UNIVERSITY OF LJUBLJANA
FACULTY OF ECONOMICS

MASTER'S THESIS

# SUSTAINABLE WASTE MANAGEMENT IN THE EUROPEAN UNION AND IMPLICATIONS FOR DEVELOPING COUNTRIES

Ljubljana, June 2018 MARÍA VICTORIA ECHAGÜE FERRERO

# AUTHORSHIP STATEMENT

The undersigned Maria Victoria Echagüe Ferrero, student at the University of Ljubljana, Faculty of Economics, (hereafter: FELU), author of this written final work of studies with the title Sustainable Waste Managmeent in the European Union and Implications for Developing Countries, prepared under the supervision of Professor Tjasa Redek, PhD

DECLARE

1. this written final work of studies to be based on the results of my own research;

2. the printed form of this written final work of studies to be identical to its electronic form;

3. the text of this written final work of studies to be language-edited and technically in adherence with the FELU's Technical Guidelines for Written Works, which means that I cited and / or quoted works and opinions of other authors in this written final work of studies in accordance with the FELU's Technical Guidelines for Written Works;

4. to be aware of the fact that plagiarism (in written or graphical form) is a criminal offence and can be prosecuted in accordance with the Criminal Code of the Republic of Slovenia;

5. to be aware of the consequences a proven plagiarism charge based on the this written final work could have for my status at the FELU in accordance with the relevant FELU Rules;

6. to have obtained all the necessary permits to use the data and works of other authors which are (in written or graphical form) referred to in this written final work of studies and to have clearly marked them;

7. to have acted in accordance with ethical principles during the preparation of this written final work of studies and to have, where necessary, obtained permission of the Ethics Committee;

8. my consent to use the electronic form of this written final work of studies for the detection of content similarity with other written works, using similarity detection software that is connected with the FELU Study Information System;

9. to transfer to the University of Ljubljana free of charge, non-exclusively, geographically and time-wise unlimited the right of saving this written final work of studies in the electronic form, the right of its reproduction, as well as the right of making this written final work of studies available to the public on the World Wide Web via the Repository of the University of Ljubljana;

10. my consent to publication of my personal data that are included in this written final work of studies and in this declaration, when this written final work of studies is published.

Ljubljana, July 13th, 2018 Author's signature: 

# TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES



## LIST OF APPENDIXES

## LIST OF ABREVIATIONS

| | |
|---|---|
| CE | Circular Economy |
| EC | European Commission |
| EEA | European Environmental Agency |
| EU | European Union |
| ISWM | Integral Solid Waste Management |
| LAC | Latin America and the Caribbean |
| MS | Member States |
| MSW | Municipal Solid Waste |
| SD | Sustainable Development |
| SDGs | Sustainable Development Goals |
| SWM | Solid Waste Management |
| UN | United Nations |
| UNEP | United Nations Environment Programme |

# INTRODUCTION

Generation and accumulation of solid waste is a natural consequence of life in urban areas (Tchobanoglous, Theisen & Vigil, 1994). Therefore, management of wastes has existed for centuries (UNEP, 2011). While urban populations rise, waste volume grow and production and consumption patterns change (EEA, 2007; Marshall & Farahbakhsh, 2013). Consequently, unsustainable levels of waste materials outputs are generated (Silva, Stocker & Gorissen, 2017). This increase in generation and complexity in the composition of solid waste is contributing to climate change by generating the degradation of air, water quality and public health (Ma & Hipel, 2015). In ten years, the rate of global waste generation raised from 0.64 kg/capita/day i.e. 0.68 billion tonnes/ year to 1.2 kg/capita/day i.e. 1.3 billion tonnes/year and the tendency is to increase up to 2 billion tonnes/year i.e. 1.42 kg/capita/day from 4.3 billion of residents in urban areas by the year 2025 (Hoornweg & Bhada-Tata, 2012; UNEP, 2015). Thus, Solid Waste Management (hereinafter SWM) has become a global concern (Ilic & Nikolic, 2016).

This problem is even more critical in developing countries (Marshall & Farahbakhsh, 2013; Abid, 2017; Gathak, 2016), where most of the solid waste is still disposed in landfills and open-air sites causing serious health and environmental problems (Potdar, Singh, Unnikrishnan, Naik, Naik, Nimkar & Patil, 2016). Although the generation of solid waste is lower comparing with industrialized countries, the inadequate SWM makes the situation more difficult to handle (Ilic & Nikolic, 2016). Because of its complexity the waste sector is now part of the sustainability agenda worldwide, requiring holistic solutions that would include concepts as sustainable production and consumption, resource efficiency and circular economy (hereinafter CE) (Silva, Stocker & Gorissen, 2017). It is moving towards a sustainable management of solid waste, with integrated policies, leaving behind conventional landfilling and recycling systems (UNEP, 2011; Pires, Martinho & Chang, 2011). This means a transition from end-to pipe technologies to new integrated management resource systems that would take into consideration new economic, social, cultural and legal elements (Wilts, Dehoust, Jepsen & Knappe, 2013). However, sustainable management of wastes is still a pending topic in Latin America and the Caribbean (hereinafter LAC) (Hernández-Berriel, Aguilar-Virgen, Taboada-Gonzalez., Lima-Morra, Eljajek-Urzola, Marquez-Benavides & Buenrostro-Delgado, 2016).

Therefore, the aim of this research is to analyse the SWM in the European Union (hereinafter EU); explore the history of waste and SWM in the EU, developments in legislation, that supported an emergence of comparatively very efficient waste management system and examine in detail good practices in order to identify the key factors that make EU more efficient in managing solid waste to determine the next steps that LAC should follow to improve their SWM. The purpose of the thesis is to identify key elements of success of EU, key elements limiting developing countries, in particular LAC, from success and key learnings from EU. It will be first analysed the legal framework and data related to SWM in

EU. This will include Eurostat data, strategies and targets, goals, evaluation of efficiency, analysis of regulations and incentives. To continue, the same factors will be analysed in LAC. This analysis will enable to identify key elements in SWM, identify strengths and weaknesses to be able to finally identify which actions could LAC implement to improve their SWM.

Considering the research purpose, five key questions will be analysed.

1. What is waste, solid waste and sustainable waste management?
2. What are the characteristics of waste generated in developed and developing countries of LAC, what are the main trends?
3. What are the characteristics of waste management in the EU? Which are the key elements for the success of EU in managing solid waste?
4. What are the characteristics of waste management in the developing countries, in particular in LAC?
5. What could developing countries, especially LAC countries, learn from EU to improve their waste management?

The type of research is mainly descriptive with analysis of secondary source data (primarily Eurostat data). The theoretical part, relies on desk research, primarily description, analysis and synthesis of literature to provide to the reader an overview of main concepts and problems related with sustainable development (hereinafter SD) and waste management. The second part of thesis deals with the description of the situation in the EU. In this part, secondary source data (primarily Eurostat) was analyzed. The study is focus mainly in municipal solid waste (hereinafter MSW) because is the waste stream with most complete data sets available (Watkins et. al., 2012), MSW has a high political visibility, is one of the hardest sources of waste to manage efficiently, and it tends to be more heterogeneous comparing with other sources of wastes (Mc. Dougall, White, Franke & Hindle, 2001). The indicators used to analyse SWM were the generation of MSW, types of waste treatment implemented, percentage of recycling and landfilling. Policy analysis and the analysis of situation in LAC also rely on description, analysis and synthesis of literature.

The main limitation in the preparation of the text was the lack of detailed data, length of time series and availability of data for LAC countries. A better data-set would allow a more in-depth analysis and also statistical analysis.

# 1 SOLID WASTE. DEFINITION AND CLASSIFICATION.

The definition of solid waste may change in different spaces, times and cultures (Botega Palma, 2004). Most of the definitions will normally refer to any substance or object that lacks of use or value or is no longer required by the owner (Gharfalkar, Court, Campbell, Ali & Hillier, 2015; Mc. Dougall, White, Franke & Hindle, 2001; Eurostat (2017), Directive of the

European parliament and of the Council, 2008/98/EC). However, many authors describe them as a by-product (or resource) derived from human activity because of its potential value for reuse or recycle (Mc. Dougall, White, Franke & Hindle, 2001; Gharfalkar, Court, Campbell, Ali & Hillier, 2015; Toledo, 2006).

In the Directive 2008/98/EC (Article 22), the EU introduced the concept of by-products in the legislation differentiating them from wastes as follows. By-products are those substances or objects generated as a result of a production process, but not as the main purpose of this process. It will be considered a by-product and not a waste every time it is safe for a posterior re-use of the substance, when its use is legal, when the substance or object is a consequence of a production process and when it can be directly re-used without any additional transformation.

There are many possible ways to classify solid wastes (Tchobanoglous & Kreith, 2002). We can group them, for example, by material (glass, paper, etc), by use (food waste, packaging waste, etc.); according to the risks for the environment (hazardous or non-hazardous); according to their origin (where or who generates them). Taking into consideration their physical properties can be classified in combustible, compostable and recyclable, or by their physical nature in dry or humid; and according to their chemical composition can be divided in organics or inorganics (CEMPRE, 1998; Mc. Dougall, White, Franke & Hindle, 2001).

It is important to mention that the definition of terminologies and classification of solid wastes can change substantially in the different literature (Tchobanoglous, Theisen & Vigil, 1994). The selection of classification criteria and the use of published data will depend on the practical purpose. Consequently, it will require considerable care, judgement and common sense, rather than scientific precision (Sztern y Pravia, 1999; Tchobanoglous, Theisen & Vigil, 1994; Tchobanoglous & Kreith, 2002).

For the purposes of this report, in continuing classification of solid waste by three criteria is discussed:

- By source of generation.
- According to the safety for health and environment.
- By its chemical composition.
- European classification for statistical purposes.

### 1.1 Classification according to the source of generation (origin)

Classification of solid wastes according to their source of generation may vary in different literature. When classifying according to the sources, solid wastes are generally related to use of land and zoning. Although many classifications can be used, the following ones could be the most useful: MSW (includes residential, institutional, commercial, non-process

wastes from industries), municipal services, construction and demolition, treatment plants sites, industrial and agricultural (Tchobanoglous & Kreith, 2002). In Table 1 are described the typical facilities, activities or locations where these wastes are generated and the typical types of solid waste generated by source.

*Table 1. Sources of Solid Waste in a Community*

| Source | Typical facilites or activities of waste generation | Types of solid wastes |
|---|---|---|
| **Municipal Solid Waste** | Households residencies, commercial activities (stores, markets, hotels, etc.), Institutional (schools, hospitales, etc.) Family residencies and apartments, etc and industrial (non-process wastes of all industries). | Food wastes, paper, plastics, glass, textiles, aluminium, yard wastes, special wastes (as bulky waste, batteries, tires, among others), household hazardous wastes. |
| **Construction and demolition** | New construction sites, road repair, etc. | Wood, steel, concrete, dirt, etc. |
| **Municipal Services (excluding treatment facilities)** | Street cleaning, landscaping, recreational areas such as parks and beaches. | Special wastes, common garbage, street sweeings, general wastes similar to institutional ones. |
| **Treatment facilities** | Water, wastewater, industrial treatment processes, etc. | Principally residual sludges. |
| **Industrial** | Construction, chemical plant,s factories, light and heavy manufacturing, refineries, , power plants, demolition, etc. | Industrial process wastes, non-industrial waste such as wastes similar to MSW, construction and demolition wastes, ashes special wastes, hazardous wastes. |
| **Agricultural** | Fiel and row crops, plantations, vineyards, farms, dairies, feedlots, etc. | Food wastes, agricultural wastes, common garbage, and hazardous wastes. |

*Source: Tchobanoglous & Kreith (2002).*

The term MSW usually comprises all the wastes generated in a community with the exception of wastes generated by treatment plants, municipal services, and agriculture. For the EPA reports, it includes wastes from residential, commercial, institutional, and some industrial sources (Tchobanoglous & Kreith, 2002).

Eurostat (2017) defines MSW as the waste collected by or in behalf of municipalities and wastes with similar characteristics and composition collected by the private sector (in most of the cases for reprocess purposes). In a large extent, it consists on waste generated by

households, but it can also include similar waste generated by small businesses and institutional wastes. This part of the MSW may differ in different countries and municipalities, depending on the local SWM system (Eurostat, 2017). The Eurostat definition must be in line with the definition in the waste legislation to ensure reliable statistical data for report and monitoring of the SWM system. For these purposes, the MSW will include electronics, bulky and garden waste from households, waste from street and market cleansing; and will exclude sewage sludge, construction and demolition waste (2008/98/EC).

This report will focus principally in MSW for several reasons. It is the waste stream for which the most complete data sets are available (although definitions of MSW can be vary in different countries) (Watkins et. al., 2012). The MSW have a high political profile because it depends on the municipalities and the general public (the voters). Furthermore, household is, naturally, one of the hardest sources of waste to manage efficiently. Comparing with other sources of wastes (industrial for instance), MSW tend to be more heterogeneous and thus, includes a diverse range of materials (organics and inorganics as metal, glass, paper, plastics) totally mixed. The composition of MSW can also vary greatly both seasonally and geographically (different countries and from urban to rural areas). Therefore, managing MSW can be most challenging, but also, once a country achieves a good management of these types of wastes it most likely will mean a good management of the rest of the solid wastes (Mc. Dougall, White, Franke & Hindle, 2001).

### 1.2 Classification according to the safety for health and environment

The Commission Decision 2001/118/EC of 16 January 2001, amending Decision 2000/532/EC as regards to the list of wastes, has its own classification of wastes according to the source of generation and other criteria. When we classify wastes according to the safety for health and environment, they commonly divided into hazardous or non-hazardous. There are not many differences in the definition of hazardous wastes in the literature. They are referred as those wastes, in any physical state, that because of their corrosive, toxic, poisonous, reactive, explosive, flammable, biological, infectious or irritant condition represents a danger to the ecological balance, to the current or future quality of the environment, or the health and life quality of the human beings. As a consequence, non-hazardous wastes will be considered all the wastes that don't possess any of the mentioned characteristics and therefore, can be managed as common wastes in the local SWM system.

Many of the products used every day in the home, such as cleaning products and personal care products are considered hazardous (Tchobanoglous, Theisen & Vigil, 1994). Batteries and fluorescent lamps, for example, are classified as hazardous materials because they contain heavy metals that can enter the food chain (CEMPRE, 1998). Common tubular and compact fluorescent lamps release mercury when they are broken, burned or buried in landfills (Monteiro et al., 2001).

Lund (1996) states that in the domestic waste stream the percentage of hazardous waste is very low. However, the small amounts of hazardous waste in MSW are significant because they exist in every source of generation of MSW and their persistence when discarded into the environment; they also have a negative impact on the recovery of materials, conversion products (for example, compost), incineration products and landfills (Tchobanoglous, Theisen & Vigil, 1994).

### 1.3 Classification according to chemical composition

Waste is classified also by its organic composition. In this case it is divided into organic and inorganic waste.

Organic materials are all material that once had life, all easily putrescible wastes (Alter Vida, 2004, p. 10). It includes a great diversity of wastes that originate naturally as a consequence of physiological functions or that are the product of the exploitation by man of biotic resources (Sztern & Pravia, 1999). Some examples are food waste, garden waste, wood, etc. (Alter Vida, 2004).

Inorganic materials are materials that did not have a life as the word "inorganic" strictly means that it does not have and has not had life (Alter Vida 2004). This category covers all those wastes of mineral origin and substances or compounds synthesized by man; usually include metals, plastics, glass, etc. (Sztern & Pravia, 1999). According to Alter Vida (2004), other materials such as animal leather are also included in this category because, although they come from living beings, they take a long time to decompose.

### 1.4 European Waste Classification for Statistical Purposes

The EU has developed its own harmonized List of Wastes (Low) in order to classify the wastes ensuring the generation of reliable and comparable waste data and thus, an appropriate treatment of wastes (Eurostat, 2010a). The classification procedure is described in the Annex of the Commission Decision (2001/118/EC). Additionally, Eurostat (2010a) has developed a guidance on classification to help on the implementation of the regulation.

Wastes are identified by a six-digit code for the waste and a respective two-digit and four-digit chapter headings (2001/118/EC, Annex). Therefore, to be able to identify and classify a specific waste it is necessary to follow the following steps (Eurostat, 2010a, page 4; 2001/118/EC, Annex):

1. Identify the source of the waste in chapters 1 to 12 or 17 to 20. Some industrial units can find the sources in different chapters depending on the activities.
2. If it cannot be found the waste category in chapters 01 to 12 or 17 to 20, chapters 13, 14 and 15 must be studied.

3. If the waste does not fit any of the mentioned chapters, it should be identified with a waste category in chapter 16.
4. If no appropriate waste category was found in chapter 16, the 99 code (XX YY 99) must be used in correspondence to point 1.
5. The wastes marked with and asterisk (*) are considered hazardous according to Directive 91/689/EEC.

The LoW (2001/118/EC, Annex) includes 51 categories and comprises 20 different chapters. Each chapter represents the field of activity where the waste is generated. The chapter 20 corresponds to MSW (including separately collected fractions) which consist principally of household waste, similar commercial and institutional wastes.

This chapter is divided in three subchapters according to the source of generation as follows (2001/118/EC, Annex):

**a. Separately collected fractions, which are further divided into:**

- *Non- Hazardous:* Paper board and cardboard, glass, biodegradable waste from kitchen and kanteen, clothes, textiles, edible foil and fat, paint, inks, some adhesives and resins. Additionally, it includes the following (every time they were not included in other chapters): detergents, medicines, batteries and accumulators, discarded electrical and electronic equipment, wood, plastics, metals, wastes from chimney sweeping, other fractions not otherwise specified.

- *Hazardous:* solvents, acids, alkalines, photo-chemicals, pesticides, fluorescent tubes and other mercury-containing waste, discarded equipment containing chlorofluorocarbons, oil and some types of fat, detergents containing dangerous substances, cytotoxic and cytostatic medicines paint, inks, adhesives and resins containing dangerous substances, batteries and accumulators and unsorted batteries and accumulators containing these batteries, discarded electrical and electronic containing hazardous components, wood containing dangerous substances.

b. **Garden and park wastes,** which includes non-hazardous, biodegradable waste, soil and stones, other non-biodegradable wastes.

c. **Other municipal wastes,** which includes non-hazardous mixed MSW, waste from markets, street-cleaning residues, septic tank sludge, waste from sewage cleaning, bulky waste, MSWs not otherwise specified.

# 2 SUSTAINABLE DEVELOPMENT, WASTE MANAGEMENT AND CIRCULAR ECONOMY

An **Integral Solid Waste Management** (here in after **ISWM)** or **Sustainable Waste Management (SWM)** must deal with different actors, governmental and non-governmental at all levels (local, national, regional, supranational) and thus, calls for a specific form of governance (Boh, 2004). Acknowledging this and the need to battle environmental challenges (such as SWM) and encourage SD, policy makers such us European Comission (EC), and business advocacy bodies like Ellen Mc Arthur Foundation started to discuss and introduce the concept of CE (Korhonen, Nuur, Feldmann & Eshetu Birkie, 2017). In the following sub-chapter, the CE and its relation with SWM and consequent contribution to SD will be explained.

## 2.1 Sustainable Development

The concept of SD has been debated for decades, but the most mentioned definition is still from the Report of the World Commission on Environment and Development Our Common Future, better known as the Brundtland Report (UN, 1987, paragraph 27), which was the starting point for the debate. Brutland defines SD as the development that allows current generations to meet their own needs without compromising the ability of future generations to meet theirs.

Sustainability is a broad concept that implies economic growth ensuring equitable opportunities for all and respecting the environment (UN, 1987). Therefore, this concept rests in three basic pillars or dimensions; social, economic and environmental (Sinakou, Boeve-de Paw, Goossens & Van Petegem, 2018; UN, 1987).

Sustainability is the basis for today's leading global framework for international cooperation; the UN's Resolution adopted by the General Assembly on 25 September 2015 Transforming our world: the 2030 Agenda for SD, A/RES/70/1, which defines 17 Sustainable Development Goals (hereinafter SDGs) that integrate and balance the three dimensions of SD (Sinakou, Boeve-de Paw, Goossens & Van Petegem, 2018). Each goal has specific targets to be reached over the next 15 years. For the goals to be achieved, everyone needs to do their part: governments, the private sector, civil society and the rest of the people (UN, n.d.).

