How can household waste management strategies from European Union countries be adopted and implemented effectively in Bogota D.C, Colombia, to improve recycling rates and mitigate the negative impact of solid waste on the environment?

Graduating Project

Paula Sofia Arteaga Chacon

Bogotá D.C. Colombia

2025.

How can household waste management strategies from European Union countries be adopted and implemented effectively in Bogota D.C, Colombia, to improve recycling rates and mitigate the negative impact of solid waste on the environment?

Graduating Project

Paula Sofia Arteaga Chacon (Marketing y Negocios Digitales)

Dr. Youenn LOHEAC

Bogotá D.C. Colombia

2025.

Declaración de originalidad y autonomía

Declaro, bajo la gravedad del juramento, que he escrito el documento de título How can household waste management strategies from European Union countries be adopted and implemented effectively in Bogota D.C, Colombia, to improve recycling rates and mitigate the negative impact of solid waste on the environment? en la Opción de Grado Doble Titulación y que, por lo tanto, su contenido es original. Declaro que he indicado clara y precisamente todas las fuentes directas e indirectas de información y que este trabajo no ha sido entregado a ninguna otra institución con fines de calificación o publicación.

Paula Sofia Arteaga Chacón

Declaración de exoneración de responsabilidad

Declaro que la responsabilidad intelectual del presente trabajo es exclusivamente de sus autores. La Universidad del Rosario no se hace responsable de contenidos, opiniones o ideologías expresadas total o parcialmente en él.

Paula Sofia Arteaga Chacón

Declaration of Academic Integrity and Personal Work

"I, the undersigned, Paula Sofia ARTEAGA CHACON declare on my honor that this submitted Graduating Project "How can household waste management strategies from European Union countries be adopted and implemented effectively in Bogota D.C, Colombia, to improve recycling rates and mitigate the negative impact of solid waste on the environment?." is my own work. No part of this research has been submitted in the past for publication or for degree purposes. I also confirm that,

□ I did not use generative AI

□ I used generative AI for (in details):

For proofreading translation of documents, improving writing, and looking up synonyms of words. Clarification on how certain functions of the SPSS software work. It was never used for content creation or analysis, only as a support tool.

I am aware of and understand RSB ACADEMIC INTEGRITY POLICY on Academic Dishonesty and its consequences. I am fully responsible for the truthfulness of this declaration.

Date: 30 October 2024

Signature:

Confidentiality Agreement for Graduating Project

Family name: ARTEAGA CHACON

First name: Paula Sofia

Program attended at RENNES School of Business: MSc in Sustainable Management & Eco-Innovation.

TITLE OF THE GRADUATING PROJECT: How can household waste management strategies from European Union countries be adopted and implemented effectively in Bogota D.C, Colombia, to improve recycling rates and mitigate the negative impact of solid waste on the environment?

Date of submission: 31 October 2024

Appendices: YES (X)

Confidentiality: NO (X)

Comments: N/A

Acknowledgments

I want to thank my supervisor Youenn Loheac for all the support provided during the research and development of the work. His guidance and expertise were key to the achievement of this work. He was always willing to help me when unsure how to proceed with this research.

I would also like to thank my friends and family, who were always encouraging me and helped me to stay motivated during this process. Finally, I would like to thank all the people who participated in the survey, thank you for taking the time to respond, you provided very important insights into this research.

