Waste management to recover materials

Material		2014	2015	2016
Glass		98.000	88.800	90.500
Plastic		184.400	183.800	186.600
Paper & Cardboard		330.700	326.100	334.300
Metal	Aluminium	19.200	20.900	21.700
	Steel	69.600	66.900	62.900
	Total	88.800	87.800	84.600
Wood		45.600	50.200	50.800
Other		5.400	5.300	5.500
Total		747.900	742.000	752.300

Source: https://ekpaa.ypeka.gr/wp-content/uploads/2019/09/Soer_2018_GR_Waste-Management.pdf

The data in Table 18 show a large discrepancy in the quantities of packaging waste generated compared to 2011, about 100.000 less is recorded than the quantity produced that was driven for recovery. This is a data that does not provide an explanation from the sources of information identified in the context of this research. However, the value of the quantity produced in relation to the value of the quantity that led to recovery differs significantly and leads to a first conclusion that the 100.000 tonnes that may have been produced were not recovered.

The following data provided by the Hellenic Recycling Organization and the Hellenic Recycling Company are used for Commercial Packaging Waste (see Table 19). More specifically, data was received for all Packaging Materials produced by the Hellenic Recycling Organization (2018), which include household and commercial packaging waste.

Table 19: Production and Recovery of Packaging Materials for the year 2018 in Greece

	Production of Packaging Materials (t)	Recovery of Packaging Materials (t)
Paper / Cardboard	369.700	327.610
Plastic	187.600	81.970
Metals	92.100	63.630
Glass	99.300	34.960
Wood	54.900	13.870

Other	7.300	
TOTAL	810.900	522.040

Source: National Waste Management Plan 2020 - 2030

According to the data from the Hellenic Recycling Organization, the Industrial and Commercial Packaging Waste constitutes 60% of the recovered packaging waste, which was 313.224 tonnes. For the distribution of the Industrial and Commercial Packaging Waste in the streams: Paper / Cardboard, Plastic, Metal, Glass and Wood, data from the report of the Hellenic Recycling Organization (2018), which is the largest recycling company in the country, were used. The following table shows the quantities of the Industrial and Commercial Packaging Waste collected per stream, according to the National Waste Management Plan.

Table 20: Quantities of Produced Industrial and Commercial Packaging Waste for the year 2018 in Greece

	Quantities of produced Industrial and Commercial Packaging Waste (t)	Percentage in relation to the produced Municipal Solid Waste (t)
Paper / Cardboard	255.737	4,63%
Plastic	45.973	0,83%
Iron	50.352	0,91%
Aluminum	11.822	0,21%
Glass	13.418	0,24%
Wood	34.675	0,63%
TOTAL	411.978	7,46%

Source: National Waste Management Plan 2020 - 2030

To calculate the qualitative composition of Municipal Solid Waste, the proportional share of each amount of remaining stream from the total Municipal Solid Waste was calculated, by subtracting the quantities of Industrial and Commercial Packaging Waste.

Table 21: Quality composition and quantities of Municipal Solid Waste in 2019 in Greece

	Quantities (2019) (t)	Percentage (t)
Organic	2.397.803	46,0%
Paper / Cardboard	1.100.618	21,1%
Plastic	736.014	14,1%
Metals Fe	95.962	1,8%
Metals Al	51.067	1,0%
Glass	217.572	4,2%
Fabrics	116.242	2,2%
Wood	166.205	3,2%

Electrical & Electronic Equipment Waste	112.543	2,2%
Small Amount Hazardous Waste	5.627	0,1%
Large volume waste	112.543	2,2%
Other	95.277	1,8%
TOTAL	5.207.472	100%

Source: National Waste Management Plan 2020 - 2030

Observing the quantities of municipal waste from 2011 to 2019 we observe large fluctuations. This is due to different measurements as in other cases there are measurements that specifically state that they concern packaging waste to be recovered and in other cases to generated waste as in the case of the years 2011 and then 2014-2016. However, the discrepancy between the data 2018 and 2019 is also large. Initially, the produced and recovered packaging materials for the year 2018 are measured in 2018 and separately for industrial waste, while for 2019 the prices refer to total municipal solid waste for which it is not known if they can be compared with the prices of 2011 or 2018. It is worth noting that our research identifies as a disadvantage of data processing the fact that there is no fixed measurement size during the decade under consideration.

5.2 Analysis of digital data on waste production

Four scenarios were observed in the National Waste Management Plan 2020 – 2030. The prevailing scenario predicts stable production of the Municipal Solid Waste in with reference year in 2020. According to this scenario, due to the prevention measures, the production of Municipal Solid Waste is not directly linked to the GDP and the per capita production of Municipal Solid Waste for the period 2020-2030 stabilizes. Waste generation varies only according to population. The reduction in the Municipal Solid Waste production in 2020 due to the COVID-19 pandemic is taken into account, and then per capita Municipal Solid Waste production does not return to pre-pandemic levels but is stabilized as a result of prevention measures. So in fact compared to the year 2019 there is a reduction and not just a stabilization, something that is even more in line with the EU guidelines for waste prioritization and the circular economy with a priority in waste prevention. Table 22 shows projections of the total Municipal Solid Waste produced by permanent population in Greece.

Table 22: Projections of the total Municipal Solid Waste produced by permanent population in Greece

	2018	**2019**	**2020**	**2025**	**2030**
Total Municipal Solid Waste produced by permanent population (tonnes)	5.339.181	5.432.234	5.092.938	5.004.216	4.905.659

Source: National Waste Management Plan 2020 - 2030

Table 23 presents the projections for the Municipal Solid Waste produced in every Region in Greece for the years 2011, 2020, 2021, 2022 and 2023.