The SDGs in its short version are: Goal 1. End poverty; Goal 2. End hunger; Goal 3. Improve Health and Wellbeing; Goal 4. Ensure quality education for everyone; Goal 5. Achieve gender equality; Goal 6. Ensure availability and sustainable management of water and sanitation; Goal 7. Ensure affordable and reliable clean energy for all; Goal 8. Promote decent work and sustainable economic growth; Goal. 9. Industry, innovation and infrastructure; Goal 10. Reduce inequalities; Goal 11. Make cities and communities

sustainable; Goal 12. Ensure responsible consumption and production; Goal 13. Combat climate change; Goal 14. Protect life below water; Goal 15. Protect life on land and combat desertification; Goal 16. Promote peaceful and just societies and strong institutions; Goal 17. Strengthen global partnerships for the goals (UN, n.d.; UN, 2015, p. 14).

The Communication from the Commission Europe 2020 "A strategy for smart, sustainable and inclusive growth", COM (2010) 2020, 3.3.2010, says that to achieve a sustainable growth, it is necessary to build a resource efficient and competitive economy in order to save money, reduce emissions and boost economic growth. This change must start with the development of a framework of policies that recognize the interdependence between the economy, social wellbeing and natural capital, and provide a fair and coherent basis for business to operate and grow without compromising the environment and social wellbeing (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — Roadmap to a Resource Efficient Europe, COM (2011) 571 final, Brussels, 20.9.2011). Sustainable Waste Management and CE are key concepts to tackle this challenge. Therefore, in the next sub-chapters will be explained these concepts, their interrelation and their contribution to SD.

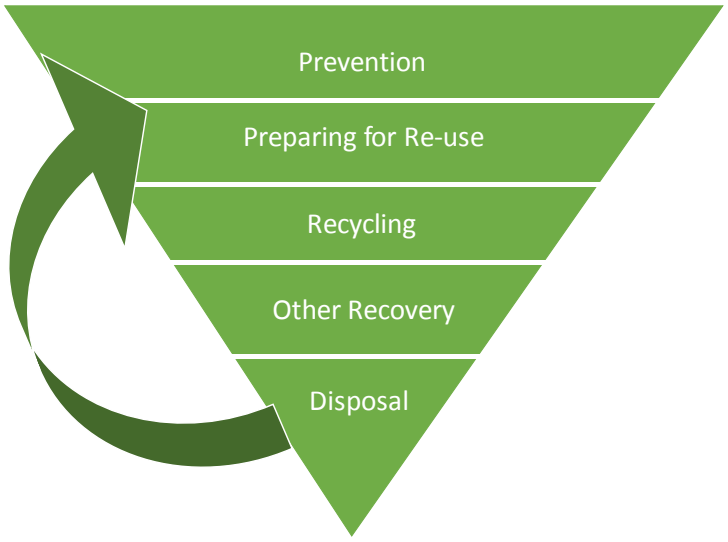
## 2.2 Solid Waste Management

Generation and accumulation of solid waste is a natural consequence of life in urban areas. Therefore, management of waste has existed for centuries (Tchobanoglous, Theisen & Vigil, 1994). Eurostat (2016) defines waste management as the collection, transportation, treatment and final disposal of all the wastes produced in the community (including final disposal sites). The UNEP (in Botega Palma, 2004; Silva, Rosano, Stocker & Gorissen, 2016) defines an Integral Waste Management (IWM) as a frame of reference for designing and implementing new waste management systems and for evaluating and optimising existing ones. According to different policies and book texts, the main goal of an IWM system is to first, obtain the maximum reduction possible of waste generation, secondly, the maximum reuse and recycling of materials, and as the last option, the correct final disposition. Therefore, in the next sub-chapter the waste management hierarchy will be explained.

Although the importance of reducing wastes is always mentioned in the literature, so far, the SWM has mostly provided end-of-pipe solutions, mostly focus on recycling and final disposal. This means that these strategies have been unable to stop the growing demand for raw materials and their impacts in the environment, result of the throwaway consumerism economy. Nonetheless, in the last decade important policy innovations in waste management have arisen in response. Thus, the world is now going in a direction of ISWM policies to achieve sustainability (Silva, Rosano, Stocker, & Gorissen, 2016).

A good example of this progress in legislation is the development of the CE Package by the EU and the related improvements in the waste management policies in Europe. The EU's Sixth Environment Action Programme (2002- 2012) identified waste prevention and management as one of four top priorities. Additionally, the Waste Framework Directive (2008/98/EC), the cornerstone of EU waste policy, presents a five-step waste hierarchy (see Figure 1) where prevention is the best option, followed by re-use, recycling, other forms of recovery, and disposal (such as landfill) as the last option (EC, 2010). Reducing the amount of waste generated through prevention and re-use is essential to improve resources and materials efficiency (Humphris-Bach, Essig, Morton & Harding, 2015). Landfill is the last option because it takes up land space and landfilled resources are lost to the economy and can have negative environmental impacts due to the generation of methane and leachate (Humphris-Bach, Essig, Morton & Harding, 2015; EU, 2018). Thus, EU waste legislation aims to move SWM up the waste hierarchy (EC, 2010).

- *Figure 1. The Waste Hierarchy*




*Source: EC (European Commission) (2010).*

Managing solid waste will always be an important part of the planning of a sustainable future (Tchobanoglous & Kreith, 2002). A sustainable system for solid waste management must integrate the three pillars of sustainability. It must be environmentally effective, economically affordable and socially acceptable (Mc. Dougall, White, Franke & Hindle, 2001).

- ***Environmentally effective****:* reduce maximum possible the potential negative impacts in environment of waste management.
- ***Economically affordable:*** a waste management system should be adapted to the existing local infrastructure and must operate at an affordable cost for the community.

- ***Socially acceptable**:* the community must accept the operation of the waste management system. Therefore, it is necessary to develop trust through dialogue with and education of the community.

A SWM must be **integrated** and must be accompanied by a correct solid waste treatment (Mc. Dougall, White, Franke & Hindle, 2001). Waste treatment is defined as the processes (physical, thermal, chemical or biological) applied to wastes, which modify its characteristics, and aims to reduce its volume or hazardous nature, to facilitate its management and recovery (EC, 2017). Normally, those treatments would include material recycling, biological treatment of organic materials, thermal treatment (such as incineration with energy recovery), and landfill (Mc. Dougall, White, Franke & Hindle, 2001).

An IWMS cannot follow a simple set of rules because each of them operate under specific conditions and circumstances. However, the following principles can must be considered (Mc. Dougall, White, Franke & Hindle, 2001).

- ***Market oriented:*** An effective recycling scheme must have a market for its outputs. These markets are normally very sensitive to prices and consistency in quality and quantity of supply. Therefore, setting material quality standards is very important, but those standards must not be rigid in prescriptive legislation because the market needs can change over time.

- ***Flexibility:*** Since social, economic and environmental conditions may change over time and region the scheme must have the flexibility by design to adapt and operate under different conditions.

- ***Scale:*** ISWM should be grounded ideally on a large-scale regional basis because of the cost that the scheme will imply and the need for consistency in quality and quantity of the recycled materials, energy or by-products. Only the waste collection could use up to 75% of the waste management budget.

- ***Social Acceptability:*** public participation is essential in any SWM scheme, their collaboration in separating domestic waste, as well as understanding their role and their cooperation with the local authorities is fundamental.

### 2.3 Circular Economy

CE is a new approach towards the traditional economy that has the potential to make a substantial contribution to SD by helping to reach many of the 17 SDGs (Systemiq & Ellen Mc Arthur Foundation (EMF), 2017). It proposes to move out from the traditional economic model of "take-make-dispose" into a regenerative and cyclical type of model. Therefore, not only contributes to an economic growth, but also has a positive impact in the environment

(such as waste reduction) and society (WBCSD & BCG, 2018; Korhonen, Nuur, Feldmann & Eshetu Birkie, 2017; EMF, 2013).

CE has a strong relationship with waste management by applying principles, in which waste is considered a resource and by retaining the maximum value possible from resources avoiding waste generation. These principles are based on durability, renewability, reuse, repair, replacement, refurbishment, cascading, upgrading, and reduced material use. It also represents an alternative to increase the resource productivity in companies and reduce waste (EC, 2015; WBCSD & BCG, 2018; Braungart, McDonough & Bollinger, 2007). Thus, waste generation is one indicator of a company's circular economy compliance (Systemic & EMF, 2017, p. 41).

The literature related to CE is emerging and, from a scholarly perspective, the conceptual discussions are still in their early stages. For this reason, there is still a need of deeper analysis of the concept, but Korhonen, Honkasalo and Seppälä (2017, p. 39) propose an interesting practical definition from a consumption- production perspective, in line with the current academic, policy and industry consensus. They define it as a SD initiative with the aim of changing the traditional linear system of production and consumption of materials to a circular system approach that includes material cycles, renewable and cascade-type energy flows. At the same time, it promotes the development of the cooperation of different actors of the SD such as producers and consumers.

In a practical level, China was the first country in the world that adopted a law for the implementation of the CE in 2008 (Korhonen, Honkasalo & Seppälä, 2017, p. 37). Since then, others have followed; The EU, for example, has created a CE package that comprises legislative proposals on earlier waste policies and aims to contribute to "closing the loop" of product lifecycles, and consequently, reduce waste generation and increase recycling and re-use (Bourguignon, 2017).

The CE is based on three key principles (Systemiq & EMF, 2017, p. 23):

1. *Preserving and enhancing natural capital,* by using scarce resources efficiently, controlling non-renewable natural reserves and balancing the flows of the renewable ones. An example would be replacement of fossil fuels with renewable energy.

2. *Optimising the use of resources,* by circulating products and materials at the highest utility possible in both technical and biological cycles. For example, by sharing or looping products and extending product lifetimes.

3. *Improving system effectiveness,* by finding and eliminating negative externalities, such as pollution of any component of the natural environment.

The implementation of circular solutions is expected to boost innovation, disrupt current industries and business models, and reshape customer demand into more sustainable consumption, building as a consequence new relationship between markets, customers and natural resources (WBCSD & BCG, 2018; Naustdalslid, 2017; Braungart, McDonough & Bollinger, 2007). It will incentivize solutions that involve rethinking of products and services using the mentioned principles and subsequently, will stimulate high value material cycles instead of recycling only for low value raw materials like in traditional recycling (Ghisellini, Cialani & Ulgiati, 2016).

In this context, the **main business actions** for these principles are (Systemiq & EMF, 2017):

- **Regenerate:** Change to renewable materials and energy. Regain, retain, and restore the health of ecosystems.

- **Share:** Share assets (such as rooms, materials, cars, etc.). Promote second-hand market (reuse). Extend life through maintenance. Design products to be durable, reused or recycled, etc.

- **Optimise:** Increase efficiency of products. Reduce waste in production and supply chain. Increase control with automation, remote sensing and big data.

- **Loop:** Remanufacture products or components. Materials recycling and digestion of organic waste.

- **Virtualize:** Use of digital technology to avoid generation of additional waste such us online shopping.

- **Exchange:** Use new product/service (such as multimodal transport). Apply new technologies such as 3D printing. Replace old with advanced non-renewable materials.

# 3 WASTE MANAGEMENT IN THE EUROPEAN UNION

In Europe, 16 tons of materials per person per year are currently used, from which nearly 5 tons become waste. The management of those wastes is continuously improving in the EU, despite of this there is still a lot to do. Recycling is still limited in many of the EU Member States (hereinafter MS). Just in terms of MSW alone, each person in Europe is currently producing an average of almost half a ton per year, from which 30 % is reused or recycled and, in some countries, more than 80% still goes to landfill (EC, 2018).

Over the last two decades, European countries have realized about the need of moving MSW management up the "waste hierarchy" (see Figure 1) to extract more value from the

resources, while reducing environmental impacts and moving the economy. Therefore, EU started to shift the focus from end-of-pipe solutions, to prevention and recycling (EEA, 2013a). This new approach towards waste and resources implied an evolving political challenge that has resulted in the reconceptualization and reframe of waste policy, bringing new policies and targets towards waste reduction and recovery (Silva, Rosano, Stocker & Gorissen, 2016).

After Rio 20 and its Programmes for Sustainable Consumption and Production, innovation in sustainable waste management started to be recognized as a priority in EU (Silva, Rosano, Stocker & Gorissen, 2016). In the last 30 years legislation has evolved towards a more resource efficient economy. In this context, waste prevention and management hast been identified as one of four top priorities in the EU's seventh Environmental Action Program. The main goal is to detach economic growth from increase in waste generation and consider waste as a valued resource instead of an unwanted burden. Moreover, it aims to maximize recycling and reuse, reduce waste generation, restraint incineration of non-recyclable wastes, eliminate landfilling, use unavoidable waste as a resource and minimize the extraction of natural resources (EC, 2010; EU, 2018).

Turning waste into a resource is a key for a CE in the EU. One of the main factor of success in the improvement in waste management in the EU have been the objectives and targets set in the legislation. This included the stimulation of innovation, increase of recycling rates, reduce of landfilling rates and modification of consumer behavior through incentives. These legislations are developed in the framework of a number of wider EU policies and programmes that include the 7th Environment Action Programme, the Resource Efficiency Roadmap and the Raw Materials Initiative. The Waste Framework Directive is the cornerstone of EU waste policy (EU, 2018).

### 3.1 Legal framework

The EU waste policy landscape has evolved considerably in the last 30 years and EC has adopted more than 200 pieces of environmental legislation since the 1970s (EEA, 2015; EEA, 2013a; EEA, 2016a). The development of EU waste legislation takes place within the framework of a number of broader EU policies and Programmes that are interrelated and entails environmental and economic policies. Even though the importance of waste prevention has been recognized in European waste legislation for almost 40 years, effective waste prevention is a work in progress (EEA, 2016b).

Waste legislation started in 1975 with the **Waste Framework Directive (75/442/EEC)**, and then **Directive on Packaging and Packaging Waste (94/62/EC)** in 1994. With the years it started to be consider from a broader perspective which resulted in the creation of new broader legislation and modification of specific waste legislations. The modern approach towards waste management is included under the umbrella of resource efficiency concept

and has the waste hierarchy as cornerstone (see figure 1). This new approach intends to decouple economic growth from environmental pressures, materials and energy consumption (EEA, 2016a; EU, 2018/). These policies include: the 2030 Agenda for Sustainable Development (A/RES/70/1), the 7th Environmental Action Programme (Decision of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet', 1386/2013/EU), the Roadmap to a Resource Efficient Europe (COM(2011) 571 final), The Circular Economy Package (Bourguignon, 2016) and The raw materials initiative- meeting our critical needs for growth and jobs in Europe (COM(2008) 699 final).

**The EU Strategy for SD (2001)** was one of the early policies that implicitly adopted the concept of resource efficiency by focusing on breaking the link between economic growth and the use of resources and generation of waste. It specifically included as an objective avoiding the generation of waste and boost efficient use of natural resources by applying life-cycle thinking and promoting reuse and recycling (EEA, 2016b, p. 23).

In 2005, the **Thematic Strategy on the prevention and recycling of waste- Taking sustainable use of resources forward** was adopted (COM (2005) 666 final). It was one of the seven thematic strategies planned by the 6th Environmental Action Plan and intended to link waste policy with wider policies on resources. Here waste prevention is seen as a tool for improving material resource efficiency. The strategy developed end-of waste criteria for some specific waste streams and put waste prevention policies into action (EU, 2018; EEA, 2016b, p. 23).

The Thematic Strategy on Waste Prevention and Recycling of Waste resulted in the revision of the **Waste Framework Directive** in 2008 (revised Directive 2008/98/EC), the cornerstone of EU waste policy. The revision marked a shift away from thinking of waste as an unwanted burden to seeing it as a valued resource. In 2010, the EU adopted Europe 2020, a European strategy to achieve sustainable and inclusive growth (EEA, 2016b, p. 26). The Flagship initiative for a resource-efficient Europe, included among the seven priority initiatives, the political goal of 'allowing the economy to create more with less' (EEA, 2016b, p. 24).

In 2008 was emitted the Communication for the **Raw Materials Initiative- meeting our critical needs for growth and jobs in Europe (**SEC (2008) 2741), which set out a strategy for tackling the issue of access to raw materials in the EU. It includes the importance of being resource efficient and the supply of "secondary raw materials" through recycling schemes.

The European Commission's (hereinafter EC) September 2011 Communication, **Roadmap to a Resource Efficient Europe** (COM (2011) 571 final), provides more operational directions (EEA, 2016a). The roadmap is the first step for the design of a suitable action framework that shows how policies interrelate and build on each other. This action

framework provides the first perspective for the transformation towards a sustainable economy by 2050. Every country member of the EU, on its side, must develop their own strategies to implement the policies and legislative proposals (COM (2011) 571 final). It proposes a way to increase resource productivity by decoupling economic growth from resource use and its consequent environmental impacts (EU, 2018).

In 2013, the EU adopted the **7th Environmental Action Programme,** Decision of the European Parliament and of the Council (1386/2013/EU) which will be guiding the European Environmental Policy until 2020 with the programme "Living well, within the limits of our planet". Its vision for 2050 includes key concepts as CE, the sustainable management of natural resources, and the decoupling of low-carbon growth from resource use.

All these concepts are incorporated inside the development of an economic framework and business model that focuses on increasing resource efficiency creating a new type model of sustainability management, the CE (Silva, Rosano, Stocker & Gorissen, 2016). To stimulate the transition towards the CE the EU developed in 2014 a **CE Package**. In 2015, were developed four legislative proposals on waste management and an action plan (EEA, 2013a; Bourguignon, 2017). These proposals introduced new targets for reuse, recycling and landfilling, new definitions, guidelines promoting waste prevention and extended producer responsibility, calculation methods and reporting obligations for targets (Bourguignon, 2017). The mentioned proposals were:

- **Amending Directive 2008/98/EC on waste (COM/2015/595 final- 2015/0275 (COD**). This is considered the main legal framework for MSWs, which contains the main concepts linked to waste management. It stablishes the "waste hierarchy" (Figure 1), which determines the order of priority in waste management (reuse, re-use, recycle, recovery). Introduces the "polluter pays principle" that stablishes that the producer has to pay for the cost of waste management. Includes also the concept of "extended producer responsibility" and the distinction between waste and by- products explained in Chapter 1 (Bourguignon, 2017).

- **Amending Directive on the landfill of waste (1999/31/EC)**, known as the Landfill Directive which bans landfilling of untreated waste and set new targets.

- **Amending Directive on packaging and packaging waste (94/62/EC)**, which requires MS to prevent generation of packaging waste and develop packaging waste reuse systems. The amended version sets more strict targets with regard to recovery and recycling of these wastes (EU, 1994; EU, 2004; Bourguignon, 2017).

- **Amending Directives 2000/53/EC on end-of-life vehicles**, Directive 2006/66/EC on batteries and accumulators repealing Directive 91/157/EEC, and Directive 2012/19/EU of the European Parliament on waste electrical and electronic equipment (WEEE).

The proposals are expected to deliver economic and environmental benefits, but also some costs. The cost of creating an efficient recycling system would be around €108 billion, but the benefits are bigger. The EC estimates that it will create over 170 000 jobs in the EU by 2035; will avoid greenhouse gases emissions (over 600 million tonnes of $CO_2$ equivalent between 2015 and 2035); increase the efficiency of the EU waste management, recycling and manufacturing sectors; reduce the dependence on raw material imports; and reduce the administrative burden. In addition, the proposals would reduce the impacts on environment and human health described earlier (Bourguignon, 2017, p. 8).

All the legislative efforts mentioned are developed under the umbrella of the **2030 Agenda for SD "Transforming our World" (**A/RES/70/1) which introduces 17 SDGs and 169 targets that were adopted on 25 September 2015. This journey started in June 2012 with the Rio+20 Conference on SD. In this conference governments decided to develop the global SDGs providing a shared global vision towards SD for all and forming the basis for a final Agenda package which includes natural resource management, sustainable consumption and production, good governance, and others (EU, 2018).

Other policies that set specific targets for specific waste streams for the collection, recycling and recovery of wastes between 2011 and 2020. These policies and their waste streams are presented in Table 2.

Table 2. *Policies according to different waste streams*

| **Policy** | **Waste Stream** |
|---|---|
| **Directive 2006/66/EC** | Batteries |
| **Directive 2008/98/EC** | Construction and demolition waste and MSW |
| **Directive 2000/53/EC** | End of life vehicles |
| **Directive 2002/96/EC** | Electric and electronic equipment |
| **Directive 94/62/EC amended by Directive 2004/12/EC** | Packaging waste |
| **Directive 1999/31/EC (Landfill Directive)** | Biodegradable MSW |

*Source: Adapated from EEA (2013).*

### 3.2 Strategies and targets

Waste policies in EU set minimum requirement for managing different types of wastes. The most relevant for SWM according to EEA (2016a) are: The Waste Framework Directive's (2008/98/EC) which set targets on recycling and preparing for reuse for specific wastes for households; the Landfill of Waste Directive (1999/31/EC) which set diversion targets for biodegradable MSW; and the Packaging and Packaging Waste Directive's (94/62/EC) which set recycling targets. Table 3 synthetizes the main objectives and targets related to waste sector and the deadlines for their implementation.