Table of Contents

Declaration of Academic Integrity and Personal Work 5

Confidentiality Agreement for Graduating Project 6

Acknowledgments 7

Table of Figures 11

Table of Tables 12

Abstract 13

Keywords. Waste management, recycling, landfill, households, solid waste. 15

1. Introduction 16

1.1. Problem Statement 16

1.2. Research Question 19

2. Literature Review 20

2.1. Final disposal system of solid waste in Colombia 20

2.1.1. Limitation: Reliability and traceability of the information. 22

2.1.2. Final disposal system of solid waste in Bogota: Doña Juana Landfill 25

2.2. Classification of solid waste in Colombia 27

2.3. Why is there such a low recycling culture in Bogota? 29

2.3.1. Willingness of households to recycle. 33

2.4. What is sustainability in solid waste management? 35

2.4.1. Challenges of Waste Management 38

2.5. European Union Circular Economy 41

2.6. Waste Treatment in the European Union 43

2.6.1. Recovery or recycling in the European Union 46

2.7. European Union strategies for improving household waste management in Bogotá. .. 47

2.7.1. Pay as You Throw System 49

2.7.2. *Pfand* System – Bottle Return System in Germany. 52

2.7.3. Use of a graphical helps, the Triman-logo – Example of France 55

2.7.4. Separate containers for glass recycling. 56

3. Methodology 59

3.1. Hypothesis and variables 59

3.2. Research Design 60

3.3. Research Question 62

3.4. Data collection 62

3.4.1. Survey. 62

3.4.2. Description of the sample 65

3.4.3. Data Analysis 66

4. Results and analysis 71

4.1. Descriptive Analysis 71

4.2. Inferential Analysis 76

4.2.1. Spearman correlation 76

4.2.2. T-test of a sample 78

4.2.3. Lineal regression 80

5. Conclusions 82

5.1. Current scenario 82

5.2. Main Challenges 83

5.3. Factors that contribute to a low recycling rate 84

5.4. Recommendation to implement EU strategies to improve Bogota's recycling rate 85

6. Recommendations & Future approaches 87

7. Limitations and Assumptions 90

8. References 93

Table of Figures

Figure 1 Waste disposal in Colombia by Department 21

Figure 2 Level of information reporting to SUI by departments in force 2020, 2021, 2022 24

Figure 3 Color coding for source separation at the national level. 32

Figure 4 Fine for leaving waste in a public way in France 39

Figure 5 European Union Waste Hierarchy 43

Figure 6 Waste treatment by type of recovery and disposal in the EU 44

Figure 7 Some alternatives for implementation of PAYT 50

Figure 8 Pfand symbols for recognizing bottles that have a deposit..... 53

Figure 9 The DPG deposit process..... 54

Figure 10 Example of a dedicated container for glass containers in Villejuif, France. 58

Figure 11 Generational Classification and relevance for the Age variable..... 67

Figure 12 Age Distribution by Gender with Trend Lines 70

Figure 13 Survey Question What is the main obstacle you face to recycling in your household? Results..... 74

Figure 14 Color Code Knowledge by Bag Type..... 76

Figure 15 Relationship between Age, Level of Knowledge of Waste Separation System, and Frequency of Waste Sorting in Bogota 80

Table of Tables

Table 1 *Hypothesis and variables of the study* 59

Table 2 Characterization of the variables 68

Table 3 Descriptive analysis for ordinal variables 71

Table 4 Spearman's Correlation between Variables 77

Table 5 t-test for EU Waste Management Strategies 79

Glossary

Circular Economy: An economic model focused on reducing waste and maximizing resource use through the practices of reusing, recycling, and repurposing materials.

Landfill: A designated area for burying waste materials, commonly serving as the main waste management solution in Bogotá.

Recycling: The method of transforming waste materials into new products to minimize waste, decrease the use of raw materials, and reduce greenhouse gas emissions.

Solid Waste Management (SWM): The processes involved in collecting, treating, and disposing of solid waste generated by households, industries, and other sectors.

Source Separation: The practice of sorting waste into various categories (such as organic, recyclable, and non-recyclable) right at the point of generation, like in households.

Pay-as-You-Throw (PAYT): A waste management approach where users pay according to the volume of waste they throw away, encouraging waste reduction and recycling efforts.

Pfand System: A deposit return program in Germany where consumers pay a deposit on beverage containers, which is refunded when they return the containers for recycling.

Triman Logo: A labeling system in France that indicates a product is recyclable and provides guidance on how to sort waste properly.

Greenhouse Gases (GHG): Emissions such as methane (CH_4) and carbon dioxide (CO_2) released from landfills, which contribute to climate change.

Abstract

There is an imminent need for Bogota to implement a change in its entire waste management policy. Poor waste management is the third cause of greenhouse gases in Bogota. On the other hand, the Doña Juana landfill is already classified as a critical site, with a useful life of less than 1 year. Therefore, this waste disposal site represents an environmental hazard for the community and the planet.