Table 23: Projections of the Municipal Solid Waste produced in the Greek Regions in 2011, 2020, 2021, 2022, 2023

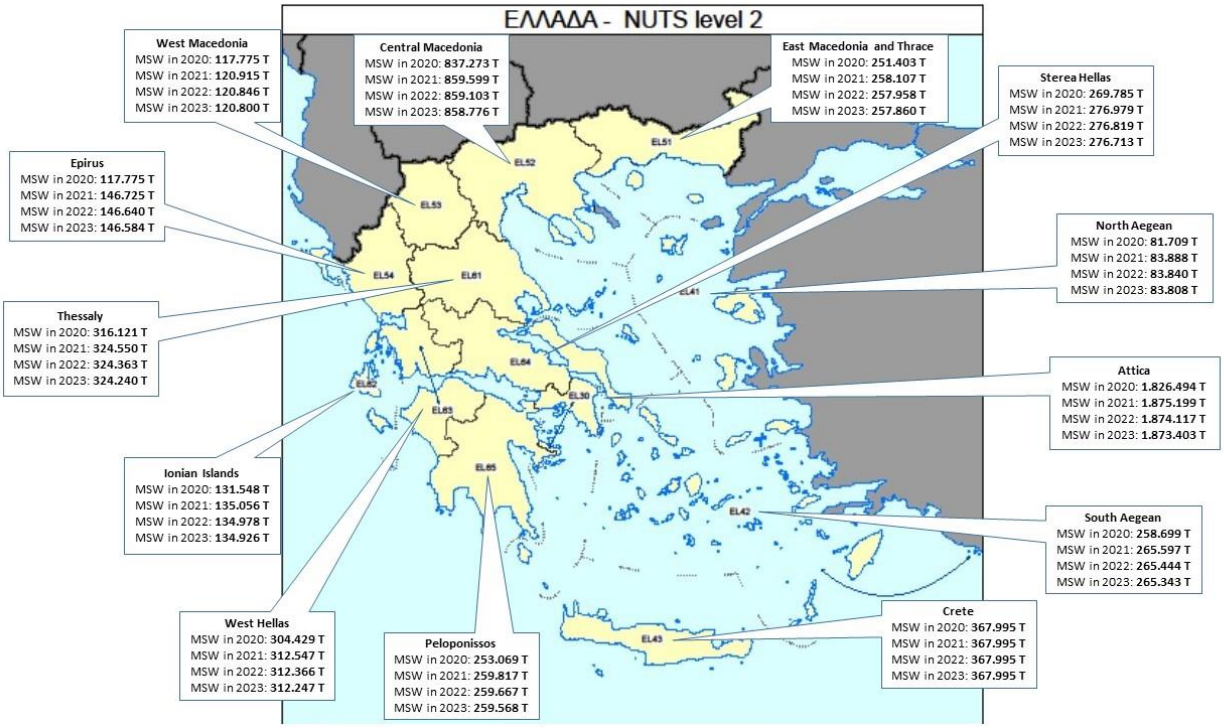
	Municipal Solid Waste produced (tonnes)				
	2011*	**2020**	**2021**	**2022**	**2023**
Region of East Macedonia and Thrace	1.708	251.403	258.107	257.958	257.860
Region of Central Macedonia	3.390	837.273	859.599	859.103	858.776
Region of West Macedonia	9.893	117.775	120.915	120.846	120.800
Region of Thessaly	2.434	316.121	324.550	324.363	324.240
Region of Epirus	1.166	142.914	146.725	146.640	146.584
Region of Ionian Islands	360	131.548	135.056	134.978	134.926
Region of West Hellas	1.484	304.429	312.547	312.366	312.247
Region of Sterea Hellas	4.357	269.785	276.979	276.819	276.713
Region of Peloponnisos	3.438	253.069	259.817	259.667	259.568
Region of Attica	4.030	1.826.494	1.875.199	1.874.117	1.873.403
Region of North Aegean	489	81.709	83.888	83.840	83.808
Region of South Aegean	664	258.699	265.597	265.444	265.343
Region of Crete	1.883	367.995	367.995	367.995	367.995

Source: National Waste Management Plan 2020 - 2030

* thousand tons (**Source**: National Waste Management Plan 2015)

5.3 Projection of waste generators on infographic map

Map 2 depicts the amounts of the Municipal Solid Waste that are expected to be produced in each one of the Greek Regions in 2020, 2021, 2022 and 2023.



Map 2: Projections of the Municipal Solid Waste produced in the Greek Regions in 2020, 2021, 2022 and 2023

Source: Data from the National Waste Management Plan 2020 – 2030,

Map from Eurostat (https://ec.europa.eu/eurostat/documents/345175/7451602/2021-NUTS-2-map-EL.pdf)

Chapter 6. Information about waste management facilities at the beginning of 2020 and a forecast vision of waste transportation routes for the period 2022 – 2023 in the Regions of Greece

6.1 Analysis of facilities for collection, sorting, temporary storage, incineration processing of waste, their final disposal by type, as well as enterprises transporting waste in the beginning of 2020

At Regional level, the Regional Waste Management Plan of the Region of Central Macedonia, in accordance with the provisions of Directive 2008/98 on waste and Law 4042/2012 (Government Gazette 24 / A / 2012) as amended and is in force, as well as the provisions of the National Waste Management Plan and the National Prevention Plan incorporates after evaluation the Local Waste Management Plans approved the by Municipalities of the Region of Central Macedonia. It is a management plan of all the waste generated in the Region of Central Macedonia and defines the general directions for their management.

The Solid Waste Management Bodies are the competent bodies of the Primary Local Government that according to Law 4071/2012, their purpose is the integrated solid waste management, according to the Regional Waste Management Plan. In particular, the purpose of Solid Waste Management Bodies is the specialisation and implementation of the objectives and actions of each Regional Waste Management Plan regarding the temporary storage, transhipment, marine transport of Municipal Solid Waste, treatment and disposal, placing of the solid waste of their territorial jurisdiction, in accordance with the Joint Ministerial Decision No. 2527/2009 (Government Gazette 83 / AD / 2009). The institutionalized body responsible for the management of municipal waste in the Region of Central Macedonia is the "Regional Association of Solid Waste Management Bodies of Central Macedonia".

6.1.1 Main Municipal Solid Waste management infrastructures

In Greece there were operating 6 Mixed / residual Municipal Solid Waste treatment units and Bio-waste treatment units in 2018. In Table 24 there is a list of them.

Table 24: Operating Mixed / residual Municipal Solid Waste treatment units and Bio-waste treatment units in Greece

Type	Location
Mixed / residual Municipal Solid Waste treatment unit	Kozani, West Macedonia
Mixed / residual Municipal Solid Waste treatment unit	Ioannina, Epirus
Mixed / residual Municipal Solid Waste treatment unit	Serres, Central Macedonia
Mechanical Recycling and Composting Factory	Fili, Sterea Ellada (Attica)
Mechanical Recycling and Composting Factory	Chania, Crete
BioWaste Treatment Unit	Amfissa, Sterea Ellada

Source: National Waste Management Plan 2020 - 2030

Ten (10) Mixed / residual Municipal Solid Waste treatment units and Bio-waste treatment units were ready to operate or under construction and six (6) in procurement process in 2018.