In 2005 EU took an important step for the strategy related with solid wastes. As part of the 6$^{th}$ Environmental Action Plan, the Thematic Strategy on Prevention and Recycling of Waste (COM (2005) 666 final) was developed as one of the seven thematic strategies (EC, 2016). As a result, the Waste Framework Directive was revised in 2008 (2008/98/EC). Here, for the first time, a "waste hierarchy" was included to prioritize waste management activities (see Figure 1) giving maximum priority to prevention of wastes (EEA, 2013a).

In strategic terms, EU waste policy intends to guarantee that by 2020 waste will be managed as a resource. Consequently, waste generation per capita will decline, and re-use and recycling will turn into attractive options, markets for secondary raw materials will be developed, more types of materials will be recycled and recycling quality will increase, energy recovery will be limited to non-recyclable materials, illegal shipments will be eradicated and landfilling will be virtually eliminated. Waste legislation will be fully implemented (COM (2011) 571 final).

*Table 3. Waste sectors objectives and targets timeline (2010-2030)*

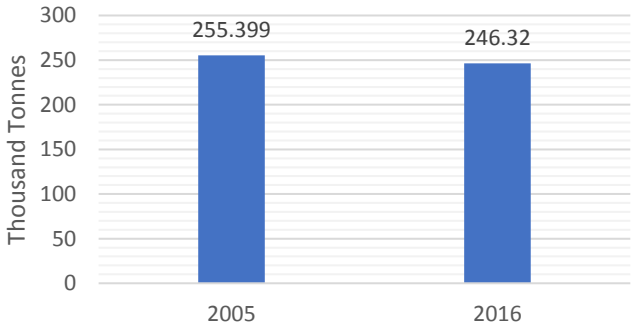
| **Sub-Sectors and objectives** | **Sources** | **Deadline for implementation** | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2015 | 2016 | 2019 | 2020 | 2025 | 2030 |
| **General** | | | | | | | |
| Waste is managed as a resource | COM (2011) 571 | | | | → | | |
| Achieve an absolute decline of waste generated per capita | COM (2011) 571 | | | | → | | |
| Ensure high-quality recycling | COM (2011) 571 | | | | → | | |
| Limit energy recovery to non-recyclable materials | COM (2011) 571 | | | | → | | |
| Virtually eliminate landfilling | COM (2011) 571 | | | | → | | |
| Eradicate illegal shipments of waste | COM (2011) 571 | | | | → | | |
| **Reuse, Recycling and Recovery Targets** | | | | | | | |
| Targets for end-of-life vehicles (by average weight per vehicle per year): reuse and recovery: 95 %; reuse and recycling: 85 % | Directive 2000/53/EC | | | | → | | |
| Recycling and reuse of 70 % by weight of non-hazardous construction and demolition waste | Directive 2008/98/EC | | | | → | | |
| Recycling and reuse of 50 % by weight of households and similar waste | Directive 2008/98/EC | | | | → | | |
| MSW: 60 % recycling and preparing for reuse by weight (*) | Amending Directive 2008/98/EC | | | | | → | |
| MSW: 65 % recycling and preparing for reuse by weight | Amending Directive 2008/98/EC | | | | | | → |
| Packaging waste: 75% of all packaging wastes prepared for reuse and recycling | Amending Directive 94/62/EC | | | | | | → |
| 55% plastic, 60% wood, 75% ferrous metal, aluminium, glass, and paper prepared for reuse and recycling | Amending Directive 94/62/EC | | | | | → | |
| 90 lightweight plastic carrier bags per person and/or are not provided free of charge | Amending Directive 94/62/EC | | | → | | | |
| 40 lightweight plastic carrier bags per person and/or are not provided free of charge | Amending Directive 94/62/EC | | | | | → | |
| **Collection and disposal** | | | | | | | |
| Separate collection for glass, plastic, metal, paper | Directive 2008/98/EC | → | | | | | |
| Reduction in disposal to 35 % of total 1995 biodegradable MSW | Directive 1999/31/EC | | → | | | | |
| Collection target for WEEE: 45 % of the average weight of EEE placed on the market in the three preceding years in the Member State concerned | Directive 2012/19/EU | | | → | | | |
| Below 10% of MSW landfilled | Amending Directive 1999/31/EC (2015) | | | | | | → |
| **Production** | | | | | | | |
| No heavy metals (Pb, Hg, Cd, hexavalent Cr, PBB and PBDE) in new electrical and electronic equipment | Directive 2011/65/EU | | | → | | | |
| | | | | | | | |

*Source: Adapted from EEA (2016, p. 4); EEA (2013b, p.12); Bourguignon (2017, p. 4); 2008/98/EC. (*) Due to large differences between MS in respect to their waste management performance, MS which in 2013 recycled less than 20% (Eurostat data) will have additional time to comply with the targets.*

### 3.3 Waste data in the EU (Eurostat data)

Every year 2.7 billion tonnes of waste are thrown in the EU, (EC, 2011), from which an average of 251.674 thousand tonnes correspond to MSW (Eurostat, 2017). In general, the trend of waste generation is quite stable, with exception of some waste streams that are increasing over the years, like construction and demolition waste (EC, 2011). The total amount of MW has been slightly reduced in the past 11 years from 255.399 thousand tonnes in 2005 to 246.320 thousand tonnes in 2016 (see figure 2) (EC, 2011). This reduction can be a consequence of the introduction in the EU of new policies and amendments related to solid waste management (hereinafter SWM). However, because there are different definitions and data collection methods in the different countries, it is important to be careful at the moment of interpreting the data presented in the following graphics (EEA, 2016b; Eurostat, 2017). Currently, the information used to analyse the performance on waste management (generation, collection, recovery, recycling, landfilling, etc) across MS is provided every year by each of them (Eurostat, 2017).

*Figure 2. Total Generation of Municipal Waste in the EU- comparison 2005/2016*



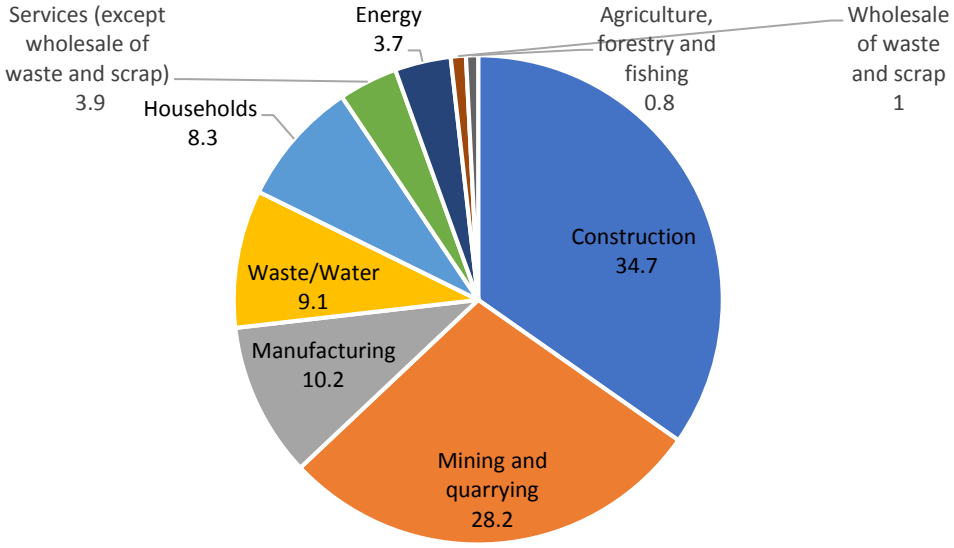

*Data Source: Eurostat (2018). *Online data code: env_wasmun.*

#### 3.3.1 Waste generation by source

The relative importance of the several sources of waste varies between countries and depends on their own economic structure (Eurostat, 2010b). The waste generated by economic activity in 2014 is presented in Figure 3. It is possible to observe that the Industry is the main waste generator in the EU countries. Industry includes mining and quarrying, electricity, gas and water supply, manufacturing activities and construction (Eurostat, 2010b). Construction (34.7 %), Mining and Quarrying (28.2%) have the biggest contribution to the total amount of solid wastes. Big part of these wastes is generally classified as major mineral wastes. In 2014 almost two-thirds (64 % or 3.2 tons per inhabitant) of the total waste generated in the EU correspond to major mineral wastes. The rest of the economic activities have a lower contribution, as manufacturing (10.2%), waste and water services (9.1 %), households (8.3%), services (3.9%), energy (3.7%), agriculture, forestry and fishing (0.8%). MW represents close to the 10% of the total generation and it mostly includes economic activities

such households and part of the wastes from manufacturing and services (Bourguignon, 2017, p. 2). In a large extent, it consists on waste generated by households, but it can also include similar waste generated by small businesses, institutional wastes manufacturing and services. This part of the MSW may differ in different countries and municipalities, depending on the local waste management system (Eurostat, 2017).

*Figure 3. Waste generation by economic activities and households, EU-28, 2014 (%)*




*Source: Eurostat (2018). *Online data code: env_wasgen.*

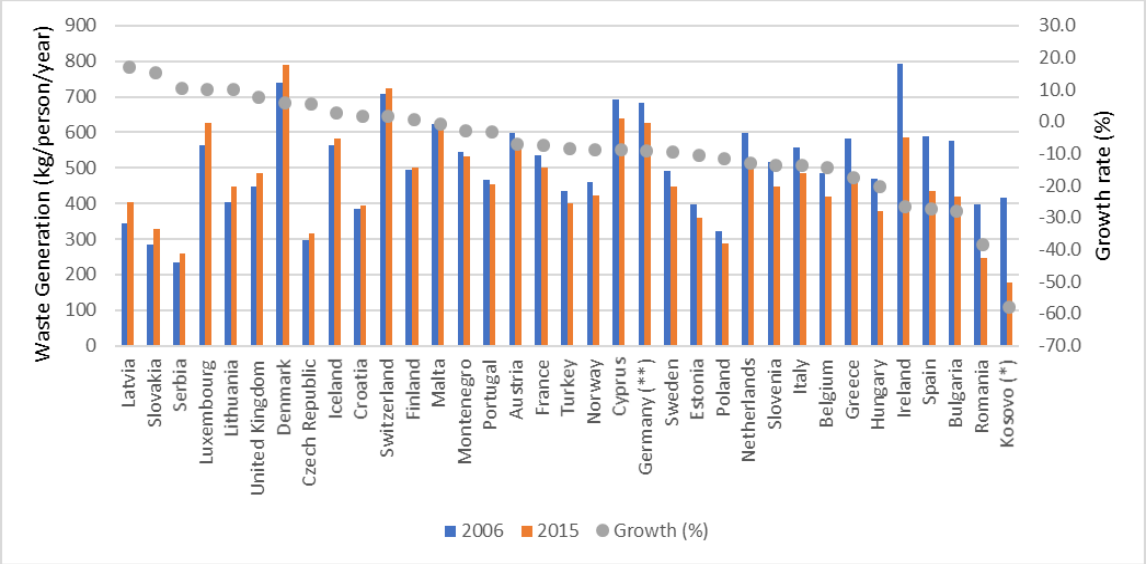
### 3.3.2 Generation of Municipal Waste

Generation of MSW per capita is a good indicator to evaluate the prevention of wastes in a country or city. If the amounts of MSWs are decreasing over time it means that the wastes are being prevented according to the first objective of the waste hierarchy (see Figure 1). In addition, calculation of per capita generation is a way to normalize the data and eliminate the effect of changes in population size. Consequently, it facilitates the comparison of generation of wastes between countries and among different periods of time (EEA, 2013a).

Figure 4 shows that, overall, less waste is being generated across Europe. It presents the generation of wastes by countries expressed in kg per capita per year, and the growth rates in the period 2006-2015. It decreased from generating 515 kg/person/year in 2005 to 482 kg/person/year in 2016. Although it is not a big improvement in the EU as a whole, it is a good sign. While, according to EEA (2013a, p. 10) twenty- one countries increased their waste generation between 2001-2010, Figure 4 shows that twenty-two countries decreased their waste generation between 2006-2015. This represent a good improvement in the performance of the MS. However, caution with the interpretation of the data is needed due to uncertainties caused by the differences in methodology, definitions and data missing, even

some countries could have changed their definition of MSW in this period of time (EEA, 2013a).

*Figure 4. Municipal Waste per Capita by countries (kg/person/year) and growth rates (percentage)*




*Data Source: Eurostat (2018). Online data code: env_wasmun. Note: Due to data availability issues, the following data changes: data of 2014 instead of 2016 for Ireland, data of 2014 instead of 2016 for Portugal, 2011 instead of 2005 for Montenegro, 2006 instead of 2005 for Serbia and 2008 instead of 2005, 2013 instead of 2016 for Bosnia and Herzegovina.*
**Albania has not been included due to lack of consistent and reliable data.*
*** Until 1990 former territory of the FRG*

The reduction of wastes can be explained in two ways. First, it is possible to deduce that the changes in environmental legislation had a positive effect in the reduction of wastes. In the last years, the European Commission has produced revised legislative proposals for waste defining clear targets for reducing waste and presenting an ambitious long-term path for waste management and recycling. This suggests that MS are producing and consuming goods more efficiently and it could be an evidence that dissociation of economic growth and materials use is starting to take place (Humphris-Bach, Essig, Morton & Harding, 2015). Secondly, the economic crisis of 2008 could have had an additional impact in the decrease of wastes from this year onwards (EEA, 2013a, p. 11).

From Figure 4 can be deduced that there is a correlation between the economic situation of the countries and the consumption patterns. The wealthier countries tend to generate more waste per person than the others. It is possible to see that Denmark, Norway and Switzerland have the highest generation of MSW per capita, while Romania, Serbia and Kosovo present the lowest rates. In the case of Cyprus and Malta, tourism can contribute to a high generation of wastes (EEA, 2016a, p. 2).

It is important to stress that there is a noticeable significant gap in generation of MW among countries. While Denmark had a generation of 789 kg per capita in 2015 (2.2 kg per capita/day), Romania generated less than the half, 247 kg per capita (700 g/per capita/day) during the same year. These disparities, do not depend only on the consumption patterns and the economic wealth, but also on how the MSW is classified, collected and managed in every country (For example, some countries might include or not as MW wastes from commerce, trade, administration, etc.) (Eurostat, 2018b).

The trends are not always in line with the current picture of wastes generation. Cyprus, for example has one of the highest waste generation, but it shows a decreasing trend (-8%). Switzerland and Denmark, not only have the highest generation of wastes, but also high growth rates (2 % and 7% respectively). Serbia, despite of having one of the lowest generations shows one of the biggest growth rates (11 %) as well as Slovakia (16%) and Latvia (18%). Kosovo, Romania and Bulgaria present the biggest reduction rates in generation (57%, 38 %, 27% respectively).

### 3.4 Treatment of Municipal Waste in the EU

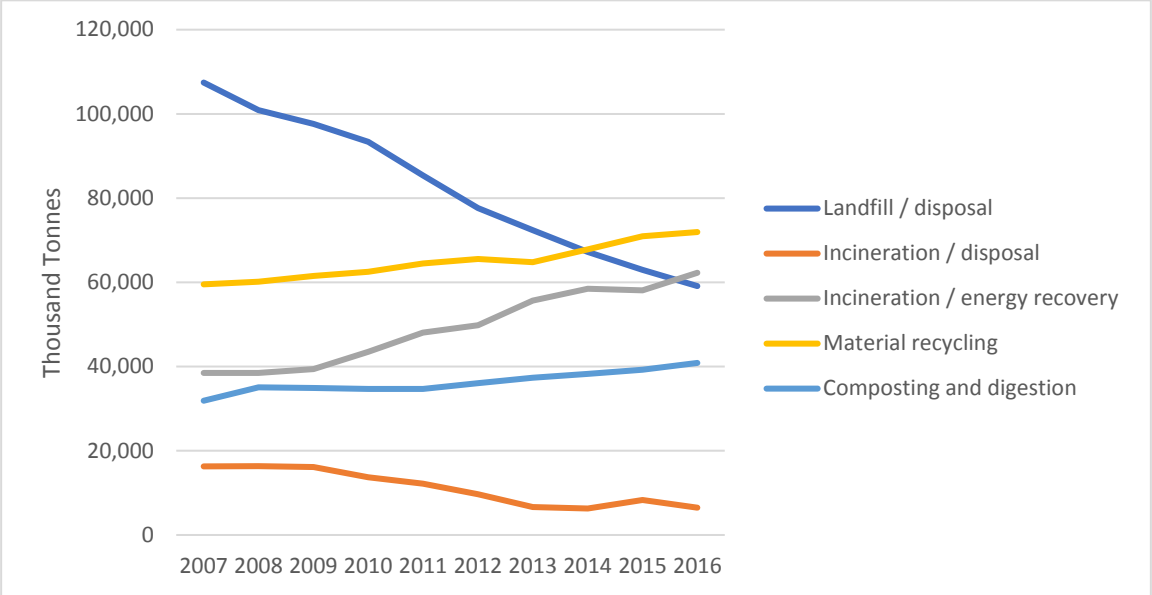
The way that MSW has been managed in the EU is another evidence of a move up the waste hierarchy (EEA, 2013a). It is possible to observe in Figure 5 the declining trend of landfilling, while recycling, incineration and composting are clearly increasing. The declining trend of landfilling is higher than the increasing trend of recycling because it is being replaced by a combination of different techniques and technologies as incineration (with and without energy recovery), recycling, and even mechanical-biological treatment in some cases (EEA, 2013a).

Figure 5 indicates that landfilling of MSW has decreased in almost 50 million tons in the period 2007-2016. Incineration as final disposal has also decreased in almost 10 million tonnes, whereas incineration with energy recovery has increased in 24 million tonnes. Material recovery, composting and digestion have increased by nearly 12 million tonnes and 9 million tonnes respectively. However, it is important to keep in mind that although this general picture shows a great improvement in waste management in the EU, there are still big differences in the performance of the different MS.

To have a better picture about the treatment of MW, Figure 6 contrasts the different treatments in percentage between 2007 and 2016. It is possible to see that in 2007 almost the half of all wastes produced where going directly into two types of final disposal, landfill (42%) or incineration (6%). Those percentages have been replaced in 2016 for a combination of treatments; an incrementation in material recycling, composting and digestion, and incineration with energy recovery. In 2016, the overall final disposal rate was 27 % (landfill and incineration/disposal), which indicates that over two-thirds of the waste in EU is being re-used, recovered or recycled. Thus, material recycling, composting and digestion increased

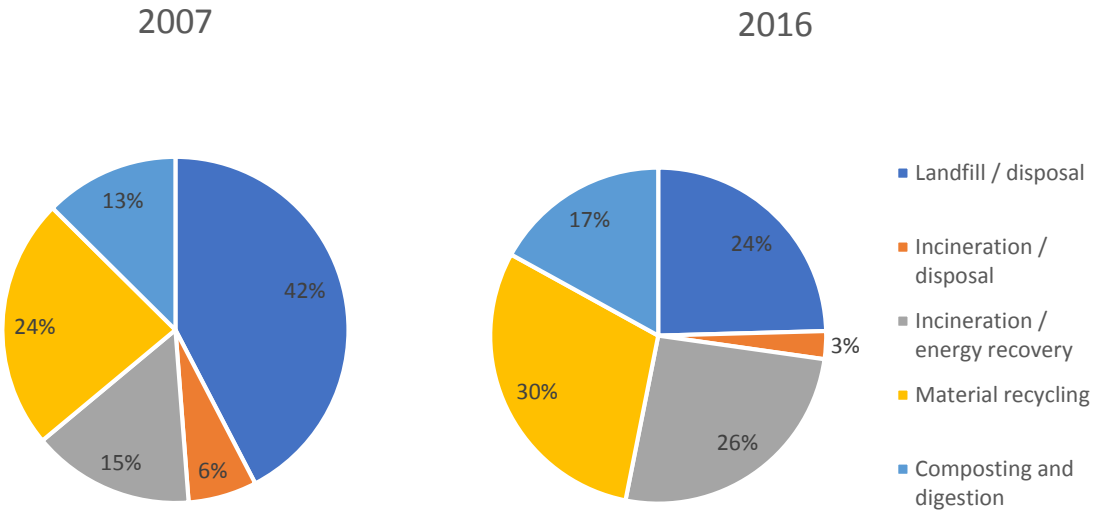
by 11%, 4%, and 6 % respectively, while landfill and incineration/ disposal decreased in 18% and 3% respectively.