The city has a very low recycling rate of only 17%. This figure demonstrates the current situation and the importance of rethinking the projects and strategies that are being implemented. Bogota's recycling process is made up of 7 phases. Each of these has different challenges to address, and in general, there is unsustainability along the whole chain. However, it is important to start solving the problem at the root, by reducing the amount of waste that is generated.

This degree work seeks to recommend strategies from European Union countries that promote recycling among citizens and households. Guided by a circular economy policy and a change of mentality about waste. Seeing it as a resource, rather than as something to be disposed of that has no value. However, to achieve this, the willingness of citizens to improve their waste separation habits is very important. It has been shown that if household members are surrounded by individuals who have good household solid waste management practices, they are more likely to adopt the same behaviors.

This study uses a quantitative methodology to demonstrate that the main factor contributing to the city's low recycling rates is the lack of a clear understanding or knowledge of the waste separation system. And that the implementation of a combination of EU-inspired strategies

would significantly increase recycling rates and improve overall household waste management in Bogotá.

Keywords. Waste management, recycling, landfill, households, solid waste.

1. Introduction

1.1.Problem Statement

The production of solid waste is inherent to our consumerist configuration of modern society and there is a positive correlation between population growth and fast-increasing solid waste production (Padilla & Trujillo, 2018a). However, the treatment process of this waste has not been the most effective in the planet's history. Due to environmental regulations and new technologies, there has been an improvement, but this has not been enough, especially in countries like Colombia. Where landfills are the main waste treatment system. According to the National Report on Final Disposal of Solid Waste 2021, prepared by the Superintendencia de Servicios Públicos Dominiciliarios or Superservicios [1](in English Superintendency of Household Public Services), by 2021 there were 266 final disposal sites, of which 165 correspond to landfills (Superintendencia de Servicios Públicos Domiciliarios, 2023b). They are present in 91.27% of the country's municipalities and therefore receive 97.15% of the annual tons of garbage.

The landfill disposal system was intended as a solution for short-term waste management and that is why it is an insufficient method for the accelerated production of waste today. Jiménez (2023) explains that landfills do, broadly speaking, dispose of the waste on the ground in a presumably safe manner so that it is then compressed and thus reduces its volume to the minimum possible. Finally, it is covered by a layer of earth. Nevertheless, in Colombia, there are

[1] Abbreviation that will be used in the rest of the document.

serious management and handling problems in these places, which have generated environmental impacts, such as the emission of methane and CO_2, the generation of leachate liquids, the creation of a toxic urban landscape, etc. Actually, in 1997 there was an explosion of the Doña Juana landfill (the main waste disposal site for the Colombian capital, Bogota) due to the accumulation of gases and leachates.

According to figures from Greenpeace, (2023) and Superintendencia de Servicios Públicos Domiciliarios (2023a), approximately 3 million tons of garbage are produced in Bogota per year. This translates to around 8,300 tons daily, of which only between 16% to 17% is being recycled and the rest ends up in landfills, water sources, and other ecosystems, generating pollution. Consequently, poor waste management is the city's third cause of greenhouse gases. Around 6,500 tons of garbage per day arrive at the Doña Juana landfill, more than half of which is organic waste.

According to the National Report on Final Disposal of Solid Waste 2021, another issue that the city is facing is the dwindling remaining useful life of the Doña Juana landfill, being 3.2 years by December 2021. Being classified as a critical site (validity between 0 and 3 years)[2]. This implies a possible materialization of some environmental and health risks; therefore, planning mechanisms must address this situation quickly and comprehensively. However, government processes take too much time. What has been done in recent years is to extend the environmental license or build more hectares to expand the landfill capacity, which is not sustainable. Therefore, it is necessary to move the scope and look for other types of solutions that

[2] According to Superintendencia de Servicios Públicos Domiciliarios This criterion of useful life is a variable that allows the control organisms to foresee the existence of a sanitary and/or environmental risk. When a landfill is classified as critical, it is because it already implies an environmental and public health risk that must be resolved by the relevant authorities through different mechanisms and strategies. (2023b)

address the root of the problem, and this work seeks this. Propose new strategies for households to reduce their negative impact on solid waste management (Superintendencia de Servicios Públicos Domiciliarios, 2023b).