There are 44 Recycling Material Sorting Centers in Greece, including some refining centers for separately collected materials. The Recycling Material Sorting Centers by Region are listed as follows:

- Region of Eastern Macedonia - Thrace: 5 (Didymoteicho, Alexandroupolis, Komotini, Xanthi and Drama)
- Attica Region: 5 (Elefsina, Koropi, Aspropyrgos, Aspropyrgos and Fili)
- North Aegean Region: 2 (Lesvos, Chios)
- Region of Western Greece: 2 (Patras and Agrinio)
- Western Macedonia: 1 (Kozani)
- Region of Epirus: 1 (Ioannina)
- Region of Thessaly: 3 (Larissa, Magnesia-Volos and Western Thessaly-Karditsa)
- Ionian Islands Region: 2 (Corfu and Zakynthos)
- Region of Central Macedonia: 7 (Thermi, Ionia, Sindos, Tagarades, Serres, Katerini and Kallithea-Neochorouda)
- Region of Crete: 2 (Heraklion and Chania)
- South Aegean Region: 6 (Mykonos, Thira, Paros, Naxos, Kos and Rhodes)
- Peloponnese Region: 4 (Kalamata, Tripoli, Corinth and Sparta)
- Region of Central Greece: 4 (Lamia, Avlida, Tanagra and Schimatari)

As far as the Alternative Management Systems is concerned, there are 22 approved Systems operating in Greece, which cover packaging waste, portable batteries and accumulators, excavation, construction and demolition waste, lubricating oil waste, end-of-life vehicles, waste batteries for vehicles and industry, waste electrical and electronic equipment (household and non-household) and used vehicle tires. In summary, the number of Alternative Management Systems per managed waste stream is shown in Table 25 below:

Table 25: Alternative Management Systems operating in Greece in 2018

Type of Alternative Management System	Number of Systems
Packaging waste	4
Portable batteries and accumulators	1
Excavation, construction and demolition waste	9
Lubricating oil waste	1
End-of-life vehicles	1
Waste batteries for vehicles and industry	3
Waste electrical and electronic equipment (household and non-household)	2
Used vehicle tires	1
TOTAL	**22**

Source: National Waste Management Plan 2020 - 2030

6.1.2 Waste management facilities in the Municipality of Thessaloniki

In the Region of Central Macedonia, where the Municipality of Thessaloniki belongs, there is one (1) operating Mixed / residual Municipal Solid Waste treatment unit in the city of Serres and seven (7) Recycling Material Sorting Centres (Thermi, Ionia, Sindos, Tagarades, Serres, Katerini and Kallithea-Neochorouda).

The vehicles and construction machinery of the Municipality of Thessaloniki are parked in a rented space that includes a building and the surrounding yard and outdoor space. The area of the outdoor fenced parking space of vehicles and construction machinery is 12.063 m^2, the area of the plot in which the Depot building is located is 6.250 m^2, the total area of the building is 1.463,74 m^2 of which 1.258m^2 is storage space, and 205,20 m^2 offices. The Municipality uses for the collection, transport and cleaning the vehicles shown in Table 26. Some vehicles seem to be simply parked in the area of the Municipality, such as bicycles and buses transporting people with disabilities.

Table 26: Vehicles and Machinery of the Municipality of Thessaloniki for the collection and transport of waste

Type of vehicle – machinery	Number
TRUCK WITH SELF-LOADING CRANE	7
CLOSED NON-DUMP TRUCK	22
OPENED DUMP TRUCK	32
OPENED NON-DUMP TRUCK	7
TRICYCLE / TRUCK	29
PASSENGER CAR	13
BICYCLE	61
OPEN CONTAINER TRANSPORT TRUCK	12
PASSENGER CAR	5
BUS	4
WATER TANK TRUCK	8
OPEN CONTAINER TRANSPORT TRUCK	1
TRAILER WITH OPEN TRAILER FOR CONTAINER	13
ELECTRIC VEHICLE	2
RECYCLABLE WASTE COLLECTION TRUCK	11
TRACTOR (DIAGNOSTIC EVALUATION & SUPPORT CENTERS)	1

Source: Local Decentralized Waste Management Plan of the Municipality of Thessaloniki, 2016

The Municipality of Thessaloniki has developed two large collection networks to cover the main waste streams, mixed and packaging waste, which serve all households in the Municipality. In particular, in terms of equipment for the collection and temporary storage of the mixed fraction, the installed green bins are 6.863. The 5.253 of the installed green bins have a capacity of 1.100L, 149 bins have a capacity of 770L and 1.461 bins have a capacity of 360L.

The Municipality of Thessaloniki has 5 press containers located at peak points, such as open public markets. For the collection and temporary storage of packaging waste, the Municipality of Thessaloniki has 4.950 blue bins. The 4.650 of the installed blue bins are with a capacity of 1.100L and 300 bins are with a capacity of 660L, to collect paper, plastic, metal (aluminum and tinplate) and glass. In addition, the Municipality of Thessaloniki has 154 glass collection "bells" (bins) for the collection of glass packaging produced by the catering and leisure companies-entertainment centers. 590 businesses are served in the city center. A pilot project is being implemented with the installation of additional 202 household glass collection "bells". Recently, 34 small recycling bins have been installed in the certified playgrounds of the Municipality.

The Recycling and Cleaning Department of the Municipality of Thessaloniki carries out on a daily basis collection routes of the installed green and blue bins. More specifically, for the service of the collection network of the mixed fraction (green bins), there are 19 morning itineraries, 7 noon and 12 night itineraries. For the service of the collection network of the recyclable fraction (blue bins) there are 12 morning itineraries, 11 noon and 6 night itineraries daily. A total of 13 press-type garbage trucks are used to collect recyclable packaging materials. The glass packaging collection "bells" that serve the catering and leisure businesses are collected by a contractor. On a weekly basis, there are routes for the collection of excavation, construction and demolition waste and bulky waste, with open type trucks (Local Decentralized Waste Management Plan of the Municipality of Thessaloniki).