*Figure 5. Treatment of Municipal Waste in the EU – Period 2007-2016*




*Data Source: Eurostat (2018). *Online data code: env_wasmun.*

*Figure 6. Treatment of Municipal Waste in the EU – Comparison 2007/2016 (%)*



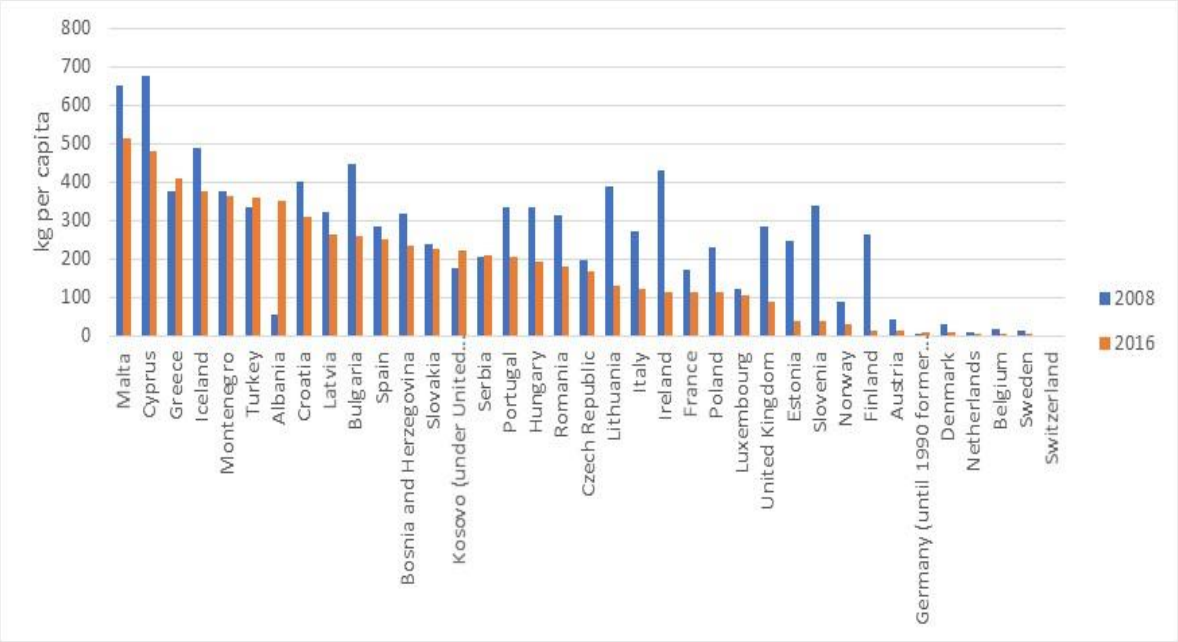

*Data Source: Eurostat (2018). *Online data code: env_wasmun. Note: The figure covers EU-32 MS.*

Figure 7 compares landfilling of MW in kg per capita among MS between 2008 and 2016. Comparing Figure 4 with Figure 7, it is possible to see that, in general, it seems to be a

correlation between the economic situation of the countries and the landfilling rate. Before it was mentioned the correlation between the economic situation of the countries and the consumption patterns, the better the economic situation the higher the consumption and consequently the generation of wastes. It seems to be a reverse relation between the economic situation and landfilling of wastes. The better the economic situation, the lower the landfilling rate is and the better the waste treatment.

While wealthier countries as Denmark, Norway and Switzerland showed in Figure 4 the highest rates of waste generation per capita, they show the lowest landfilling rates (see Figure 7). In fact, in Austria, Belgium, Denmark, Germany, Netherlands, Norway, Sweden and Switzerland, essentially no MSW is sent to landfill (EEA, 2016b). On the other hand, countries like Romania, Serbia and Kosovo, show the lowest rates of waste generation, but the highest rates of landfilling.

*Figure 7. Landfill of Municipal Waste (kg per capita)- comparison 2008/2016*

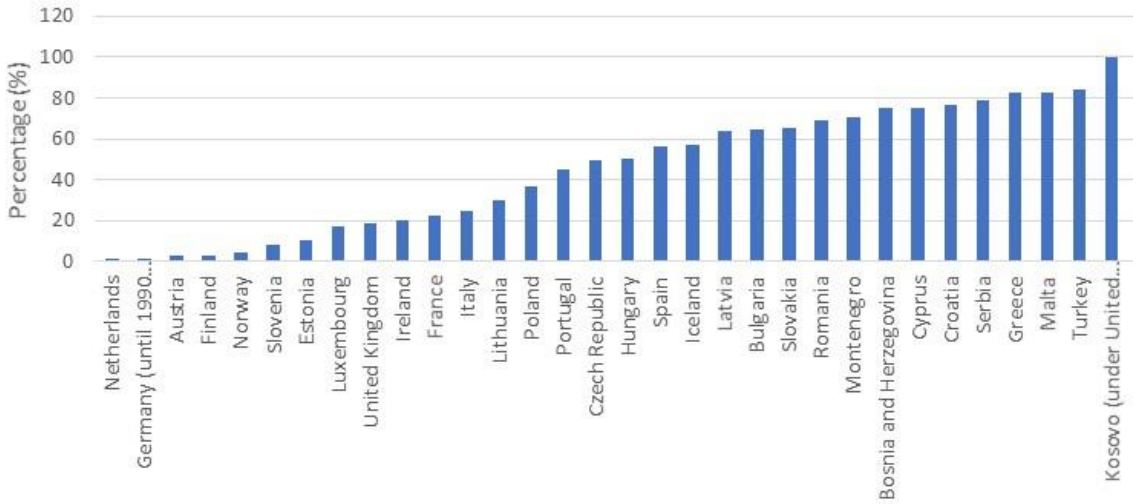



*Data Source: Eurostat (2018). *Online data code: env_wasmun.*

Additionally, Figure 8 shows the landfilling rate per country. This gives a better idea of the percentage of landfill in each country, comparing with other types of treatment. If most part of the wastes generated are being landfilled it means that wastes are being treated poorly according to the waste hierarchy of wastes. Kosovo, Turkey, Malta and Greece still landfill more than three quarters of their MSW. They landfill 100%, 84%, 83% and 82% of the MW respectively. This indicates that these countries have a lot of work ahead to improve resource efficiency and divert materials away from landfill.

Eleven MS showed landfilling rates of less than 10% in 2016, namely Switzerland, Sweden, Belgium, Denmark, Netherlands, Germany, Austria, Finland, Norway, Slovenia, Estonia. The first six countries have essentially no landfilling. On a positive note, roughly all MS have reduced their landfilling rates since 2010, with particularly good performance recorded by Latvia and Slovenia with an improvement of 32 and 16 percentage points respectively (Humphris-Bach, Essig, Morton & Harding, 2015).

*Figure 8. MW landfill rate per country (per capita) in 2016*




*Data Source: Eurostat (2018). *Online data code: env_wasmun. Obs.: Albania was not included due to lack of data availability about waste generation.*

The different policies modifications that have been introduced in the EU in the past years have been helping to drive landfill diversion towards other options further up the waste hierarchy in most of the EU countries. Landfill tax has been one of the successful policies. Additionally, some MS like Austria, Germany, The Netherlands and Sweden prohibited sending some wastes as recyclable materials or biodegradable wastes to landfill. The result is that their landfill rates are the lowest in Europe (almost cero) (Humphris-Bach, Essig, Morton & Harding, 2015).

Moreover, Directive 31/1999 on landfill imposed that MS had to reduce the amount of biodegradable MSW on landfills to 75 % by 16 July 2006, to 50 % by 16 July 2009 and to 35 % by 16 July 2016. The reduction was calculated in accordance to the total amount of biodegradable MSW produced in 1995. Each country has decided the strategies they would implement, namely composting, incineration and pre-treatment like mechanical-biological treatment. Consequently, the recovery of organic material through composting has grown with an average annual rate of 5.2 % from 1995 to 2016. Composting and recycling together reached the 46 % of the total waste generation in 2016 (see figure 6).

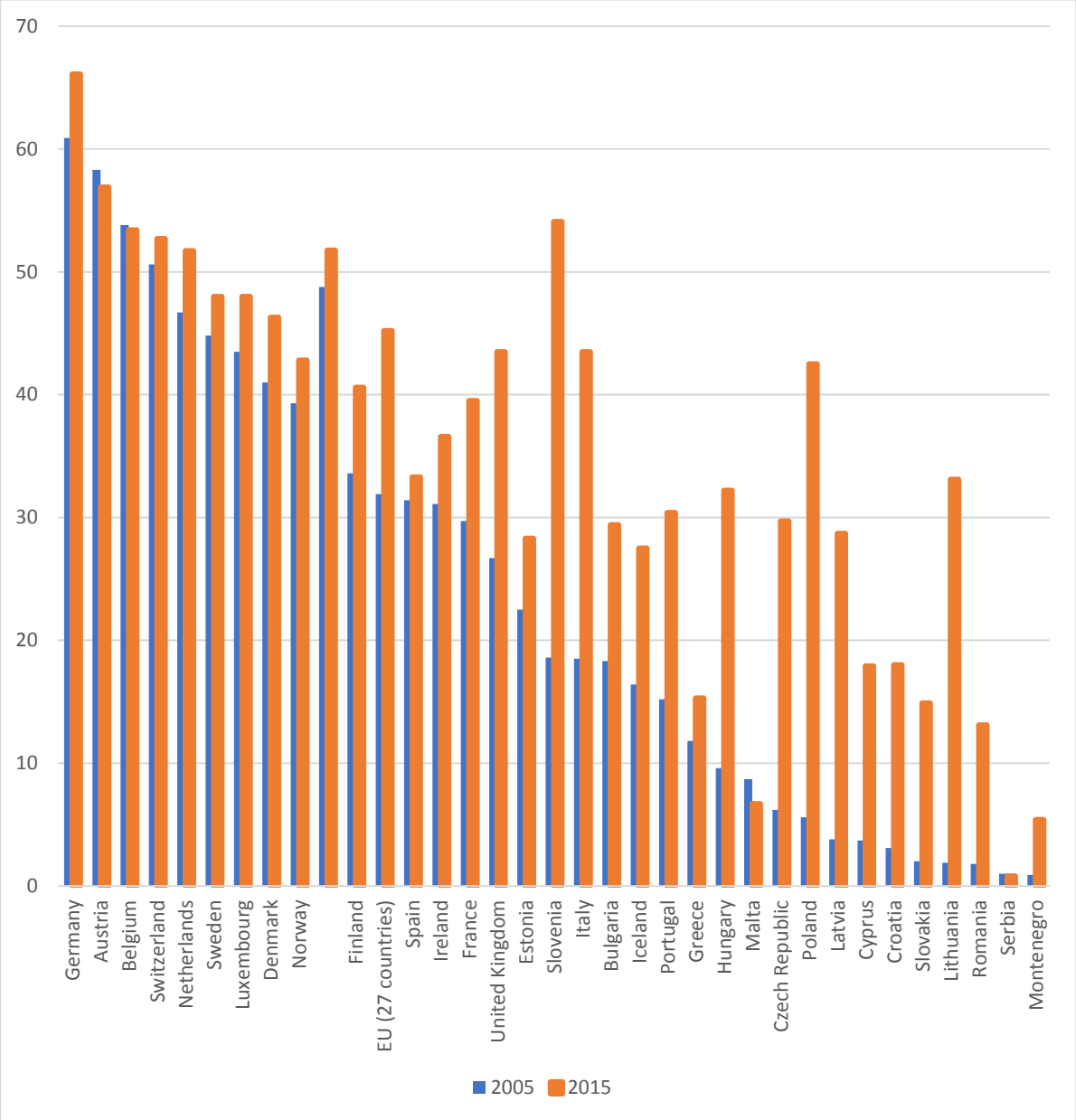
Policies that promoted recovery of wastes, contributed also to the diversion of wastes from landfill. For instance, Directive 62/1994 on packaging and packaging waste boosted the separate collection and recovery of those wastes. By 2001, MS had to recover at least 50% of all packaging put on the market. By 2008, after the revision of the directive, a recovery target of 60% had to be achieved (Eurostat, 2017).

Another way to measure the waste management performance is through the recycling rates. Generally, there is a solid correlation between low landfill rates and high recycling rates (Humphris-Bach, Essig, Morton & Harding, 2015). According to EEA (2016), the increase in recycling rates of MSW (including composting and digestion of bio-wastes) is one of the big achievements of the environmental policy in Europe. In average, countries of the EU shown in Figure 9 have achieved 34% of recycling rate in 2015, compared with 23% in 2005. Over the same period the EU as a whole achieved an average rise in recycling rate of 13%.

Figure 9 shows a comparison of the share of recycling rates of 34 countries EEA members. Most of the countries show a visible increase in the recycling rate when comparing 2005 and 2015, from which 13 countries presented ten or more percentage points of improvement. Poland, Slovenia and Lithuania recorded the biggest increase, of more than 30 percentage points in 10 years (see Figure 10). Only 4 countries slightly decreased (in less than two percentage points) their rates. It is also possible to observe that there are big differences in the recycling rates among the countries. Despite of this, there is an obvious significant improvement in the general performance.

It is possible to note that countries that started with low recycling rates (e.g. Slovenia, Ireland, Poland) between 2001 – 2005 recorded the biggest improvements between 2001 – 2005 while countries that started as pioneers of recycling in Europe (like Germany and Switzerland) recorded a slower growth during 2001 – 2005 (See Figure 10). There are two explanations for this "limited improvement" in front runners. First, some of them might have moved up the waste hierarchy. Secondly, countries that started with high recycling rates might face more challenges for increasing recycling rates, like technical limitations, high cost for the recycling of some products or even some materials that were not designed for recycling, and/or competition with waste incineration capacity (EEA, 2013a).

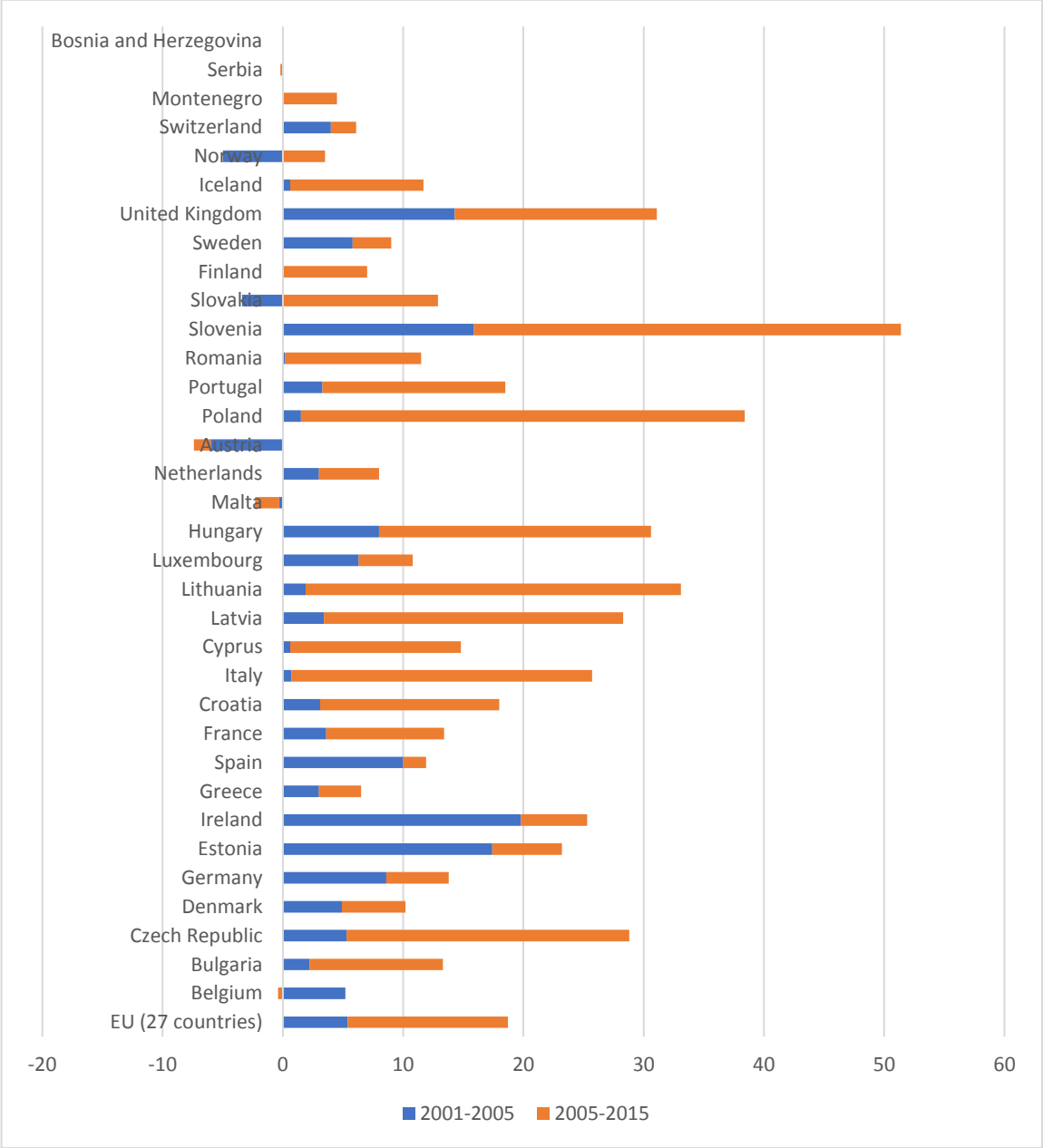
Figure 9. *Recycling Rate of Municipal Waste (%)*




*Data Source: Eurostat (2018). *Online data code: env_wasmun.*

*Note: Data of 2015 is not fully comparable with data in 2005 because of changes in methodology in some countries like Austria, Cyprus, Malta, Slovakia and Spain. Estimated data for year 2005 for EU (27 countries), Bulgaria, Check Republic, Ireland, Lithuania, Austria, Poland and Romania. Estimated data for year 2015 for EU, Check Republic, Germany, Spain, France, Cyprus, Luxembourg, Poland and Slovenia. Due to data availability, instead of 2005 data, 2007 data were used for Croatia, 2012 data for Montenegro, 2013 data for Serbia and 2008 for Bosnia and Herzegovina. For the same reason, instead of 2015 data, 2012 data were used for Ireland.*

Figure 10. *Percentage point increase in total recycling share (%) of municipal waste in two-time frames: 2001-2005 and 2005-2015*




*Data Source: Eurostat (2018). *Online data code: env_wasmun.*

*Note: Data of 2015 is not fully comparable with data in 2005 because of changes in methodology in some countries like Austria, Cyprus, Malta, Slovakia and Spain. Estimated data for year 2005 for EU (27 countries), Bulgaria, Check Republic, Ireland, Lithuania, Austria, Poland and Romania. Estimated data for year 2015 for EU, Check Republic, Germany, Spain, France, Cyprus, Luxembourg, Poland and Slovenia. Due to data availability, instead of 2005 data, 2007 data were used for Croatia, 2012 data for Montenegro, 2013 data for Serbia and 2008 for Bosnia and Herzegovina. For the same reason, instead of 2015 data, 2012 data were used for Ireland.*

### 3.5 Overview of policy instruments and analysis of efficiency

Economic and financial instruments, commonly named market-based instruments, typically include taxes/fees, grants, eco-charges, and different investment or financial support programmes (EEA, 2016a). All MS use a variety of policy instruments and incentives to divert waste from landfill and move up the waste hierarchy. The Table in Appendix 2 shows an overview of those instruments for the period 2001-2015. The table lists the policies used by each country and reflects how the instruments are implemented. Although the list of instruments is not exhaustive, it is possible to draw some conclusions (EEA, 2016b).

First, there seems to be a correlation between the number of instruments used and the recycling rates of the country. Countries using several instruments showed higher recycling rates in comparison to the countries using few or none. However, the way countries combine the policy instruments seems to be more important than the number of instruments (EEA, 2013a; EEA, 2016b).

Secondly, it seems that having regional or national plans doesn't affect the performance of the countries. Some countries with only regional plans achieved good results (EEA, 2013a).

Thirdly, pay as you throw schemes (fees charged based on the weight of the residual waste that goes to final disposal instead of recycling, the size of the residual waste bin or the frequency of collection) seems to be an effective instrument to scale up the waste hierarchy (EEA, 2013a). Although the level of implementation of these schemes vary greatly, it is possible to see that countries that are recycling more than 45% of their wastes are using these schemes or similar, while countries recycling less than 20% are not using any (EEA, 2016b).

Fourth, the introduction of mandatory separate collection systems for certain MSW contributes to higher MSW recycling levels countries (EEA, 2013a).

Fifth, there is no evident correlation between the introduction of waste management plans and a better performance of the countries. In the last 10 years most of the countries introduced at least two SWM plans, but the performance varies greatly. Therefore, it is obvious that additional initiatives are necessary to improve recycling and divert waste from landfill (EEA, 2013a).