6.2 Forecasts for transport routes in the period 2020 – 2023

6.2.1 The data of the new National Waste Management Plan 2020-2030

In general, reducing the distances of the transport of all types of waste reduces both the cost of waste management and the environmental footprint as well as the circulation and leakage of garbage trucks. At the same time, the Municipalities save resources and money from the maintenance of the garbage trucks, from the fuel, etc., which are wasted in the transport of the garbage trucks to the landfills and have the possibility to reduce the respective municipal fees. That is why they use new technologies for this purpose internationally, such as the Geographic Information System (GIS), online citizen information and professional utility in relation to collection points, routes and collection frequency.

According to the new National Waste Management Plan, its basic principles are:

- Prevention of waste production
- Enhance sorting in the source
- Promoting recycling and reuse
- Construction of 27 waste treatment units by 2023 and auction of 31 bio-waste treatment units
- Emphasis on public and private sector partnership projects

- Production of secondary fuels from waste treatment units residues
- Energy utilization of alternative secondary fuels

The following is an indicative timetable for the National Waste Management Plan:

Diagram 5: Schedule of the National Waste Management Plan
Source: National Waste Management Plan 2020 – 2030

If what the National Waste Management Plan states is implemented by 2030, the infrastructure will be different, as will the waste routes. These goals, however, are general announcements and cannot be assessed because they have not been specified.

When it will be officially announced what will happen with the energy recovery / combustion units, then we will have more information about the locations of the units, the capacity, the financing, etc. For these units it is not possible to calculate the routes, unless finalize their positions and which Municipalities they will serve. The Green Spots are also not clearly defined for the area of Thessaloniki, it is not known where the points will be made and which local authorities or population each Point will serve. For the waste treatment units there are the data of the positions, the capacities and the served local authorities but no competent body of the state or the Local Government has calculated the routes of the waste. At this stage, all planning is in progress. The National Prevention Plan is also in the process of consultation, while, as announced by the Minister of Environment and Energy, the bill for the harmonization of directives 851 and 852 is being consulted again with many changes and changes are expected in the Hellenic Recycling Organization, after the withdrawment of the Environmental Organizations WWF and Greenpeace.

The Criteria for the Location of Future / Planned Infrastructures, which are mentioned in the "National Waste Management Plan, including hazardous waste, 2020-2030" are indicative:

"The National Waste Management Plan concerns all categories of waste (Municipal Solid Waste, sludge, hazardous, etc.) and refers to all relevant categories of infrastructure related to them (storage, transhipment, treatment, disposal, etc.) of any nature, any alternative technology and of any size and capacity, therefore it is neither possible nor desirable to set binding and / or universally applicable criteria for the exclusion and location of infrastructure. At the same time, the criteria for exclusion and location of projects and infrastructure is not something "static" and unchanged, but on the contrary is dynamic over

time, as it depends on a number of parameters that are constantly changing, such as legislation, spatial plans, development of other productive activities, other management plans (indicative water). For the above reasons, the purpose and object of the National Waste Management Plan is not the establishment of exclusion and location criteria, but simply the reference of certain indicative directions, which each time are evaluated and judged during the process for the licensing of a project ".

The same text states for the stream of waste of the sanitary units that problems are still found in the management within the sanitary units (separate collection at the production point, proper transport and storage within the unit) although a significant improvement and compliance with the requirements of legislation has been observed. Also that the response of sanitary units to the submission of annual producer reports is improving, after the introduction of the Electronic Waste Register. Of particular importance is the fact that there is still only one incineration plant, resulting in a significant increase in transport costs, which is particularly acute in the case of plants in remote or inaccessible areas.

For agriculture and livestock waste is provided: Development of a network for the collection and transport of agriculture and livestock waste, as well as infrastructure management with the effort of production of useful products and recovery of materials and / or energy. Investigation of the possibility of co-processing of certain categories of agriculture and livestock with the organic fraction of Municipal Solid Waste in waste treatment units or bio-waste treatment units and / or co-processing with Municipal Solid Waste in heat recovery units with heat treatment.

Regarding the disposal of asbestos waste, the gradual reduction of cross-border transport is foreseen.

The same text of the National Waste Management Plan states on the existing networks and facilities for the Municipal Solid Waste:

a) Municipal Solid Waste collection and transportation network

The collection - transfer of Municipal Solid Waste is carried out by the cleaning services of 325 Municipalities, their Associations or Solid Waste Management Bodies. In addition, in 2011, which is a reference year for the National Waste Management, there were 502 licensed companies for the collection and transport of non-hazardous waste, to which the Municipalities had the opportunity to entrust the collection / transport of the Municipal Solid Waste. The collection of the Municipal Solid Waste covers 100% of the territory. The existing and under construction Waste Transfer Stations in the whole country in 2018 were 129.

b) Recycling / recovery

In 2011, 73% of the country's population was served for a separate collection of recyclable materials from the network of blue bins and autonomous collection (200 Municipalities). A separate collection in 4 sub-streams was carried out in 15 Municipalities of the country, serving 350 thousand permanent residents (3.2% of the population). The Recyclable Materials Sorting Centres throughout the country in 2018 were 36.

c) Disposal

The country has largely covered the basic infrastructure for safe disposal of Municipal Solid Waste in landfills. The final disposal of municipal waste at landfills covers almost the entire permanent population of the country in 2018 at 85 landfills.

Table 27: Existing Municipal Solid Waste infrastructure in the Greek territory in 2018.

Region	Waste Transfer Stations	Recyclable Materials Sorting Center	LAND FILLS
Creta	5	1	7
South Aegean	4	5	23
Peloponisse	1	3	1
Attica	15	5	2
Sterea Ellada	15	2	7
North Aegean	12	0	6
Thessaly	9	3	7
Ionian Islands	4	2	4
West Ellada	5	1	9
West Macedonia	9	1	1
Central Macedonia	25	7	12
East Macedonia and Thrace	13	5	3
Ipiros	12	1	3
ΣΥΝΟΛΟ	**129**	**36**	**85**

Source: National Waste Management Plan 2020 – 2030

6.2.2 The data in the Region of Central Macedonia

Focusing on Central Macedonia, the following data are of interest, which emerged from the National Waste Management Plan 2018:

Table 28: Existing Municipal Solid Waste Management Infrastructures in the Region of Central Macedonia (Region of Central Macedonia, 2016)

Managing Unity / Municipality - Area	Household composters	Waste Transfer Stations	Recycling, Shorting in Source Training Centres	Landfills	Waste Treatment Plants
Θεσσαλονίκης					
Αμπελοκήπων – Μενεμένης				1	
Βόβλης		2			
Δέλτα		1	2		
Θερμαϊκού		1+1*			
Θέρμης	1.100	1	2		
Χαλκιδόνας					
Καλαμαριάς	370				
Παύλου Μελά	200	1			
Πυλαίας - Χορτιάτη	120	1			
Θεσσαλονίκης					
Κορδελιού - Ευόσμου					
Λαγκαδά	400	1*			
Νεάπολης - Συκεών	850				
Ωραιοκάστρου		1*	1		
Ημαθίας					
Αλεξάνδρειας	250	1			
Βέροιας		1			
Νάουσας	800	1			
Κιλκίς					
Κιλκίς				1	
Παιονίας		1*			

Πέλλας					
Έδεσσας				1	
Πέλλας		1		1	
Σκύδρας					
Αλμωπίας				1*	
Πιερίας					
Δίου - Ολύμπου			1	1	
Κατερίνης		1		1	
Πύδνας – Κολυνδρού		1			
Σερρών					
Αμφίπολης			1	1	1*
Βισαλτίας		1			
Εμμανουήλ Παππά					
Ηράκλειας					
Νέας Ζήχνης		1			
Σερρών	150				
Σιντικής					
Χαλκιδικής					
Αριστοτέλη	1.500	2		1*	
Κασσάνδρας	300	1*		1*	
Νέας Προποντίδας		2*			
Πολυγύρου	1.500			2	
Σιθωνίας	1.250	1			
***Υπό μελέτη ή κατασκευή**					

Source: National Waste Management Plan

Table 29: Proposed Municipal Solid Waste Management Infrastructures in the Region of Central Macedonia (Region of Central Macedonia, 2016)

Managing Unity / Municipality - Area	Household composters	Central Green Spots or Recycling, Shorting in Source Training Centres	Satellite Green Spots	Waste Transfer Stations	Recycling Materials Sorting Centers	Bio-waste Treatment Plants	Waste Treatment Plants	Landfills
Θεσσαλονίκης								
Λαγκαδά	52.383*	1	6			1	1	
Βόβλης		1						
Παύλου Μελά		1	1		1			
Χαλκιδόνας		1		1		1		
Δέλτα		1						
Ωραιοκάστρου		1						
Κορδελιού - Ευόσμου		2				1		
Αμπελοκήπων - Μενεμένης		1	1					
Νεάπολης - Συκεών		1						
Θεσσαλονίκης		1	5			1		
Θέρμης		1					1	
Θερμαϊκού		1				1		
Καλαμαριάς		1	1					
Πυλαίας - Χορτιάτη		1	2					
Ημαθίας								
Αλεξάνδρειας	6.516*	1			1	1		
Βέροιας		1	1					
Νάουσας		1						
Κιλκίς								
Κιλκίς	3.726*	1		1		1		
Παιονίας		1						

Πέλλας								
Έδεσσας	6.473*	1	1	1	1	1		
Πέλλας		1	1					
Σκύδρας		1		1				
Αλμωπίας		1		1				
Πιερίας								
Δίου - Ολύμπου	5.869*	1	2	1		1		
Κατερίνης		1	2					
Πύδνας - Κολυνδρού		1	1					
Σερρών								
Αμφίπολης	8.171*	1				1		
Βισαλτίας		1						
Εμμανουήλ Παππά		1						
Ηράκλειας		1						
Νέας Ζήχνης		1						
Σερρών		1						
Σιντικής		1						
Χαλκιδικής								
Αριστοτέλη	5.389*	1	2	1		1		
Σιθωνίας		1	1		1			
Νέας Προποντίδας		1	2			1		
Πολυγύρου		1	2	1	1			
Κασσάνδρας		1						

*** By calculation**

The following conditions were used for the calculation of the home compost bins in order to achieve the set objectives for all Regions:
i) The estimated population of 2020 per Region, ii) The estimated production of Municipal Solid Waste per Region for 2020, iii) The percentage of organic in the Municipal Solid Waste (44.3%), iv) The percentage of household organic matter that can be composted domestically, which according to the researchers amounts to 25% of the organic produced, v) The targets set by Regions, vi) The average household size which for the Region of Central Macedonia is 2.6 for urban areas and 2.7 for agricultural, vii) The indicative number refers to the 120 lt bins, but obviously each Local Waste Management Plans determines the exact number and size as long as the 3% target is achieved.

Source: National Waste Management Plan

The existing and proposed infrastructure for the Region of Central Macedonia is the following:

Table 30: Total data of existing and proposed infrastructures for the Region of Central Macedonia

Management Infrastructure	Existing	Proposed
Household composters	8.790	88.527
Central Green Spots / Recycling, Shorting in Source Training Centres	-	39
Satellite Green Spots	-	31
Waste Transfer Stations	25	8
Recycling Materials Sorting Centres	7	5
Bio-waste Treatment Plants	-	12
Waste Treatment Plants	1	2
Landfills	12	1

Source: National Waste Management Plan

The number of existing Home Composers is derived from the available Local Waste Management Plans, while the number of the proposed ones, as mentioned in the Regional Waste Management Plans, results from calculations. Of the twenty-five (25) listed as existing Waste Transfer Stations, seven (7) are under construction.

In the Region of Central Macedonia there is no Bio-waste Treatment Plants, therefore the construction of twelve (12) units is correctly proposed. In January 2018 it was announced

that the studies of seven (7) Bio Waste Treatment Units (Ministry of Economy and Development, 2018b) are included in the new NSRF 2014-2020 (Ministry of Economy and Development, 2008).

The proposed Waste Treatment Plants are two (2) and they serve the Eastern and Western Sector of the Region of Central Macedonia, which will also serve neighboring prefectures (Imathia, Kilkis, Pella and Halkidiki) and is expected to include landfills as well. In January 2018 it was announced that the study of the Western Sector Waste Treatment Plant (Ministry of Economy and Development, 2018b) is included in the new NSRF 2014-2020 and in June 2018 that the study of the Eastern Sector Waste Treatment Plants (Ministry of Economy and Development, 2018c) is included, while since June 2017 the construction of Waste Treatment Plant in Serres has started.