Finally, introduction of bans on landfilling of biodegradable waste or mixed MSW and the combination with landfill taxes of at least 30 euros/ton has a positive impact in the reduction of landfilling rates. Countries with landfilling rates below the European average (28%) have applied these measures (EEA, 2016a, p. 4).

It is important to highlight that although some policy instruments can be successful in some countries, it does not mean that they will be successful in other countries (EEA, 2013a).

Although it has not been analyzed here, other factors can contribute to the increase in recycling rates. Some of these factors are the level of wealth, waste management tariffs, increase in environmental awareness and strict implementation of waste management legislation. Countries that entered the EU in 2004 or later present recycling rates below 30% (EEA, 2016a, p. 4).

It is possible to conclude from this analysis that there are still important gaps in the performance of MS related to waste management and problems with the reliability and harmonization of the methodology for data collection (EEA, 2013a; EEA 2016a; EEA, 2016b). The information about the performance of waste management (generation, collection, recovery, recycling, landfilling, etc) across MS is obtained from the data that they provide every year. Therefore, they should work more on improving the quality, reliability and comparability of the data (EU, 2018).

In respect to policymaking, policies addressing economic, environmental and social dimensions of sustainability have developed without enough coordination. The new initiatives as the CE Package and the Resource Efficiency approach are important frameworks for a more coordinated work, but there is still a lot of work to do in setting indicators for measurement and harmonizing the data.

# 4 WASTE MANAGEMENT IN DEVELOPING COUNTRIES OF LATIN AMERICA AND CARIBBEAN

ISWM is still a pending subject in LAC. While EU is focused on trying to scale up the "waste hierarchy", LAC is still focus on trying to implement proper collection and final disposal systems, the rest is a pending topic (Sáez, Urdaneta & Joheni, 2014). LAC is still dealing with major issues related to SWM like the under financing of SWM in municipalities (average investment of 1-2 % of the budget), lack of skilled staff (mostly out of the main cities), low rate of correct final disposal and lack of awareness (people throw their wastes in public spaces, water bodies and all sort of inadequate places). These situations in addition to the growth in population result in a contamination of the environment and reduction of life quality (Hernández-Berriel et. al., 2016).

Recent World Bank studies estimate a future increase of MSW from 131 million tons in 2005 to approximately 179 million in 2030. Residential waste is typically 50–70 percent of the waste stream, construction and demolition waste can also account for a large share although this varies noticeably among countries. Waste collection services varies greatly in different countries, in a range from 11 percent of the population served to 100 percent, and a regional average of 93,4 percent (see Table 6). Comparing with other regions and similar economies, LAC presents relatively low rates of waste diversion, and poor practices for final disposal, although the performance differs highly among countries (Hoornweg & Giannelly, 2007).

Additionally, LAC is facing serious institutional issues such as lack of legislative framework for ISWM, lack of appropriate and sustainable SWM systems, underfunding of MSW services, lack of effective education programs that encourage source separation of wastes with recycling potential, deficient service efficiency in many countries, lack of coordination between national and municipal agencies, lack of public- private partnership, prevalence of informal waste pickers, lack of systematic and reliable data (current and forecast) about SWM performance. In general, the Mayor of LAC cities have realized that SWM should be a priority in their agendas, but it still represents a big unsolved challenge the financing, public cooperation, strengthening of institutions and creating an attractive environment for investors (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011; Hoornweg & Giannelly, 2007).

Another problem is the lack of reliable and harmonized data. The most updated and complete report of the region is the Regional Report of Urban SWM in America Latina and Caribbean (2011), therefore this document will be the main source of quotation for this section.

### 4.1 Waste generation in Latin America and Caribbean

According to Tello Espinoza, Martinez Arce, Daza, Soulier Faure and Terraza (2011, p. 104) LAC as a whole generates an average of 339.45 kg/person/year (See Table 6) while EU generated 482 kg/person/year in 2016 (Figure 2). Although the trend shows an increase in generation of wastes for LAC and a reduction in the generation of wastes in Europe, currently LAC is generating less wastes than the EU. It is also important to add the big differences in population and the total surface of the region. While LAC has a population of 525,2 million of inhabitants in a surface area of 15,769.3 thousand of square km (World Bank, 2016), Europe has a population of 508 million of inhabitants in an area 5 times smaller, 4 million of km2. Therefore, the total waste generated by EU is much greater than the waste generated by LAC (Eurostat, 2017).

There is a consensus among researchers that higher social classes with higher income generate more wastes than the lower ones. Some researches claim that there is not significative correlation between the income and the quantity of solid wastes, but there is a relationship with the type of waste streams generated (Ogweleka, 2013). Despite of this, Hernández- Barriel et. al. (2016), did not find any correlation between purchasing power of households and the generation of solid waste. It is possible to observe in Table 6 the example of Guyana, which shows one the lowest purchasing power (3.440 USD$ per cápita) and one of the highest rates of waste generation (1945.45 kg/person/year).

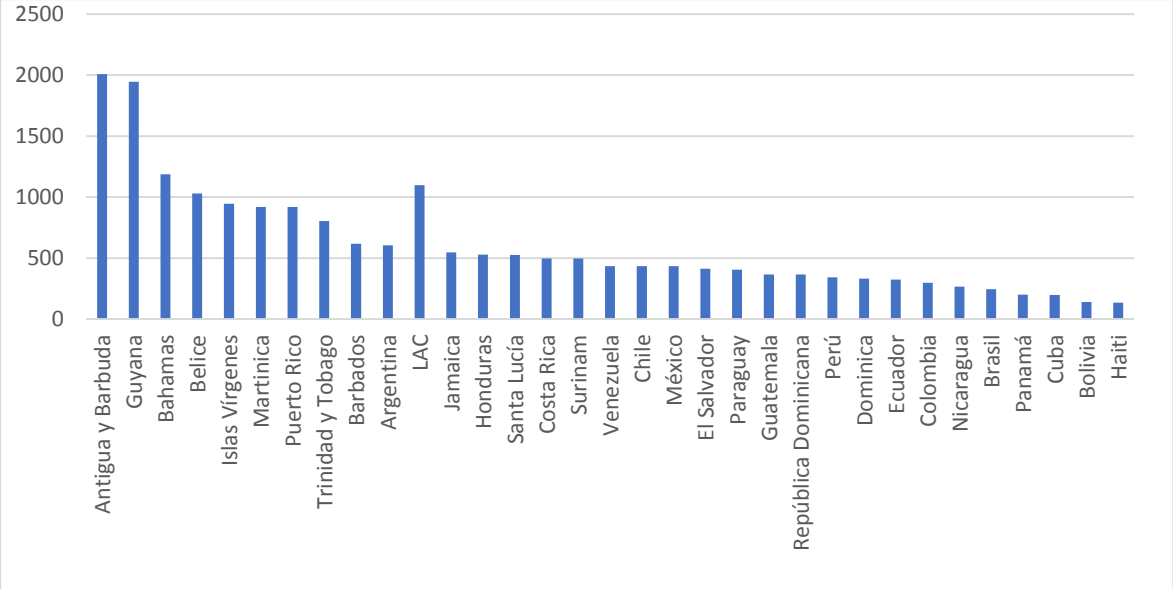
*Table 4. Solid Waste Generation Latin America and the Caribbean (kg/person/year)*

| Source | Purchasing Power (USD$) | Hernández-Barriel et. Al. (2016) | Tello et. al. (2011) | Sáez et. al. (2014) | Average |
|---|---|---|---|---|---|
| **Country** | | **Kg/Person/Year** | | | |
| **Antigua y Barbuda** | 18490 | 2007.5 | - | - | 2007.5 |
| **Argentina** | 16000 | 730 | 419.75 | 660.65 | 603.47 |
| **Aruba** | 24790 | - | - | - | - |
| **Bahamas** | 31980 | 1186.25 | - | - | 1186.25 |
| **Barbados** | 19320 | 616.85 | - | - | 616.85 |
| **Belize** | 6670 | 1029.3 | - | - | 1029.3 |
| **Bolivia** | 5100 | 167.9 | 178.85 | 69.35 | 138.7 |
| **Brazil** | 11640 | 244.55 | - | - | 244.55 |
| **Chile** | 17270 | 401.5 | 456.25 | 441.65 | 433.13 |
| **Colombia** | 10030 | 346.75 | 226.3 | 317.55 | 296.87 |
| **Costa Rica** | 12160 | 496.4 | - | - | 496.4 |
| **Cuba** | 10000 | 222.65 | - | 175.2 | 198.92 |
| **Dominica** | 9800 | 332.15 | - | - | 332.15 |
| **Ecuador** | 8670 | 412.45 | 259.15 | 299.3 | 323.63 |
| **El Salvador** | 6830 | 412.45 | - | - | 412.45 |
| **Guatemala** | 4930 | 730 | 222.65 | 146 | 366.22 |
| **Guyana** | 3440 | 1945.45 | - | - | 1945.45 |
| **Haiti** | 1170 | 135.05 | - | - | 135.05 |
| **Honduras** | 4050 | 529.25 | - | - | 529.25 |
| **Islas Caimán** | 43800 | NI | - | - | |
| **Islas Vírgenes** | 14500 | 945.35 | - | - | 945.35 |
| **Jamaica** | 8710 | 547.5 | - | - | 547.5 |
| **Martinica** | 24870 | 919.8 | - | - | 919.8 |
| **México** | 16590 | 452.6 | 343.1 | 503.7 | 433.13 |
| **Nicaragua** | 3810 | 266.45 | - | - | 266.45 |
| **Panamá** | 15590 | 200.75 | - | - | 200.75 |
| **Paraguay** | 5500 | 406.245 | - | - | 406.25 |
| **Perú** | 10230 | 365 | 273.75 | 386.9 | 341.88 |
| **Puerto Rico** | 15970 | 919.8 | - | - | 919.8 |
| **Dominican Republic** | 9800 | 365 | - | - | 365 |
| **Santa Lucía** | 11600 | 525.6 | - | - | 525.6 |
| **Surinam** | 8350 | 496.4 | - | - | 496.4 |
| **Trinidad y Tobago** | 25070 | 803 | - | - | 803 |
| **Uruguay** | 15080 | - | - | - | - |
| **Venezuela** | 12750 | - | 313.9 | 529.25 | 421.6 |
| **LAC** | 13273.14 | - | 339.45 | - | 590.7 |

*Source: Hernández-Barriel et. Al. (2016, p. 14); Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011 (2011, p. 104); Sáez, Urdaneta & Joheni (2014, p. 125).*

It is also important to remark that there is a lack of reliable and standardized data in the field of solid wastes for developing countries, and particularly, for LAC. Therefore, we have to rely on the data provided by different studies from different authors. Additionally, methodologies and concepts of MSW can vary in all of the countries. For this reason, *Table 4* shows data from three different authors which have also gathered data from different sources. Figure 11 shows the generation per capita (kg/person/year) from the data gathered from different sources.

*Figure 11. Waste Generation in Latin America and the Caribbean (kg/person/year)*




*Source: Hernández-Barriel et. Al. (2016, p. 14); Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza (2011, p. 104); Sáez, Urdaneta & Joheni (2014, p. 125).*

Determining the generation per capita of waste and composition of wastes (waste streams) within MSW is important in order to be able to design the adequate waste management systems, including separation of wastes, selective collection, treatment and final disposal (Sáez, Urdaneta & Joheni, 2014).

When it comes to waste streams there is no standardization in the criteria to characterize the wastes. This shows the importance of defining clear criteria for the whole region that will allow a better analysis of the data and comparison among countries. *Table 5* shows an estimate of the waste streams generated within MSW in Mercosur, as a sample of LAC. In all of the countries Organic matter represents the biggest percentage (55.5% in average), while glass and metals are the smallest generation (3.2 % and 1.9 % respectively).

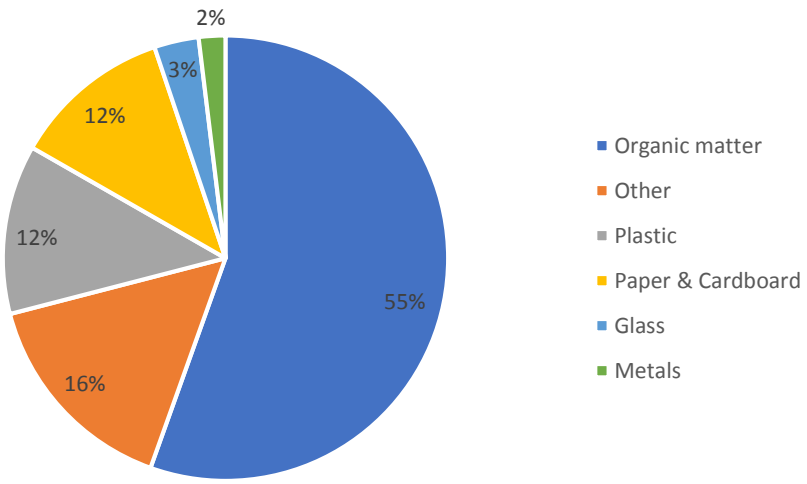
*Table 5. Type of waste streams within MSW in selected countries of LAC (%)*

| Type of waste | Uruguay | Paraguay* | Brazil | Argentina | Average |
|---|---|---|---|---|---|
| **Organic matter** | 52.5 | 66.2 | 51.4 | 48.8 | 55.5 |
| **Glass** | 4.9 | 4.2 | 2.4 | 3.1 | 3.2 |
| **Plastic** | 10.8 | 8.8 | 13.5 | 14.6 | 12.3 |
| **Paper & Cardboard** | 19.6 | 7.8 | 13.1 | 13.8 | 11.6 |
| **Metals** | 4.9 | 1.1 | 2.9 | 1.8 | 1.9 |
| **Other** | 7.4 | 11.9 | 16.7 | 17.9 | 15.5 |

*Sources: D-Waste (n.d.), * Hernández-Barriel et. al. (2016, p. 18).*

It is important to highlight that the second biggest fraction in most of these countries is the category "others" which can represent many different materials that can differ greatly among countries. According to Hernández-Barriel et. al. (2016) this category has generally materials like wood, batteries, electronics and thin residues. Additionally, this study affirms that there can be differences in the waste streams during the year. Principally the organic matter could have variations during winter and summer. There is also a general tendency to increase the generation of packaging waste. *Figure 12* shows the average generation by waste streams in the four countries that compose the Mercosur.

*Figure 12. Waste streams within MSW in Mercosur (%)*



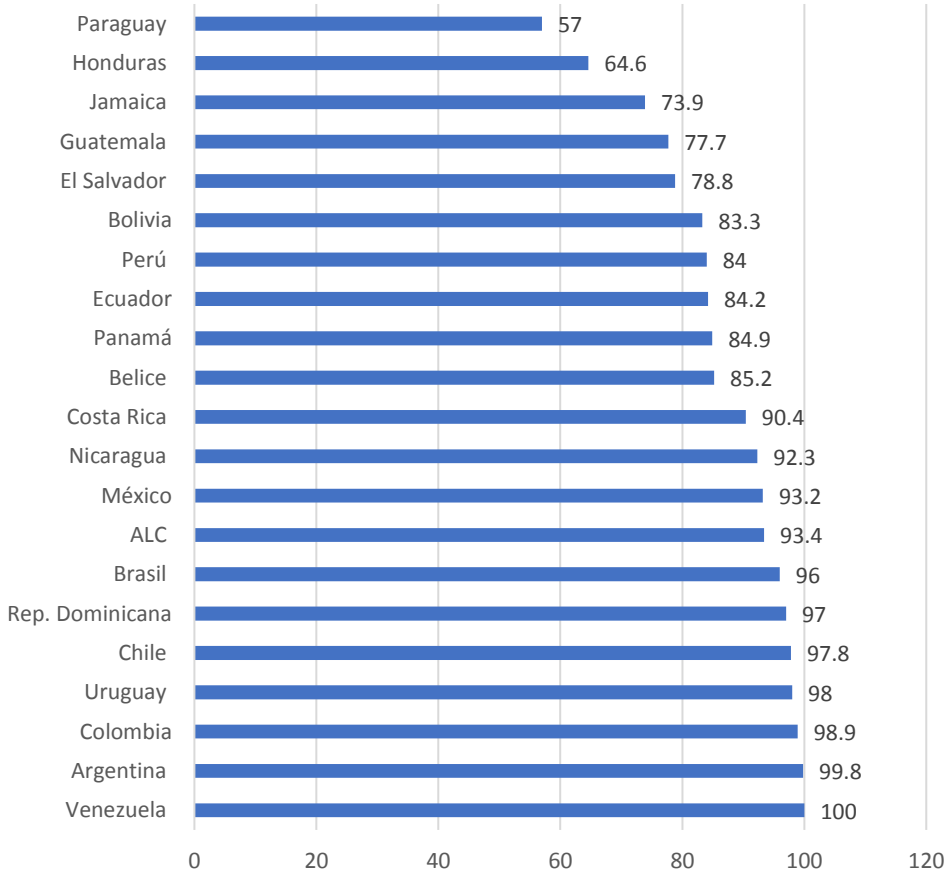

*Sources:D-Waste (n.d.), Hernández-Barriel et. al. (2016, p. 18).*

### 4.2 Collection, Treatment and Final Disposal of wastes in countries of Latin America and Caribbean

The collection of wastes has always been the main priority for countries in LAC, and it has evolved from collecting from small basket in front of every house to bigger containers located in strategic points. The average percentage of collection in the region is 93.4 %, it is

an improvement from 80% of collection in 2002. Although the general percentage of collection is higher than 80%, there are still some marginal areas and neighborhoods that don't get access to the service or the service is very poor. The percentage of collection is the percentage of population served by the national service of collection. Additionally, it is possible to observe in Figure 13 that, although most of the countries have a high rate of collection, some countries like Guatemala, Honduras, El Salvador and Paraguay still present low percentages of collection (less than 80%) and the last one present the lowest in the region (57%) (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011). Despite of having the lowest percentage of collection, Paraguay has improved slightly since 1996, from 40% to 60% in 2017 with an average rate of 2% per year (Lima Morra, 2017).

*Figure 13. Collection of wastes in LAC (% of population served)*




*Source: Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza (2011, p. 113).*

In LAC most part of the treatment of wastes is made by an informal recycling sector. The presence of "garbage pickers" is the most common practice. These people separate the wastes from households from the containers used to storage wastes and/or from the final disposal sites (Echagüe Ferrero, 2011; Sáez, Urdaneta & Joheni, 2014; Conke, 2018). Brazil has also the experience of cooperatives for garbage pickers in an attempt to formalize these activities and some cities have even contracts with these cooperatives sending them all the

recyclable wastes collected, but this is still an option not always attractive for pickers (Conke, 2018).

In terms of the economic evaluation of waste treatment, developing countries expenditure in treatment, recovery and disposal technologies of wastes is low. More than half of the budgets for waste management are used in collection alone, which remains low and inefficient. Abrelpe (2013) considers that an appropriate amount of expenditure should range between 0.3%-0.5% of GDP/capita. Most cities of LAC are below this range, while cities in Europe like Vienna for example, spend 0.4 % of GDP (Abrelpe, 2013).

Among the different ways of treatment, the most common in LAC are recycling and composting, but there are only few countries that possess a formal system for these practices. Normally, those practices are impulse by isolated initiatives from some municipalities, NGO's or other organizations and projects. In general, it is estimated that only 2.2 % of the wastes from LAC are recycled. The best examples of formal recycling of wastes are in Chile, Brazil and Colombia, and yet it is estimated that in Brazil, for example, 50% of the aluminum cans that are recycled were collected by garbage pickers, while the other half is collected by schools, supermarkets, companies or philanthropic groups (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

*Table 6* presents a compilation of information about recycling and other treatments, such as composting of wastes, in some countries of LAC. It is difficult to compare this data with the treatment of wastes in EU. Firstly, due to the informality of the activities there is not official and reliable data. Secondly, because while EU is trying to increase the percentage of recycling and reduce the generation of wastes, LAC is striving to formalize their recycling activities, improve the social issues related to the poor conditions of work and living of garbage pickers and reduce the environmental impacts of the inadequate management of waste.

According to OPS (2005) due to the informality of the recycling schemes, only 2.2 % of the wastes are being recycled in the region, from which 99% corresponds to inorganic materials. *Figure 14* shows the percentage of each type of wastes that are being recovered. The three waste streams being recovered are plastic (3.4 %), followed by Paper and Cardboard (2%) and metals (2.1 %).