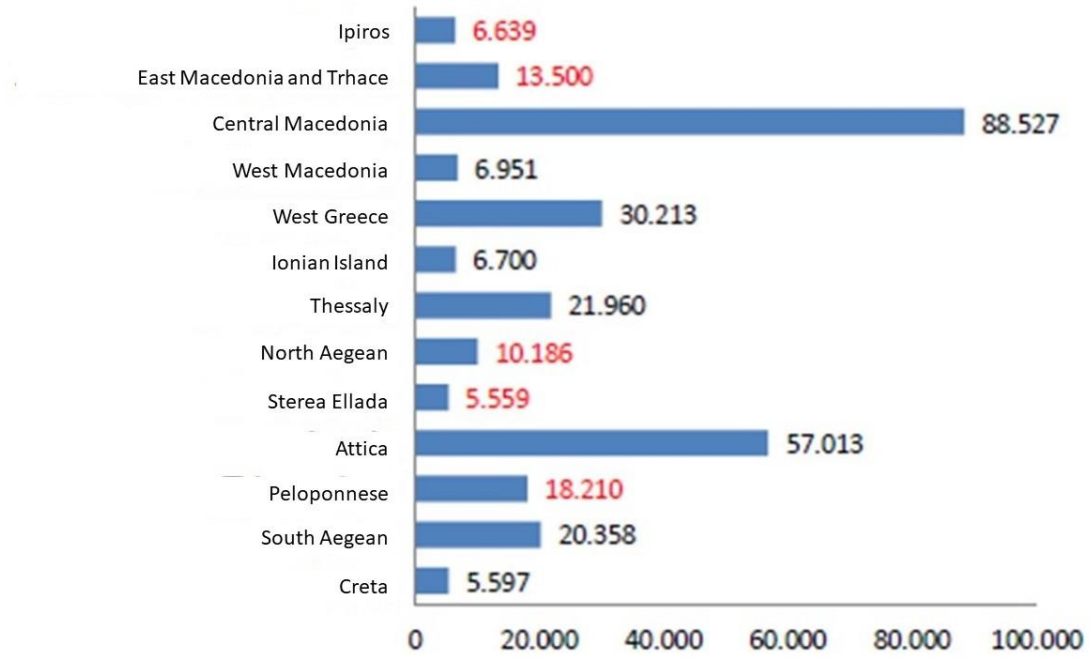


Diagram 6: Number of Proposed Household / Neighborhood Composters by Region

The comparison shows that the Region of Central Macedonia is a pioneer in the effort of home composting, with a significant difference from the second Region of Attica (the lack of data from a few Municipalities in Attica, can not affect the significant difference).

In the Regions of Epirus, Eastern Macedonia and Thrace, North Aegean, Central Greece and Peloponnese, all Household / Neighborhood Composers are incomplete and appear in red, because in the Regional Waste Management Plans of the above Regions there is either insufficient information, or do not provide data. In the Regions of Attica and Crete there is no information from very few Municipalities.

A positive element is the high total for the South Aegean Region, while the Region of Thessaly, although ranked fourth in the total, one would expect due to population, qualitative and quantitative characteristics of waste to present a higher total of Household / District Composers. The explanation could be given due to the proposal of a high number of proposed composting units and Bio Waste Treatment Units.

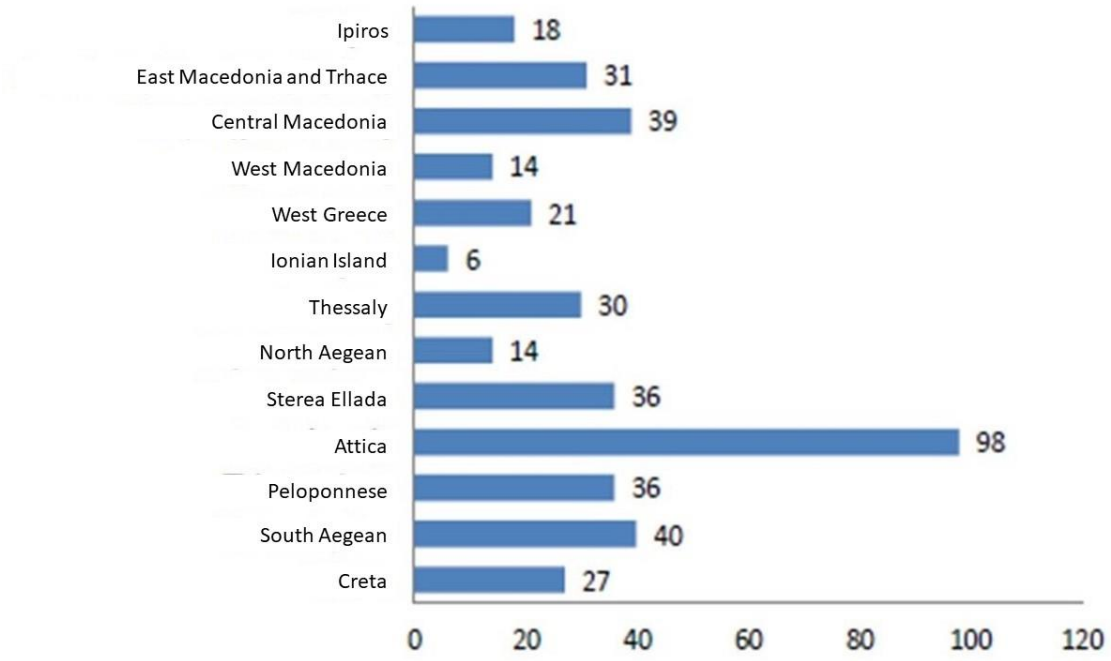


Diagram 7: Number of proposed Central Green Spots per Region

The Region of Attica obviously due to population is recorded as the Region with the most Central Green Spots (ninety eight (98)), with the Region of South Aegean following with forty (40) Central Green Spots, which is explained if one considers the choice of each island to have one Central Green Spot.

On the other hand, the Ionian Islands Region is recorded with the fewest Central Green Spots (six in total), due to the choice to build more Satellite Green Points.

The Regions of Central Macedonia, Central Greece, Peloponnese, Eastern Macedonia - Thrace and Thessaly present from thirty (30) to thirty nine (39) Central Green Spots.

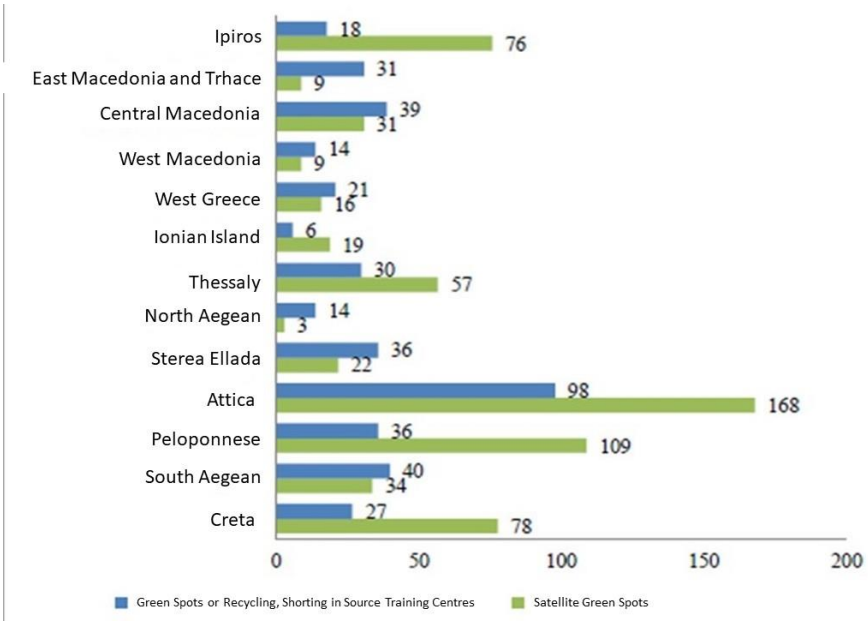


Chart 8: Central Green Spots or Recycling, Shorting in Source Training Centres and Satellite Green Spots by Region

In the Regions of Epirus, Ionian Islands, Thessaly, Attica, Peloponnese and Crete, a larger number of Satellite Green Spots is proposed than the Central Green Spots.

On the contrary, in the Regions of Eastern Macedonia and Thrace, Central Macedonia, Western Macedonia, Western Greece, North Aegean, Central Greece and South Aegean, more Central Green Spots than Satellite Green Spots are proposed.

In most Regions the difference in quantity between Central Green Spots and Satellite Green Spots is large, in proportion. Only in the Regions of Western Macedonia, Western Greece and the South Aegean the distance that separates the two categories of Green Spots is small.

6.2.3. The experience from the Waste Transfer Station (SMA) of Efkarpia

From the available data for the two years of operation of the Waste Transfer Station in Efkarpia, Thessaloniki, the Solid Waste Management Agency (FODSA) of Central Macedonia the waste trucks of the Municipalities of Thessaloniki, which went directly to the landfill of Mavrorachi, drove a distance of four million kilometers less, resulting in a significant reduction in waste transportation costs. This for local authorities translates into lower costs for fuel, lubrication and maintenance of vehicles, but also in working hours, a benefit that also affects citizens, since municipalities can reduce municipal fees. An additional benefit also arises for the environment, as pollutants have been reduced.

(https://www.makthes.gr/meiothike-simantika-to-metaforiko-kostos-ton-skoypidion-logo-toy-sma-eykarpias-199331)

In more detail, the data of the respective service of the Solid Waste Management Agency Central Macedonia, offer the following image:

Table 31: Number of incoming vehicles per Municipality of the Regional Unit of Thessaloniki

Year 2017			
Municipality	**No. of incoming vehicles**	**Total weight (Tonnes)**	**Kilometres saved by the Municipalities**
ΑΜΠΕΛΟΚΗΠΩΝ-ΜΕΝΕΜΕΝΗΣ	2187	13.367.750	87.480
ΔΕΛΤΑ	1474	9.395.490	58.960
ΘΕΡΜΑΙΚΟΥ	618	5.460.720	24.720
ΘΕΡΜΗΣ	951	6.065.510	38.040
ΘΕΣΣΑΛΟΝΙΚΗΣ	194	983.840	7.760
ΚΑΛΑΜΑΡΙΑΣ	2934	19.284.630	117.360
ΚΟΡΔΕΛΙΟΥ-ΕΥΟΣΜΟΥ	3541	24.018.650	141.640
ΝΕΑΠΟΛΗΣ-ΣΥΚΕΩΝ	2890	17.545.830	115.600
ΠΑΥΛΟΥ ΜΕΛΑ	3860	22.527.280	154.400
ΠΥΛΑΙΑΣ-ΧΟΡΤΙΑΤΗ	1982	13.874.010	79.280
ΩΡΑΙΟΚΑΣΤΡΟΥ	1692	9.921.500	67.680
ΓΕΝΙΚΟ ΣΥΝΟΛΟ 2017	**22.323**	**141.461.370**	***892.920***

Από 1 Ιανουαρίου 2018 έως και 24 Αυγούστου 2018			
Municipality	**No. of incoming vehicles**	**Total weight (Tonnes)**	**Kilometres saved by the Municipalities**
ΑΜΠΕΛΟΚΗΠΩΝ-ΜΕΝΕΜΕΝΗΣ	1.629	10.044.270	65.160

ΔΕΛΤΑ	1.483	9.888.730	59.320
ΘΕΡΜΑΙΚΟΥ	774	7.433.381	30.960
ΘΕΡΜΗΣ	1.649	9.984.480	65.960
ΘΕΣΣΑΛΟΝΙΚΗΣ	5.368	27.514.630	214.720
ΚΑΛΑΜΑΡΙΑΣ	2.439	16.343.950	97.560
ΚΟΡΔΕΛΙΟΥ-ΕΥΟΣΜΟΥ	3.000	19.768.120	120.000
ΝΕΑΠΟΛΗΣ-ΣΥΚΕΩΝ	2.335	14.026.470	93.400
ΠΑΥΛΟΥ ΜΕΛΑ	3.068	18.156.730	122.720
ΠΥΛΑΙΑΣ-ΧΟΡΤΙΑΤΗ	1.722	11.835.290	68.880
ΩΡΑΙΟΚΑΣΤΡΟΥ	1.451	8.478.390	58.040
ΓΕΝΙΚΟ ΣΥΝΟΛΟ	**24.918**	**153.474.441**	**996.720**

Source: Regional Association of Solid Waste Management Agency of Central Macedonia, Department of Transportation and Processing of Municipal Solid Waste, Department of Waste Transfer Station in Efkarpia, Municipality of Pavlos Melas (27.8.2018)

6.2.4 Συμπεράσματα

From the data collected, it appears that there are trends for changes in transport routes during the period 2020 - 2023 but these are not yet measurable.