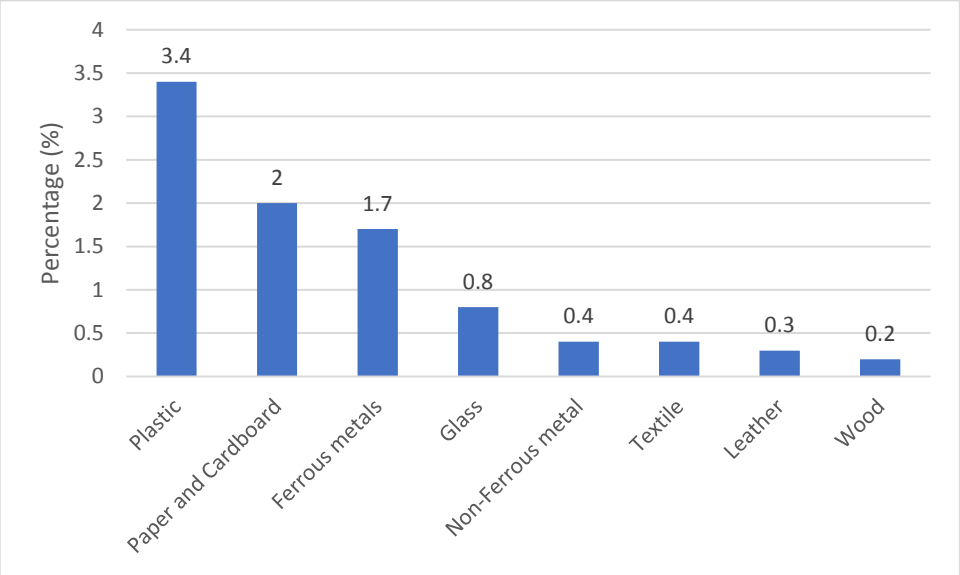
Apart from recycling EU has been introducing alternative treatments as composting and incineration with energy recovery, in LAC those alternatives are only present in few isolated cases. The trend in EU is to increase reduction of wastes and recycling, limit incineration and face out landfilling, while for LAC the main option is landfilling.

*Table 6. Treatment of wastes in Latin America and Caribbean*

| Country | MSW recycled (%) | Specific waste streams recycled or treated within MSW |
|---|---|---|
| **Mexico** | 10% | |
| **Uruguay (*)** | | PET recycling (no data of percentage)<br>Composting (no data of percentage)<br>Batteries (no data of percentage) |
| **Chile** | 12 % | 50% of wastes from paper and cardboard |
| **Brazil** | < 1% | 44% of wastes from paper and cardboard<br>87% aluminum cans<br>70% steel cans<br>45 % glass bottles<br>51 % PET bottles |
| **Ecuador** | No information | 40% of wastes from paper and cardboard<br>Vermicomposting in some cities (*) |
| **Venezuela (*)** | 10-20 % | 95% Aluminum<br>90% Iron<br>25% Glass<br>20% Paper and Cardboard<br>2% Plastic<br>1% Organic Matter |
| **Colombia (*)** | | 57% Paper and cardboard |
| **LAC** | 2.2% of MSW | |

*Source: Adapted from Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza (2011, p. 125). (*) Sáez, Urdaneta & Joheni (2014, p. 131).*

*Figure 14. Percentage of materials recycled in LAC (2005)*




*Source: OPS (2005, p. 71).*

Although most part of the waste stream in LAC is composed by organic matter, composting are not properly developed in the region. Some of the factors influencing the lack of development in this field are the lack of quality standards for the final product, lack of proper technology, and lack of knowledge and guidelines in the matter. Some countries like Mexico had composting plants 60 years ago, but due to operative and financial issues most of them didn't survive on time. Some successful cases like plants in Vila Leopoldina y São Mateus, in São Paulo, required subsidies in order to survive. La Pitana, in Chile, is another successful case of composting with energy recover that is diverting the 20% of the waste stream directed to landfilling (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

Sáez, Urdaneta and Joheni (2014) mentioned also as limiting factors for success the incorrect definition of markets, high costs of operation and transportation, bad quality of final product, lack of awareness of the community to contribute with the waste separation, lack of maintenance of the equipment, limited participation of the formal and private sectors.
Incineration is not common in LAC. Only Brazil and few islands in the Caribbean, such as Barbados and Bermuda, have experience with incinerators. Brazil has around 34 incinerators in the whole country, although most of them are located in small communities and don't have the capacity to incorporate control of emissions. In the rest of LAC incineration is mostly limited to hazardous wastes coming principally from hospitals and healthcare services. For developing countries, the increasing of strict policies related to environment incentivized the development of better technologies (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011; OPS, 2005).

The main factors that limit the introduction of incineration of wastes in LAC are: a) the high initial investment of these complex technologies, b) high percentage of humidity of the wastes, c) lack of a stable stream of combustible wastes, d) the monopoly of the energy markets which don't allow competition (Sáez, Urdaneta & Joheni, 2014: Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

In respect to final disposal of wastes landfilling is the most common practice in LAC. Tello Espinoza, Martinez Arce, Daza, Soulier Faure and Terraza (2011) estimated that there has been an increase of 31.8% in landfill of wastes from 2002 to 2010, 54.4% of wastes are currently being landfilled. Table 8 shows the final disposal of wastes in countries of LAC. Additionally, the use of open-dumps decreased from 45.3% to 23.3% during the same period of time. The main reason for this improvement has been the improvement in waste legislation forbidding open-dumps and defining the specifications and technical characteristics for appropriate landfilling (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

However, it is possible to observe in Figure 15 that there is still big percentage of controlled and open-dumps in the region, which represents almost the half of the cake chart (42%). Additionally, 4% of the wastes are still being burned in open fields or thrown into water

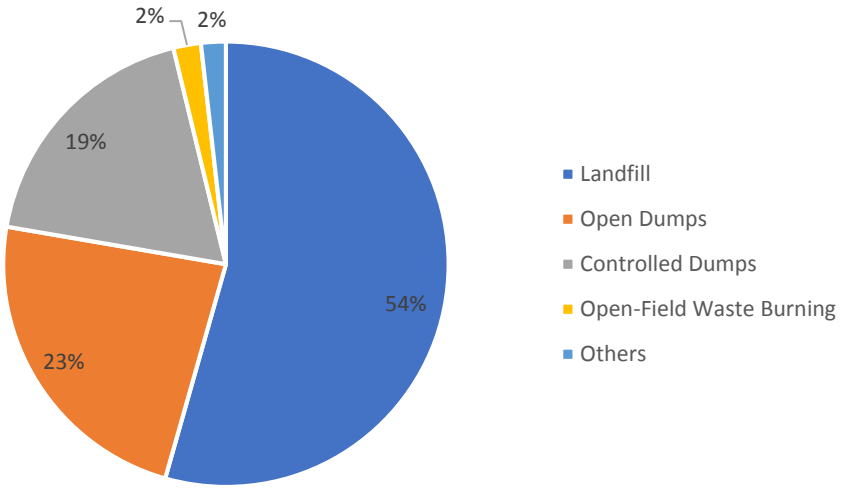
bodies causing a big damage to the environmental health of the country. It is also possible to see in *Table 7* that the situation in the different countries differ greatly, having the poorest waste disposal in countries such as Belize, Guatemala and Nicaragua with the highest rates of open dumps (85. 2%, 69.8% and 59.3% respectively), and Belize has also the highest rate of open-field burning of waste (14.8%), followed by Honduras (13%). Landfill is the best of the options presented in *Table 7*, and only two countries in the whole LAC, Chile and Colombia, have over 80% of landfilling.

*Table 7. Final Disposal of wastes (%)*

| Country | Landfill (%) | Controlled Dumps (%) | Open Dumps (%) | Open-Field Burning of Waste (%) | Others (Water bodies, etc. (%) |
|---|---|---|---|---|---|
| **Argentina** | 64.7 | 9.9 | 24.6 | 0.8 | 0 |
| **Belize** | 0 | 0 | 85.2 | 14.8 | 0 |
| **Bolivia** | 44.7 | 16.4 | 10.6 | 1.9 | 26.3 |
| **Brazil** | 55 | 20.2 | 24.5 | 0 | 0.3 |
| **Chile** | 81.5 | 13.8 | 4 | 0 | 0.7 |
| **Colombia** | 81.8 | 4.1 | 12.5 | 1.2 | 0.3 |
| **Costa Rica** | 67.5 | 23.5 | 9.1 | 0 | 0 |
| **Ecuador** | 30.2 | 46.3 | 20.5 | 0.8 | 2.1 |
| **El Salvador** | 78.2 | 0 | 13.8 | 7.3 | 0.6 |
| **Guatemala** | 15.4 | 9.6 | 69.8 | 0 | 5.1 |
| **Guyana** | - | - | - | - | - |
| **Honduras** | 11.3 | 59.9 | 15 | 13 | 0 |
| **Jamaica** | 0 | 100 | 0 | 0 | 0 |
| **México** | 65.6 | 12.1 | 12.4 | 5.94 | 9.4 |
| **Nicaragua** | 0 | 19.6 | 59.3 | 7.5 | 13.6 |
| **Panamá** | 41.7 | 16 | 23.4 | 4.7 | 14.2 |
| **Paraguay** | 36.4 | 40.2 | 23.4 | 0 | 0 |
| **Perú** | 43.5 | 10.6 | 45.3 | 0.6 | 0 |
| **Rep. Dominicana** | 33.7 | 24.5 | 31.6 | 10 | 0.2 |
| **Uruguay** | 3.8 | 68.2 | 18.1 | 0 | 9.8 |
| **Venezuela** | 12.9 | 40.9 | 45.6 | 0.5 | 0 |
| **LAC** | 54.4 | 18.5 | 23.3 | 2 | 1.8 |

*Source: Tello Espinoza, Martinez Arce, Daza, Soulier Faure and Terraza (2011, p. 132). Obs: no data available from Guayana.*

*Figure 15. Final disposal of wastes in LAC (%)*




*Source: Tello Espinoza, Martinez Arce, Daza, Soulier Faure and Terraza (2011, p. 132).*

### 4.3 Institutional and Legal Framework

The institution in charge for SWM in LAC are, in most of the cases, the Municipalities. On the other hand, policy development, planning of the sector and the allocation of budgets for these ends, remains a national responsibility and responsibility of the regional instances in the federative countries. In the last fifteen years the structure in the countries have evolved to the level that in most of the countries SWM are already part of the Ministries of Environment and National Resources (OPS, 2005).

During the last years, the use of regional solutions for the proper management of solid waste throughout LAC has increased. Many Municipalities in the region have been associated in groups of municipalities with the aim of achieving important economies of scale and better application of the standards of regulation. This has been a key for a better integrated waste management since they can cooperate and share infrastructure (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

In respect to planning, there is a lack of integral planning in a national and regional level. The lack of a single institution in charge of SWM resulted in a problematic implementation of policies and plans with superposition of roles (OPS, 2005). In a national level, it is possible to see in Figure 16 that there are many cities in LAC that already have SWM plans, although most of them don't have a National Plan. Once again, it is possible to see that differences among countries are big and the general average planning is low, reaching only 19.8 % in a regional level. In general, the big cities with big population are the ones that have plans, while small ones are left behind. Among countries stands out the low performance of Brazil

(1.6%), Nicaragua (1.2%), Dominican Republic (5.1%), and Jamaica (0%) (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

However, it is important to point out that the fact that some countries, such as Uruguay and Argentina, have a high percentage of municipalities with plans doesn't necessary reflect the quality of the plans and its proper implementation and execution. In many of the cases the plans are not being implement due to a lack of resources, knowledge, capacitation of the personnel, finance, etc. Uruguay has a good example of comprehensive planning with a 25 years projection, the Director Plan of Residues of Montevideo its Metropolitan Area (2003-2005 (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

An additional limitation for the countries is the lack of information and information sharing for planning. To solve this problem there have been good initiatives like the information sharing systems created by SERMANAT (Secretaría del Medio Ambiente y Recursos Naturales) in Mexico and SIGERSOL (Sistema de Información en Gestión de los Residuos Sólidos) in Peru (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011). In Paraguay, the Statistics and Census Directorate started to include in their permanent survey and census some data about solid waste since 2002, based on previous studies made by Lima Morra (1996). Unfortunately, according to the same author the census of 2012 does not contain reliable data (Lima Morra, 2017).

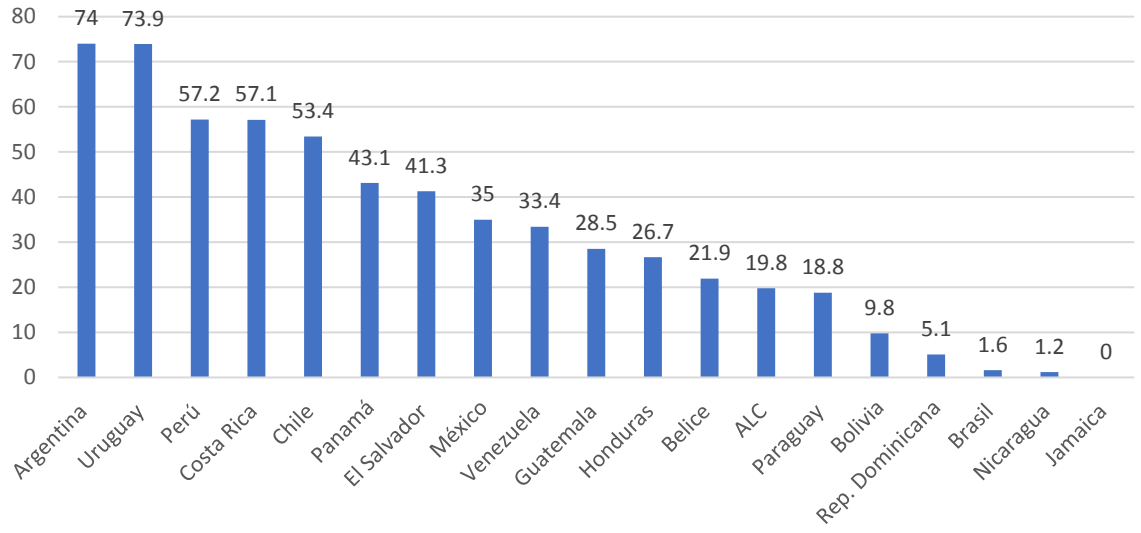
Although Paraguay has one of the lowest performances in SWM in the region, with 18.8 % of municipalities with waste management plan, some improvement has been made through the years. In 1996 only 4% of the municipalities had programs for recycling and reduction of wastes, and it increased to a 20% in 2017. However, this shows that the level of commitment of the authorities is still low (Lima Morra, 2017).

Table 8 shows a summary of the legal framework in LAC. In the next sub-chapter, the legal framework will be analyzed in more detailed and compared with EU. In general, the it is composed by National Policies of Wastes and some other legislations depending on the country, such as the Organic Health Code or the Organic Health Law that includes everything related to environmental sanitation (OPS, 2005). In Paraguay, for example, the Resolution S.G. Nº 750/02 of the Ministry of Public Health was for many years the main legislative tools for SWM (Echagüe Ferrero, 2011).

Additionally, some countries include Penal Laws of Environment for those activities that can cause damage to environment. Organic Municipal Law stablish the politic, administrative and financial autonomy of municipalities. Specific regulations stablish technical standards or rules for specific activities related to SWM. Municipal ordinances regulate the service and taxes. Contracting and Bidding laws of the Public Administration set the rules for the participation of private sector. However, in most of the times waste legislation is not

integrated into a single framework, they are isolated and regulate different aspects of SWM (OPS, 2005). It is possible to see in Table 8 a summary of the legal framework in LAC.

Figure 16. Municipalities with waste management plans in countries of LAC (%)




*Source: Tello Espinoza, Martinez Arce, Daza, Soulier Faure and Terraza (2011, p. 69). Note: No information available for Colombia, Ecuador and Guyana.*

Table 8. *Legal Framework in LAC*

| **Legal Instrument** | **Area of application** | **Relation with SWM** | **Emit sanctions** | **Responsible Entity** |
|---|---|---|---|---|
| **State Constitution** | Whole country | Generic | Does not apply | Executive authority |
| **Treaties, International Conventions (Basel, UNFCCC)** | Whole country | Partial | Yes | Ministry/Secretary of Environment |
| **Health Code** | Whole country | Partial | Yes | Public Health Ministry |
| **Environmental Law** | Whole country | Partial | Yes | Ministry/Secretary of Environment |
| **SWM Law** | Whole country | Partial | Yes | Ministry/Secretary of Environment |
| **Code/Municipal Law** | City | Partial | Yes | Municipality |
| **Technical regulations** | Whole country | Complete | No | Ministry/Secretary of Environment/Local Government |
| **Ordinances** | City | Complete | Yes | Municipality |

*Source: OPS (2005, p. 43).*

### 4.4 Analysis of Legal Framework in Latin America and Caribbean and Comparison with the EU

Most of the states in LAC have comprehensive environmental laws overseen by pertinent environmental agencies. On paper, these laws seem solid, showing South American countries as equal partners in the global fight against climate change. Upon closer inspection, it becomes clear that the legislation lost its potency by either subsequent legislative amendments, inadequate infrastructure or the lack of enforcement capabilities from the environmental agencies (Almeida, 2013).

There are several layers of environmental protection in the South American legal system starting with the constitution and followed by state laws, regulations and technical standards. The implementation of these is being monitored by environmental agencies, administrative courts and Non-Governmental Organizations (Kadas & Fraker, 2014). Citizens can find additional remedies through mechanisms provided by international trade agreements like NAFTA, where they can file direct citizen submissions whenever their country fails to uphold environmental laws (Allen, n.d.).

The constitutions of LAC states offer different levels of environmental protection ranging from simple political rights, like the right to a healthy environment (Article 41 of the National Constitution of Argentina), through more deliberate wording establishing state control over natural resources (Constitución Nacional Política de Perú, art. 66-69), all the way to adopting specific protections into their structures (Bolivia adopting Mother Earth protections into its constitution). A big benefit of having environmental rights written into the constitution is the ability of directly filing claims at the national constitutional court, adding another procedural layer of protection (Constitución Política de los Estados Unidos Mexicanos, art. 103, 107; Ley de Amparo, Reglamentaria de los Artículos 103 y 107 de la Constitución Política de los Estados Unidos Mexicanos, D.O.F. 10.01.1936).

Some constitutions establish mutual jurisdiction over natural resources between national and local governments. In these cases, the local governments can apply stricter measures to those prescribed by the national legislation (Constitución Política de los Estados Unidos Méxicanos, art. 115). Most constitutions reserve ownership over public resources and give out rights to use them through the system of concessions (Constitución Política de los Estados Unidos Méxicanos, art. 27; Constitución Política de Ecuador, 2008, art. 332)

Unlike the EU, the LAC states do not possess a common environmental programme or a joint enforcement and legislative agency. Most of the policies integrated into the countries environmental protection programmes are adapted from free trade agreements and international treaties like the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the United Nations (hereinafter UN) Framework Convention on Climate Change, the Montreal Protocol on Sub- stances that

Deplete the Ozone Layer, and the Rio Declaration on Environment and Development (Almeida, 2013). A large problem with these treaties is that they often lack enforcement measures and their implementation suffers due to lack of commitment from MS. Table 9 shows the International Agreements subscribed by countries in the region.

Table 9. *International Agreements related to Solid Wastes*

| Name | Objectives related to SWM | Date of adoption | City of adoption |
|---|---|---|---|
| **Protocolo de Montreal** | Control of ozone-depleting substances | September, 1987 | Montreal |
| **Basilea Convention** | Control of Transboundary Movements of Hazardous Wastes and its final Disposal | May, 1989 | Basilea |
| **Agenda 21 ONU** | Sustainable management of wastes | June, 1992 | Rio de Janeiro |
| **UN Framework Convention on Climate Change (UNFCCC)** | Reduction of Greenhouse emissions and clean Development Framework | May, 1992 | New York |
| **Kioto Protocol** | Elimination of solid wastes on land and eradication of burning agricultural waste in the field | December, 1997 | Kioto |
| **Stockholm convention** | Reduction and elimination of Persistent Organic Pollutants (POPs) | May, 2001 | Stockholm |

*Source: Avedaño Acosta (2015).*

In regard to the legal framework, regulations for environmental issues show superposition and vagueness, lack of uniformity in the use of terminologies and definitions, such as MSW definition. As a consequence, data is not reliable and comparable. According to Tello Espinoza, Martinez Arce, Daza, Soulier Faure and Terraza (2011), the most important issue is the lack of proper regulations regarding the financial and economic part of SWM and no entity that could regulate the taxes, fees, conditions for the service, capacity of the people to pay for the service, and all the economic aspects necessary for the sustainable management of the sector. The only country that has an appropriate taxes and fees scheme for SWM is Colombia.