It should be borne in mind that, according to European data, the trend of municipal waste generation is declining. The recycling rate in Greece is stagnant at around 17% and is much lower than the EU average of 47%. In addition, although the percentage of waste driven to landfill in Greece fell from 84% in 2015 to 82% in 2016, the percentages are particularly discouraging, as the average in the corresponding category for the EU is 25%.

Note that countries with recycling rates above 45% use a similar economic incentive. In contrast, countries that have not adopted such policies have recycling rates below 20%. This suggests that "polluter pays" practices are an effective mean of recycling / reusing.

Regarding the quantitative and qualitative data for the Municipal Solid Waste provided by the thirteen (13) Regional Waste Management Plans of the respective Regions, it is concluded that no specific line was followed, although each Region submitted in its planning its available data.

These findings, combined with the admission of the National Waste Management Plan "it is neither possible nor desirable to set binding and / or universally applicable criteria for the exclusion and location of infrastructure", do not facilitate either safe conclusions or forecasts for transport routes during in the period 2020 - 2023. This will be possible when the planned projects will be implemented throughout the Greek territory and the implementation policy of the zero waste directions begins to be implemented.

References

Birkun, A., (2009). "Marine Litter in the Black Sea Region"(http://www.blacksea-commission.org/_publ-ML.asp).

Compactor Management Company: https://www.norcalcompactors.net/waste-disposal-methods/

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

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

European Commission. 2014. Towards a circular economy: A zero waste programme for Europe.

European Commission, "Being wise with waste: the EU's approach to waste management", Luxembourg, 2010.

European Commission, "Making sustainable consumption and production a reality", Luxembourg, 2010.

European Parliament: https://www.europarl.europa.eu/news/en/headlines/society/20180328STO00751/eu-waste-management-infographic-with-facts-and-figures

European Parliament: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:l28027&from=EL

Eurostat: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics&oldid=503336#Total_waste_generation

FAO – Food and Agriculture Organisation (2020). "The State of Mediterranean and Black Sea Fisheries 2020. (http://www.fao.org/3/cb2429en/CB2429EN.pdf).

Scheiner Gabriela, Hellenic-German Assembly - Thessaloniki Office, www.grde.eu, presentation at a conference: https://gr.boell.org/el/2019/04/15/dimioyrgia-kentroy-epanahrisis-sto-dimo-thessalonikis.

Governemntal Gazette, 13 February 2012, No 24, Criminal protection of the environment - Harmonization with Directive 2008/99 / EC – Waste production and management framework - Harmonization with Directive 2008/98 / EC - Regulation of issues of the Ministry of Environment, Energy and Climate Change.

Greek Law 4042/2012 Criminal protection of the environment - Harmonization with the Directive 2008/99/EK - Waste generation and management framework - Harmonization with the Directive 2008/98/EK - Regulation of issues of the Ministry of Environment, Energy and Climate Change.

Hellenic Statistical Authority (www.statistics.gr).

http://waste-prevention.gr/waste/wp-content/uploads/2015/10/2015_Strategy%20on%20the%20prevention%20and%20recycling%20of%20waste%201_GR.pdf

Joint Ministerial Decision 29407/3508/2002 - Government Gazette B-1572/16-12-2002 Measures and conditions for waste landfill.

Katsigainnis, C. (2009). “The Waste Management in the Greek Regions by the Local Government Organizations ‘The case of the Municipality of Kalamata’”. Technological Educational Institution of Kalamata, Faculty of Management and Economy, Department of Local Governance.

Kamzola, E. L. (2014). “Alternative packaging management-recycling in Greece through the Hellenic Recovery Recycling Corporation”. Bch Thesis, Aegean University, Faculty of Environtment.

Leblanc, R. (2020). “An Introduction to Solid Waste Management”. The balance small business. Updated October 28, 2020 (https://www.thebalancesmb.com/an-introduction-to-solid-waste-management-2878102)

Leblanc, R. (2019). “Integrated Solid Waste Management (ISWM) - An Overview”. The balance small business. Updated April 14, 2019 (https://www.thebalancesmb.com/waste-treatment-and-disposal-methods-2878113).

Leblanc, R. (2019). “Waste Treatment and Disposal Methods”. The balance small business. Updated May 09, 2019 (https://www.thebalancesmb.com/an-introduction-to-solid-waste-management-2878102).

Lumen – Environmental Biology: https://courses.lumenlearning.com/suny-monroe-environmentalbiology/chapter/15-2-waste-management-strategies/.

Meng-Chuen Chen, D., Bodirsky B., Krueger, T., Mishra, A. and Popp, A. (2020). “The world’s growing municipal solid waste: trends and impacts”. Environmental Research Letters, 15.

Ministry of Environment and Energy, "National Waste Management Plan", Athens, 2015

Ministry of Environment and Energy, "National Waste Management Plan, Including Hazardous Waste 2020 - 2030", Athens, 2020.

Municipality of Thessaloniki, "Local Decentralized Waste Management Plan", Thessaloniki, 2016.

Panagos, V. and Sandalakis, V. (2015). “Municipal Waste Composting”. Bachelor Thesis. Technological Educational Institute of Eastern Macedonia and Thrace. School of Applied Technology. Department of Oil and Gas Technology Engineering.

Region of Central Macedonia, "Regional Waste Management Plan of Central Macedonia and Strategic Environmental Impact Study", Thessaloniki, 2016.

Simon, J., M. (2019). “A Zero Waste hierarchy for Europe: New tools for new times. From waste management to resource management”. (Zero Waste Europe: https://zerowasteeurope.eu/2019/05/a-zero-waste-hierarchy-for-europe/).

SIMS Lifecycle Services (https://www.simslifecycle.com/press-releases/surfsara/).

The World Bank (https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html).

Valta, A. (2019). “Utilization of household food waste and organic waste from the food industry in the context of the circular economy”. PhD Thesis. National Technical University of Athens, School of Chemical Engineering.

Vitoraki, M. (2017). “Municipal management of bio-waste in Greece: overcoming weaknesses”. Proceedings of 5th International Conference on Sustainable Solid Waste Management, Athens, 21 – 24 June 2017.

Zero Waste Europe. (2020). “Sustainable Finance for a Zero Waste Circular Economy”.

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Address: Ptolemaion 29a, P.C.56430, Thessaloniki

Tel:+30 2310285688

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