However, some progress has been made, seven countries in the region have promulgated their National Framework Law for Solid Wastes, such as, Argentina, Peru, Paraguay, México, Venezuela, Costa Rica and Brazil. The limitations to promulgate the legislations have been, social aspects related to garbage pickers, interest of private sector, new responsibilities for municipalities. In general, those legislations include key topics as valuation of wastes, separation of wastes in the source of origin, recycling and sustainable financing of the services. Additionally, some municipalities developed key ordinances like Buenos Aires that includes the diversion and reduction of wastes going to landfill with concrete objectives, goals and progressive deadlines, although some of the goals have been too ambitious (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

Mexico was the first to introduce substantial legislation in the field of waste management. The Environment Secretariat and Natural Resources enacted the Mexico's General Law for the Prevention and Integral Management of Wastes in 2003 and was later followed by governments of other South American countries, which also enacted framework legislations with different success rates at its application. Problems in the application of legislation are generally weak infrastructure, inefficient collection services and not enough landfill capacity (Godoy, 2012). Therefore, even effective regulatory measures cannot solve the lack of funding and insufficient infrastructure. The situation urgently calls for state-wide investment and overhaul of the waste management sector.

Brazil has adopted the National Law of Solid Wastes (Nº 12.305), promulgated in August 2010, it includes the role and responsibilities of public sector, the citizens, and private companies. According to De Sales-Lisboa (2014) some progress has to be made in order to accomplish with the legislation, such as increase public funds, better access to financing, increased workforce training related to waste treatment and greater involvement of private sector.

Even though we see a sufficient level of legislation on all kinds of environmental issues, there is a severe discrepancy in the execution of said legislation and also a serious lack of funding that prevents the countries from successfully implementing necessary solutions. Another problem is that waste legislations in LAC are written as a framework policy, and in most of the cases they are not regulated and the compliance is low. In some cases, even when they have been regulated there are not enough mechanisms for control (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011).

In the case of Paraguay, for example, it took eight years to regulate the Law of ISWM in the Republic of Paraguay (Nº 3.956/09, 2009) with the Decree Nº 7.391/2017 and it is not possible yet to evaluate its compliance. This Decree finally includes the concept of wastes recovery and by-products, defines actors and its roles and responsibilities, and provides guidelines for the preparation of plans that would include separation of wastes, reduction, reuse and recycling.

European environmental policy is mainly based on Articles 11 and 191-193 of the Treaty on the Functioning of the EU. Combating climate change is an explicit objective of EU environmental policy (under article 191 of the Treaty on EU). SD is an overarching objective for the EU, which is committed to a "high level of protection and improvement of the quality of the environment" (article 3) (Eur-Lex, n.d.).

The EU has a unified environmental programme (EEA, 2014) that is monitored by the European Environment Agency (EEA). The main tasks of the agency are to help the EU and its MS to make informed decisions about improving the environment, integrate environmental considerations into economic policies and move towards a SD in coordination

with Eionet, the network of national environmental bodies set up to help the agency. The EEA coordinates with local environmental agencies and governments to get feedback on future policies, follows progress in the implementation of key environmental issues, and advises governments on key environmental questions (https://europa.eu).

However, the EEA does not possess the power to sanction MS. That role falls to the EC. The EC, together with the Court of Justice, ensures that EU law is properly applied in all the member countries. Breaking EU's environmental law entails informal discussions and support to apply the EU rules from the EC (compliance promotion). If this does not produce results, and the matter is not properly addressed at national level, EU legal action follows. The formal procedure begins with a letter of formal notice and could end in front of the Court of Justice of the EU. If a Member State fails to abide by a Court ruling, a second referral to Court and fines may ensue (https://europa.eu).

The EU has a fine-tuned system of sanctions and applies them regularly to MS should they not comply with regulation. Its strong legal enforcement combined with sufficient funding offer a good protection to the existing environmental laws. LAC countries on the other hand have the necessary legislation, but lack proper legal enforcement. The agencies do not receive enough funding and are plagued with poor infrastructure. Environmental projects also do not get enough public support. Most projects focus on reducing unemployment and increasing productivity in the industrial sector without regard to the environment (Toumi, Le Gallo & Rejeb, 2017).

Taking into account the EU solution, LAC would most likely benefit greatly from a similar financial and legislative union since the biggest flaw in the system seems to be the lack of environmental responsibility, high levels of corruption and poor funding. Combining resources would allow LAC countries to relocate assets into areas where they are most needed while at the same time control and oversee expenditure through independent supranational bodies or agencies. Creating an independent supranational body would help with independent oversight which would bypass the corruptive local officials and allow for a more efficient use of funds. Such entity could propose new environmental legislation and enforce existing one through international courts. In sub-chapter 4.6 is detailed a proposal for regional cooperation and integration.

### 4.5 Key elements limiting Latin America and Caribbean Countries from Success and Learnings from European Union

First of all, it is important to acknowledge that a sustainable waste management in developing countries cannot be achieved through a simple copy-paste of the systems implemented in the developed countries (Abrelpe, 2013). It is important first to understand the characteristics of the countries of the region and their limitations. LAC can learn from EU, but it has to make its own management system adapted to their own reality. SWM in

LAC needs principally to make steps forward into formality and the combination of elements that will be mentioned in this sub-chapter should be taken into account for this process.

LAC is the region with the most inequal distribution of income in the world, something that remain unchanged for decades. Around 150 million of people (or 1 of 3 people) are under the line of poverty in LAC, and around 35% of urban households are poor and the 50% is concentrated in rural areas. This is a factor that limit SWM. Waste collection and management in poor areas is low or doesn't exist, and many of those people see themselves obliged to work as garbage pickers in order to survive. It is important to highlight that there are no sanitary controls or any other type of control of those activities, so these people are permanently exposing their health (OPS, 2005).

Poverty is directly related to health and education. Inadequate waste management affects the health of poor people principally because it forces them to live in an unhealthy environment. The lack of access to education brings as a consequence people that are not aware of the consequences of a wrong management of wastes and don't even know how to manage it properly (OPS, 2005).

Lack of targets and performance indicators. SWM performance indicators are a key for SWM planning, this are quantifiable measures that reflect critical success factors and help to evaluate the efficiency of SWM (Abrelpe, 2013). Setting targets and performance indicators is the base of EU environmental legislation and what allows them to evaluate the progress in the implementation.

Lack of information systems. This is directly related with the lack of indicators. In general, LAC does not count with information systems with SWM records of the main indicators. Therefore, there is a lack of updated and reliable data in the matter. In most of the cases the information is insufficient, dispersed and uncomplete. This problem is reflected in a national and regional level (OPS, 2005; Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011). Some of the records that LAC should have are data related to the generation and composition of wastes, treatment, collection, recycling rates. Additionally, should be included the parameters that determine the waste flows, such as changes in population, household size, domestic migration, GDP/capita, evolution of targets set by legislative framework, development of cleaner technologies, evolution of materials, etc.

On the other hand, in the EU all the data related to SWM is collected and shared by Eurostat, which is the statistical office of the EU and its mission is to provide high quality statistics in EU enabling comparisons between countries and regions (http://europa.eu/). However, according to EEA (2016) it still presents some flaws in waste data, creating some uncertainties for the comparison, and therefore, harmonization of national reporting methodologies is needed. The EU is trying to improve this issue through an amendment of

the Waste Framework Directive (2008/98/EC) including revision of definitions and calculation methods.

Lack of Political Will. It is not possible to build sustainable SWM systems without the participation of the Government (Sáez, Urdaneta & Joheni, 2014). The change has to start from up-down of the societal hierarchy, and not the other way around. The government should be responsible in providing all the necessary policy instruments, education, investment, incentives, etc. Every change in EU has started with political will, with definition of goals, targets and development of policies. It is possible to see the progress that EU has done in the approach towards waste management, from considering waste as an unwanted burden, to consider it as a resource. To the point that today material resource efficiency and waste management are seen as two integrated and interdependent fields and therefore, are being addressed together in the CE legislative package (EEAb, 2016).

Lack of appropriate policies and financial incentives. In general, LAC countries don't have policies or strategies in a national or regional level that would formalize the existence and the development of the recycling sector, or if they do have it they are not being implemented properly (Tello Espinoza, Martinez Arce, Daza, Soulier Faure & Terraza, 2011). An appropriate legal framework with proper tax and subsidy policies can encourage waste reduction and recycling, change the nature of products, alter waste streams, and reduce social costs. Market-based instruments, such as weight or volume-based disposal fees and collection charges for the MSW can promote waste reduction and recycling and can be powerful in modifying public behavior (Aramyan, Valeeva, Vittuari, Gaiani, Politano, Gheoldus, Mahon, Scherhaufer, Paschali, Cseh, Ujhelyi & Hanseen, 2016). Pay as you throw schemes, taxes and bans for landfilling have also shown good results in Europe. However, according to EEA (2016) the way that policy instruments are combined could be more important than the total number of policy instruments applied. Therefore, the more policy instruments adopted, the better the performance of the countries is.

Economic policies can promote the use of recycled materials, by favoring re-manufactured products in the purchasing policies (Hoornweg & Giannelli, 2007). The last initiative adopted by the EC is the Raw Materials Initiative in 2018, is a step forward and a good example in this matter, while it includes the importance of being resource efficient and the supply of "secondary raw materials" through recycling schemes (http://europa.eu/).

Low investment in SWM. An appropriate SWM should allocate necessary funds in the right places. In this context, developing countries spending in appropriate treatment, recovery of wastes and disposal technologies is low. More than half of the waste budgets are spent in collection alone, although collection remains low and inefficient. In this sense, it is considered that for a sustainable waste management system, the range of spending must be between 0,3%-0,5% of GDP/capita. Cities of LAC in general spend less than 0,3%, while European cities, like Vienna for example, spend 0,4 % of GDP (Abrelpe, 2013).

Lack of municipal capacity to ensure good service standards. According to Hoornweg and Giannelli (2007), experiences around the world show that involving the private sector could lead to efficiency where competition, transparency and accountability are present. This has to go hand to hand with the points mentioned before, such as access to information, setting correct indicators, policy framework, political will, etc.

Lack of integration of the region. According to Hernández-Berriel et. al. (2016) integration in the region is important to homogenize the legislation, regulations and environmental rules, sharing of technical capacity for proper installations of Municipal Waste Management in the region, as well as the joint strategies for the implementation of programs and plans. The closest example of integration of the region is the case of MERCOSUR. Looking at the current structure of Mercosur, we can see it has all the necessary factors for a successful and effective environmental policy implementation. It has the necessary legislative bodies as well as an enforcement body in the form of the Permanent Review Court. The entire structure could, with some procedural and jurisdiction changes, function similarly to the EU system, which also relies heavily on court enforcement. However, the institution is currently troubled by a deep lack of integration, which in the end prevents the implementation of substantive, all-encompassing solutions. It is currently focusing mostly on trade cooperation and development while ignoring other integral subjects. Despite everything, it is currently the most integrated institution in South America and is showing progress, despite it being slow, in the environmental field.

Lack of integration of policies. EU has recently realized of the interrelation and interdependence of policies and the importance of integration. For these ends it has developed framework policies for SD as the CE Package that include amendments in other legislations such as waste legislation in order to create a better coordination between legislations and follow a more efficient path towards sustainability. In this way it has recognized the relation between materials efficiency and reduction of wastes and the three pillars of sustainability.

It is important to highlight that all of the barriers mentioned are interrelated and are cause-effect of each other. Problems on one variable may influence the other, for example, householders' lack of awareness can increase the costs of the selective collection, reduce the quality of recyclable materials and increase the costs of recycling; programs financial deficit obstructs investment in equipment; the lack of tax incentives increases the price of recycling, etc. For this reason, any kind of solution should consider these cause-effect relationships (Conke, 2018).

It is important for LAC to learn from the evolution and the history of EU, not only from their successful examples. Through the years EU has realized of the importance of integration of the different policies related to the different aspects of sustainability. The CE Package is a

way of trying to integrate all the legislations related to SD and make it more coordinated and effective. However, there are still changes that need to be made in the legislation and in the market.

As it was mentioned before according to the data of waste generation provided by Tello Espinoza, Martinez Arce, Daza, Soulier Faure and Terraza (2011) and Eurostat (2018b) and the data of population provided by World Bank (2016) and Europen Union (http://europa.eu/), EU as a whole generates around 245 million tonnes while LAC generates around 7 million tonnes. Therefore, EU has to make greater effort to reduce the waste generation, while LAC has to make greater effort to formalize its SWM sector and activities and improve the management of the wastes.

Finally, according to Monier, Hestin, O'Connor, Anderson, Neubauer, Sina, Homann, and Reisinger (2011). Europe has not reached a perfect system and still has some barriers to overcome in respect to SWM policies. Currently, the implementation of treaties has to be made by MS and EU cannot act as a waste inspector and enforcement agency in the ground. Currently, the EC information of the implementation status in MS is based principally on the reports made by the same MS, formal complaints made by citizens to the commission, inquiries of the European Parliament, and other reports submitted by other institutions such as NGO's or other stakeholders. Some limitations in the performance of some MS are due to the lack of interest and/or resources, fear of high costs, inadequate SWM structures, lack of authority to tackle environmental criminal offences, complexity of the institutions (multi-level governments).

# 5 Conclusion

The purpose of the thesis was to identify key elements of success of EU, key elements limiting developing countries from success and key learnings from EU. In order to achieve this purpose five key research questions have been taken into consideration and answered in the study as follows.

The first research question intended to define waste, solid waste and sustainable waste management. It was possible to answer through synthesis of literature. Solid waste was traditionally considered as an object or substance that lacks of value and is no longer required by the owner (Mc. Dougall, White, Franke & Hindle, 2001). Currently, there is a tendency to include the concept of by-product to describe wastes with potential of reuse and/or recycle (Gharfalkar, Court, Campbell, Ali & Hillier, 2015). SWM is defined by Eurostat (2016) as the collection, transportation, treatment and final disposal of all the wastes produced in the community (including final disposal sites). However, an integral or sustainable waste management is more focused on the reduction of waste generation and should be based on the waste hierarchy presented in Figure 1 of this document. Additionally, new concepts as

CE and resource efficiency are a key for an integral management, while waste is seen as a resource and less wastes can be generated if resources are managed efficiently.

The second research question intended to identify the characteristics of waste generated in developed and developing countries, particularly in LAC, and identify the main trends. Every year 2.7 billion tonnes of waste are thrown in the EU, (EC, 2011), from which an average of 251.674 thousand tonnes correspond to MSW (Eurostat, 2017). It decreased from generating 515 kg/person/year in 2005 to 482 kg/person/year in 2015. However, caution with the interpretation of the data is needed due to uncertainties caused by the differences in methodology, definitions and data missing, even some countries might have changed their definition of MSW in this period of time (EEA, 2013a). While in EU the trend is to decrease the amount of wastes generated, in LAC is to the increase. First, it is possible to deduce that the changes in environmental legislation had a positive effect in the reduction of wastes in EU (Humphris-Bach, Essig, Morton & Harding, 2015). LAC has a lower generation of wastes per capita, of 339.45 kg/person/year, although the trend is to increase. In LAC there is no standardization in the criteria to characterize the wastes. However, in general, most part of their wastes are composed by organic matter (55,5%) followed by packaging waste (29%) and other materials not identified (15,5%).

The third research question intended to identify the characteristics of waste management in the EU and the key elements for the success of EU in managing solid waste. There is an evident declining trend of landfilling, while recycling, incineration and composting are clearly increasing. In the last nine years material recycling, composting and digestion increased by 11%, 4%, and 6 % respectively, while landfill and incineration/ disposal decreased in 18% and 3% respectively. The different policies modifications that have been introduced in the EU in the past years have been helping to drive landfill diversion towards other options further up the waste hierarchy in most of the EU countries. The implementation of more strict policies with concrete targets seems to be the main element of success of EU in improving SWM. Landfill taxes, pay as you throw schemes and policies (such as Directive 62/1994) that promoted recovery of wastes, contributed highly to the diversion of wastes from landfill and the increase in recycling rates. Other factors contribute to high recycling rates, like the level of wealth, environmental awareness, waste management tariffs and stringent implementation of waste management legislation. It is important to highlight also that although waste management in EU as a whole has improved with the years, there are still big differences in performance among countries, particularly those who were included in the EU after 2004, present recycling rates lower than 30% (EEA, 2016a, p. 4).

The fourth research question intended to identify the characteristics of waste management in developing countries, in particular in LAC. The research showed that ISWM is still a pending issue in LAC. Waste diversion is low and practices for final disposal are in general very poor and highly variable. Collection of wastes in average is high, but still very low in some countries, such as like Paraguay (57%) with the lowest rate. More than half of the budget of

municipalities. Cities of LAC in general spend less than 0.3% of their budget in waste management, while cities in Europe, like Vienna for example, spend 0.4 % of GDP (Abrelpe, 2013). Among the different ways of treatment, the most common in LAC are recycling and composting, but there are only few countries that possess a formal system for these practices. In general, it is estimated that only 2.2 % of the wastes from LAC are recycled. However, recycling is in general an informal activity in LAC. Wastes are disposed in landfills 54%, controlled dumps (18.5%), open dumps (2.3%), open-field burning of waste (2%), and others such as water bodies (1.8%). In addition, there is a lack of planning, legislation and institutional framework, underfunding of MSW services, lack of effective education programs to encourage source separation of organic and inorganic recyclables, lack of standardized and reliable data.

Finally, the researched intended to identify what could developing countries, especially LAC countries, learn from EU to improve their waste management. LAC is facing deeper problems that contribute to increase the problem of waste management such as inequal distribution of income and poverty. Apart from this, there are some learnings it could take from EU. First, set targets and indicators in order to be able to evaluate the progress in implementation. Second, implement information systems similar to Eurostat to keep records of waste generation and management for a better planning. Policy instruments and financial incentives such as pay as you throw schemes, taxes and bans for landfilling could have also good results in LAC. Give a legal framework for recycling and promote the use of recycled materials by incentivizing re-manufactured products through policies. Increase the investment in SWM. Involving the private sector could lead to efficiency where competition, transparency and accountability are present. Integration of the region similar to EU could help to boost ISWM in LAC, since it will homogenize the legislation, regulations and environmental rules and technical sharing and support in the region and will put pressure on the political will. It is important for LAC to learn from the evolution and the history of EU, not only from their successful examples.

## LIST OF REFERENCES


1. Abid, M. (2017). Does economic, financial and institutional developments matter for environmental quality? A comparative analysis of EU and MEA countries. *Journal of Environmental Management, 188* (2017), 183-194
2. Abrelpe. (2013). *Panorama dos Resíduos Sólidos no Brasil 2013*. Brazil: Abrelpe.
3. Allen, L. (n.d.). The North American Agreement on Environmental Cooperation: Has It Fulfilled Its Promises and Potential? An Empirical Study of Policy Effectiveness. *Colo. J.Int'l Envtl.L.& Pol'y, 23*(1), p. 146.
4. Almeida, C. (2013, February 21). *Latin America Analysis: Environmental policy and deforestation.* [published on blog]. Retrieved from https://www.scidev.net/global/policy/analysis-blog/latin-america-analysis-environmental-policy-and-deforestation.html

5. Alter Vida. (2004). *Manual para convertir la basura en recurso.* Asunción: Alter Vida.
6. Aramyan, L., Valeeva, N., Vittuari, M., Gaiani, S., Politano, A., Gheoldus, M., Mahon, P., Scherhaufer, S., Paschali, D., Cseh, B., Ujhelyi, K., & Hanseen, O. (2016). Market-based instruments and other socio-economic incentives enhancing food waste prevention and reduction. Wageningen: Fusions.
7. Boh, T. (2004). *Multilevel Governance: The Implementation of EU Waste Policy in Slovenia; Does Waste Matter?.* Ljubljana: University of Ljubljana.
8. Botega Palma, D. (2004). *Proposta de Gestao de Residuos Sólidos no Centro de Tecnologia da Universidade Federal de Santa Maria*. (master's thesis). Santa Maria: Universidad Federal de Santa Maria.
9. Bourguignon, D. (2017, February 21). *Circular economy package: Four legislative proposals on waste. (Briefing, EU Legislation in Progress).* Retrieved March 3, 2018 from http://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2017)599288
10. Braungart, M., Mcdonough,W. & Bollinger, A., (2007). Cradle-to-cradle design: creating healthy emissions e a strategy for eco-effective product and system design. *El Sevier, Journal of Cleaner Production 15* (2007), 1337-1348.
11. CEMPRE - Compromiso Empresarial para el Reciclaje. (1998). *Manual de Gestión Integral de Residuos Sólidos Urbanos.* Montevideo: CEMPRE.
12. Conke, L. (2018). Barriers to waste recycling development: Evidence from Brazil. *Resources, Conservation & Recycling, 134* (2018), 129–135.
13. De Sales-Lisboa, H. S. (2014). *El Mercado de los Residuos Sólidos y el Saneamiento en Brasil. (Executive Summary).* Brasilia: ICEX (España Exportación e Inversiones).
14. EC - European Commission. (2010). *Being wise with waste: the EU's approach to waste management.* Belgium: European Commission.
15. EC - European Commission. (2016, June). *Waste: Review of the Thematic Strategy on the Prevention and Recycling of waste*. Retrieved March 4 from http://ec.europa.eu/environment/waste/strategy.htm
16. EC - European Commission. (2017). *Guidance on municipal waste data collection. Eurostat – Unit E2 – Environmental statistics and accounts; sustainable development.* Directorate E: Unit E-2.
17. EC - European Commission. (2018, June). *Waste.* Retrieved February 15, 2018 from http://ec.europa.eu/environment/waste/index.htm
18. Echagüe Ferrero, M.V. (2011). *Mercado de Reciclaje del Área Metropolitana de Asunción.* (Internship Report). San Lorenzo: National University of Asunción.
19. EEA - European Environmental Agency. (2007). *The Road from Landfilling to Recycling: Common Destination, Different Routes.* Luxembourg: Office for Official Publications of the European Communities.
20. EEA - European Environmental Agency. (2013). *EEA Report: Managing Municipal Solid Waste: a review of achievements in 32 European countries*. Luxembourg: Office for Official Publications of the EU.

21. EEA - European Environmental Agency. (2013b). EEA Report: *Towards a Green Economy in Europe; EU Environmental Policy Targets and Objectives 2010-2050.* Luxembourg: Publications Office of the European Union.
22. EEA - European Environmental Agency. (2014). *Multiannual Work Programme 2014–2018: Expanding the knowledge base for policy implementation and long-term transitions.* Luxembourg: Rosendahls-Schultz Grafisk.
23. EEA - European Environmental Agency. (2016a). *Resource Efficiency and waste: Municipal Waste Management across European countries*.
24. EEA - European Environmental Agency. (2016b). More From Less: Material Resource Efficiency in Europe 2015 overview of policies, instruments and targets in 32 countries. (No 10/2016, ISSN 1977-8449). Copenhagen: EEA.
25. Eur-Lex. (n.d.*). Environment and Climate Change.* Retrieved June 30, 2018 from https://eur-lex.europa.eu/summary/chapter/environment.html?root_default=SUM_1_CODED%3D20
26. Eurostat. (2010a). *Guidance on classification of waste according to EWC-Stat categories: Supplement to the Manual for the Implementation of the Regulation (EC) No 2150/2002 on Waste Statistics*. Retrieved May 16, 2018 from https://ec.europa.eu/eurostat/.
27. Eurostat. (2010b). *Environmental statistics and accounts in Europe: Eurostat Statistical Books*. Belgium: Eurostat.
28. Eurostat. (2017, May). *Waste Statistics.* Retrieved November 15, 2017 from http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics
29. Eurostat. (2018). *Eurostat Data Base.* Retrieved November 15, 2017 from https://ec.europa.eu/eurostat/data/database
30. Eurostat. (2018b, April). *Eurostat Statistics Explained: Municipal Waste Statistic*. Retrieved May 5, 2018 from http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Municipal_waste_statistics#Data_sources_and_availability
31. EU – European Union. (2018). Official Web Site of the European Union. Retrieved May 15, 2018 from https://europa.eu/
32. Gathak, T.K. (2016). Municipal Solid Waste Management in India: A Few Unaddressed Issues. *Procedia Environmental Sciences, 35* (2016), 169 – 175.
33. Gharfalkar, M., Court, R., Campbell, C., Ali, Z., Hillier, G. (2015*).* Analysis of waste hierarchy in the European waste directive 2008/98/EC. *Waste Management, 39* (2015), 305-313.
34. Ghisellini, P., Cialani, C. & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *J. Clean. Prod*. 114, 11e32.
35. Godoy, E. (2012, January 9). *The Waste Mountain Engulfing Mexico City*. [published on Magazine]. Retrieved from https://www.theguardian.com/environment/2012/jan/09/waste-mountain-mexico-city.

36. Hernández-Berriel, MC., Aguilar-Virgen, Q., Taboada-Gonzalez., P., Lima-Morra, R., Eljajek-Urzola, M., Marquez-Benavides, L. & Buenrostro-Delgado, O. (2016). Generación y Composición de los Residuos Sólidos Urbanos en América Latina y el Caribe. *Rev. Int. Contam. Ambie. 32* (Especial Residuos Sólidos) 11-22.
37. Hoornweg, D. & Bhada-Tata, P. (2012). *What a waste: a global review of solid waste management. Urban Development Series Knowledge Paper (No. 15).* Washington, DC: The World Bank.
38. Hoornweg, D. & Giannelli, N. (2007, October). *Managing municipal solid waste in Latin America and the Caribbean: Integrating the private sector, harnessing incentives*. (Note Nª 28). GridLines. [published on blog]. Retrieved from chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/https://ppiaf.org/documents/2074/download
39. Humphris-Bach, A., Essig, C., Morton, G. & Harding, L. (2016). *EU Resource Efficiency Scoreboard 2015.* Belgium: European Commission.
40. Ilic, M. & Nikolic, M. (2016). Waste management benchmarking: a case study of Serbia. *Habitat International, 53* (2016), 453-460.
41. Kadas, M.B. & Fraker, R. (2014). Central and South America Overview: Emerging Trends in Latin America. In Martella, R.R. & Brett Grosko, J.B. (ed.), *International Environmental Law The Practitioner's Guide to the Laws of the Planet* (pp. 365-371). USA: ABA Book Publishing.
42. Korhonen, J., Honkasalo, A., Seppälä, J. (2017). *Circular Economy: The Concept and its Limitations.* El Sevier, Ecological Economics, 143 (2018), 37-46.
43. Korhonen, J., Nuur, C., Feldmann, A., Eshetu Birkie, S. (2017). Circular economy as an essentially contested concept. *El Sevier, Journal of Cleaner Production, 175* (2018), 544-522.
44. Lima Morra, RA. (1996). *Situación de los Residuos Sólidos en la República del Paraguay. Asunción: Consultora Técnica de Ingeniería S.A*. Asunción: Facultad de Ciencias y Tecnología de la Universidad Católica de Asunción.
45. Lima Morra, RA. (2017). Situación De La República Del Paraguay En La Gestión De Los Residuos Sólidos Urbanos, Actualización 2017. In Lobo García, A.L, López Martínez, A.L. & Esteban García, A.L., Cuartas Hernández, M. (Eds.), *Libro de actas. VII Simposio Iberoamericano en Ingeniería de Residuos,* (pp.762), Santander: Universidad de Cantabria.
46. Lund, HF. (1996). *Manual Mc Graw-Hill de Reciclaje*.(Vol I). Madrid: Mc Graw Hill.
47. Ma J. & Hipel, K.W. (2015). Exploring social dimensions of municipal solid waste management around the globe – A systematic literature review. *Waste Management, 56* (2016), 3–12.
48. Marshall, R. E. & Farahbakhsh, K. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste Management, 33*, (2013), 988–1003.
49. Marshall, R. E., & Farahbakhsh, K. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste Management, 33*, (2013), 988–1003.

50. Mc Dougall, F., White, P., Franke, M. & Hindle, P. (2001). *Integrated Solid Waste Management: A Life Cycle Inventory* (2nd ed.). Oxford: Blackwell Science.
51. Monier, V., Hestin, M., O'Connor, Anderson, G., Neubauer, A., Sina, S., Homann, G. & Reisinger, H. (2011*). Implementing EU Waste Legislation for Green Growth: Final Report prepared for European Commission DG ENV.* Bio Intelligence Service.
52. Monteiro Penido, JH., Figueiredo Moutinho, CE., Magalhães, AF., De Melo França, MA., De Brito, CX., De Almeida, TP., Mansur Leite, G. (2001). *Manual de Gerenciamiento Integrado de Residuos Sólidos.* Río de Janeiro: IBAM.
53. Naustdalslid, J. (2017). Circular economy in China and the environmental dimension of the harmonious society. *Int. J. Sustain. Dev. World Ecol. 21* (4), 303-313.
54. Ogweleka, T. 2013. Survey of household waste composition and quantities in Abuja, Nigeria. *Resources, Conservation and Recycling*, 77 (2013), 52– 60.
55. OPS (Organización Panamericana de la Salud). (2005). *Informe de la Evaluación Regional de los Servicios de Manejo de Residuos Sólidos Municipales en América Latina y el Caribe.* Washington: Área de Desarrollo Sostenible y Salud Ambiental.
56. Pires, A., Martinho, G., Chang, N. (2011). Solid waste management in European countries: A review of systems analysis Techniques. *Journal of Environmental Management, 92* (2011), 1033-1050.
57. Potdar, A., Singh, A., Unnikrishnan, S., Naik, N., Naik, M., Nimkar, I., Patil, V. (2016). Innovation in Solid Waste Management through Clean Development Mechanism in Developing Countries. *Procedia Environmental Sciences, 35* ( 2016 ), 193 – 200
58. Sáez, A., Urdaneta, G., Joheni, A. (2014). Manejo de Residuos Sólidos en América Latina y el Caribe. *Omnia, 20* (3), 121-135.
59. Silva, A., Rosano, M., Stocker, L., Gorissen, L. (2016). From waste to sustainable materials management: Three case studies of the transition journey. *El Sevier, Waste Management, 61* (2017), 547–557
60. Sinakou, E., Boeve-de Pauw, J., Goossens, M., Van Petegem, P. 2018. Academics in the field of Education for Sustainable Development: Their conceptions of sustainable development. *El Sevier, Journal of Cleaner Production 184* (2018) 321e332.
61. Systemiq & Ellen MacArthur Foundation (EMF). (2017). *Achieving Growth Within: A €320-Billion Circular Economy Investment Opportunity Available to Europe Up To 2025.* Davos: SYSTEMIQ.
62. Sztern, D; Pravia, M.A. 1999. *Manual para la elaboración de compost: bases conceptuales y procedimientos* (Internal Material). Montevideo: Presidencia de la Republica de Uruguay.
63. Tchobanoglous, G., Kreith, F. (2002). *Handbook of Solid Waste Management.* (2nd ed.). New York: McGraw- Hill.
64. Tchobanoglous, G; Theisen, H; A. Vigil, S. (1994). *Gestión Integral de Resíduos Sólidos.* Madrid, ES, Mc Graw Gill. v. I.
65. Tello Espinoza, P., Martinez Arce, E., Daza, D., Soulier Faure, M., Terraza, H. (2011*). Informe de la evaluación regional del manejo de residuos sólidos urbanos en América*

*Latina y el Caribe 2010*. IDB-MG-115, AIDIS -001/2011. Retrieved from https://publications.iadb.org/handle/11319/3286?locale-attribute=es.

66. Toledo Villalba, M. 2006. *Estudio cuali-cuantitativo de residuos sólidos municipales en el centro urbano del distrito de Pirapo*. (Bahelor's Thesis). San Lorenzo: Facultad de Ciencias Agrarias.
67. Toumi, O., Le Gallo, J. & Rejeb, B.J. (2017). Assessment of Latin American Sustainability. *Renewable and Sustainable Energy Reviews, 78* (2017), 878-885.
68. UN (United Nations). (1987). Report of the World Commission on Environment and Development our Common Future. Oxford: Oxford University Press.
69. UN (United Nations). (n.d.). *Sustainable Development Goals.* Retrieved January 10, 2018 from https://www.un.org/sustainabledevelopment/sustainable-development-goals/
70. UNEP (United Nations Environment Programme). (2015). *Global Waste Management Outlook.* (Report) United Nations Environment Programme.
71. UNEP. (2011). *Decoupling natural resource use and environmental impacts from economic growth: a report of the working group on decoupling to the international resource panel.* Retrieved March 18, 2017, from <http://www.unep.org/ resourcepanel/Publications/Decoupling/tabid/56048/Default.aspx>.
72. D-Waste. (n.d.). Waste Atlas. Retrieved May 21, 2018 from http://www.atlas.d-waste.com/.
73. Watkins, E., Hogg, D., Mitsios, A., Mudgal, S., Neubauer, A., Reisinger, H., Troeltzsch, J., Van Acoleyen, M. (2012). *Use of Economic Instruments and Waste Management Performances*. France: Bio Intelligence Service- European Comission (EC).
74. WBCSD & BCG (World Business Council For Sustainable Development & Global Management Consulting). (2018). *The New Big Circle: Achieving growth and business model innovation through circular economy implementation.* Retrieved February, 12, 2018 from: chrome-extension://oemmndcbldboiebfnladdacbdfmadadm/http://docs.wbcsd.org/2018/01/The_new_big_circle.pdf
75. Wilts, H., Dehoust, G., Jepsen, D., Knappe, F. (2013). Eco-innovations for waste prevention — Best practices, drivers and barrier. *Science of the Total Environment, 461–462* (2013), 823–829
76. World Bank (2016). *Migration and Remittances Factbook 2016* (3rd ed.). Washington, DC: World Bank.

# APPENDIXES

## Appendix 2: Povzetek (Executive summary in Slovenian language)

Magistrsko delo zajema pregled in primerjavo situacije ustvarjanja odpadkov v EU in v južnoameriških državah v razvoju. Namen magistrskega dela je prepoznati ključne elemente uspeha EU, ključne elemente, ki omejujejo razvoj južnoameriških držav in pa bistvene nauke EU pri upravljanju trdnih odpadkov. Analizirano je bilo pet raziskovalnih vprašanj. 1. Kaj je odpadek, trdni odpadek in vzdržno upravljanje z odpadki? 2. Kakšne so glavne karakteristike odpadkov nastalih v razvitih in razvijajočih se državah Latinske Amerike in Karibov, kakšni so glavni trendi? 3. Kakšne so karakteristike upravljanja z odpadki v EU? Kateri elementi so ključni za uspeh EU pri upravljanju s trdnimi odpadki? 4. Kakšne so karakteristike upravljanja z odpadki v državah v razvoju, s poudarkom na Južni Ameriki in Karibih? 5. Kaj se lahko države v razvoju, posebej pa države Latinske Amerike, naučijo od EU, da bi lahko izboljšale upravljanje z odpadki? Za odpadek smatramo predmet oziroma substanco, ki nima več vrednosti za odlagatelja, lahko pa ohrani vrednost z vidika ponovne uporabe ali recikliranja. Vzdržno upravljanje z odpadki se ukvarja z zmanjševanjem ustvarjanja odpadkov preko boljše, smotrnejše uporabe surovin. Magistrsko delo ugotavlja, da je ustvarjanje odpadkov nižje v južnoameriških državah (339.45 kg/osebo/leto) kot pa v EU (482 kg/osebo/leto), vendar trendi kažejo porast v prvi statistiki in padec v drugi. Upravljanje odpadkov v EU se osredotoča predvsem na preusmerjanje odpadkov stran od odlagališč. Metoda je uspešna zahvaljujoč implementaciji zakonodaje in finančnih vzpodbud, pri katerih se stroški odlaganja prenašajo na odlagatelja in določijo odlagališčni davki. V zadnjih devetih letih so se recikliranje, kompostiranje ter predelava odpadkov povečali za 11%, 4% in 6%, medtem ko sta se odlaganje na odlagališčih in sežig zmanjšala za 18% in 3%. Države Latinske Amerike in Karibov še vedno nimajo vzpostavljenega sistema integralnega upravljanja s trdnimi odpadki. V večini se ukvarjajo s problemom končnega odlaganja odpadkov, ki je v veliki meri neformalno in nevarno. 53% odpadkov odlagajo v odlagališčih, 18,5% v kontroliranih odpadih, 2,3% v odprtih odpadih, 2% odpadkov je sežganih na odprtih kuriščih in 1,8% jih zaide v vodna telesa. Recikliranje je neformalna dejavnost, ki jo v veliki meri opravljajo pobiralci odpadkov, zato primanjkujejo podatki o stopnji reciklaže in o drugih tretmajih odpadkov. Latinskoameriške države pesti resno pomanjkanje institucionalne in pravne podlage, pomanjkanje politične volje in finančne podpore za upravljanje trdnih odpadkov. Možne rešitve, ki bi jih lahko države implementirale po zgledu EU so homogenizacija in integracija zakonodaje za izboljšanje regionalnih kazalcev, vključevanje privatnega sektorja za povečanje odgovornosti in transparentnosti, implementacija informacijskega sistema po zgledu Eurostat z zanesljivo bazo podatkov, določitev ciljev in indikatorjev skupaj s homogenizacijo merilnih metod in vključitev finančnih vzpodbud kot so davki, kazni za prepovedano odlaganje in subvencije za recikliranje.

## Appendix 2: Selected policy instruments in European countries (2001-2015)

| *Country* | *Percentage of MSW recycled per MSW generated, 2014* | *Percentage of MSW landfilled per MSW generated, 2014* | *Two or more national waste management plans developed between 2001 and 2015 or latest available year* | *Only regional waste management plans* | *Landfill tax increased by more than 50% from 2001 to latest available year* | *Landfill tax at least EUR 30/ton MSW, latest available year* | *Incineration tax* | *Landfill ban on organic waste or non-pretreated MSW* | *Mandatory separate collection of bio-waste fractions* | *Pay as you throw or other economic incentives for recycling MSW* |
|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 56 | 4 | X | | X Tax on reactive waste in compliant landfills until 2009 | X Tax on reactive waste in compliant landfills until 2009 | X | X | X | X |
| Belgium | 55 | 1 | | X | (x) Wallonia increase more than 50% | X | X | X | | (x) Only in Flanders and Wallonia |
| Bulgaria | 23 | 69 | x | | x | | | | x (ordinance of 2013) | |
| Croatia | 16 | 80 | X | | (No tax) | (No tax) | | | | |
| Cyprus | 18 | 76 | x | | | | | | | |
| Czech Republic | 25 | 56 | X | | x | | | | X | (x) |
| Denmark | 44 | 1 | X | | | X | X | X | | (x) |
| Estonia | 31 | 6 | X | | X | X | | X | | x |
| Finland | 33 | 17 | Two plans in the period 1998-2000 | | X | X | | X | X | x |
| France | 39 | 26 | | X | X | X | X | X | | (x) |
| Germany | 64 | 1 | | X | (no tax) | (no tax) | | X | X | x |
| Greece | 19 | 81 | X | | (no tax) | (no tax) | | | | (x) |
| Hungary | 31 | 57 | X | | X | | | X | (x) Green waste collection mandatory since 2015 | (x) |

(Table continues)

**Appendix 2: Selected policy instruments in European countries (2001-2015)** (continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Iceland | 30 | 66 | X | | (no tax) | (no tax) | | | | |
| Ireland | 37 | 38 | | X | X | X | | (x) | X (Food Waste Collection as of 2016) | X (Regulation of 2015) |
| Italy | 42 | 31 | | X | | | | | (x) only in some regions | (x) |
| Latvia | 21 | 79 | X | | x | | | | | |
| Lithuania | 30 | 59 | X | | Tax introduced in 2016 | | | (x) Ban on landfilling biodegradable waste from gardens and parks | | x |
| Luxembourg | 47 | 18 | Two plans from 2000 to 2010 | | (No tax) | (No tax) | | X | X | x |
| Malta | 11 | 80 | X | | (No tax) | (No tax) | | | | |
| Netherlands | 51 | 1 | X | | X (Tax abolished in 2012) | | | X | X | X 40% of municipalities |
| Norway | 42 | 3 | (x) (White paper covering waste 2006-2007 and Waste Strategy 2013) | | X Tax abolished in 2015 | (x) Tax abolished in 2010 | x | | | |
| Poland | 32 | 53 | x | | x | | | (Biodegradable waste collected separately) | | |
| Portugal | 30 | 49 | X | | X | | x | | | |
| Romania | 13 | 72 | | | (No tax) | (No tax) | | | | |
| Slovakia | 10 | 66 | x | | | | | | X | X Coverage unknown |
| Slovenia | 36 | 23 | | | | | | X | | x |

(Table continues)

**Appendix 2: Selected policy instruments in European countries (2001-2015)** (continued)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Spain | 33 | 55 | X | | (Tax only in regions of Catalonia and Castilla and Leon) | | (x) Only in Catalonia | (x) Ban on the disposal of recyclable materials | (x) in Catalonia and some other municipalities | (x) |
| Sweden | 50 | 1 | X | | X | X | Tax abolished in 2010 | x | | x |
| Switzerland | 54 | 0 | | X | | | | x | | x |
| Turkey | 0.4 | 83 | x | (No tax) | (No tax) | | | | | |
| United Kingdom | 44 | 28 | | X | X | X | | | | |

*Sources: EEA (2016a, p. 4).*

*Notes: (×) means that the instrument is not mandatory for the whole country or is implemented only in some regions or municipalities. Due to lack of data: for Ireland and Greece 2013 instead of 2014 data are used; for Turkey 2012 instead of 2014 data are used.*