Although the country joined the Sustainable Development Goals in 2015 to promote recycling, and improve sanitary conditions, reducing the negative impact of waste. Only 17% of waste is recycled in Bogota, which shows that current waste separation policies, such as the mandatory use of three bags (white, green, and black) for waste differentiation. The correct disposition, cleanliness, and separation of the material with the potential to take advantage of it, are not effective or sufficient. The policy is not clear to many citizens. Who in some cases only uses one bag and bin to dispose of the residues. And the few who try to carry out the separation do not know the process that ensues, or doubts fit.

1.2.Motivation and structure of the research

This graduating project seeks to understand why current policies and strategies are not being effective for solid waste management in Bogotá households. Taking into account this diagnosis, strategies implemented in European Union countries that have proven to be effective, achieving high recycling rates and better waste management in these countries, are proposed.

The first part of the literature review focused on giving a general overview of solid waste management in Colombia. An overview of the Doña Juana landfill crisis in Bogota is explained.

The causes of this and the environmental health consequences. The main challenges for the population of the city in terms of carrying out good waste separation and what leads to a very low recycling rate are identified.

Subsequently, an overview of the circular economic ideology of the European Union (EU) and the Waste hierarchy is described. To describe 4 strategies applied in some of those countries, aimed at the population to make a correct separation of waste from their homes. Which has contributed to the high recycling rates in these countries.

The feasibility of implementing these strategies in Bogotá was evaluated through a quantitative method, a short and precise survey. The sampling was random. With the results, a statistical analysis of the data was carried out using averages, mode, standard deviation, t-test, and correlations to test the two hypotheses stated in the methodology.

1.3.Research Question

How can household waste management strategies from European Union countries be adopted and implemented effectively in Bogota D.C, Colombia, to improve recycling rates and mitigate the negative impact of solid waste on the environment?

2. Literature Review

In this section of the paper, key sources will be collected, and the information will be presented in the following way. First, an explanation will be crafted and a general overview of solid waste management in Colombia and Bogotá will be given. Then, some causes that lead to a low recycling rate in Bogotá will be presented. Finally, different strategies used in countries of the European Union will be described that help to improve the recycling culture among their citizens and that could be applied to the Colombian context.

2.1.Final disposal system of solid waste in Colombia

According to the National Report on Final Disposal of Solid Waste 2021, by Superservicios in 2021 there were approximately 11.952.449,9 tons/year, which translates to 32.746,4134 tons/day of solid waste in the country. This represented an increase of 4.16% compared to 2020. As shown in Figure 1; 6.221,42 tons correspond to Bogotá (the municipality with the highest number of tons per day and the country's capital and main city). On the other hand, for 2022 there was an increase of 0,26% with 11.983.709,7 tons/year and 32.832,0814 tons/day compared with the previous year. For Bogota, the increase was 0,79% having 6.270,48 tons/day. Being the only city in the country with more than 6.000 tons per day. Given that it is the most densely populated area in the country.

Figure 1 *Waste disposal in Colombia by Department*

Note: The translation of the conventions is as follows

- Purple: less than 140 tons/day
- Green: between 140 to 600 tons/day
- Yellow: between 600 to 1.000 tons/day
- Orange: between 1.000 to 6.000 tons/day
- Red: more than 6.000 tons/day

Source: (Superintendencia de Servicios Públicos Domiciliarios, 2023b)

In Colombia, there are 4 types of final disposal systems, of which two are authorized and regulated by Superservicios and two are not. The authorized systems and therefore with greater use within the territory are the landfill and the contingency cell. The unauthorized ones are transitory cells and open dumps. For 2021, 266 final disposal sites were registered, 5,34% less than last year. 177 correspond to authorized systems, which corresponds to 66,54%. And of this figure, 165 sites are landfills, among which is the main engineering work in the country for the

final disposal of waste. As an example of this type of disposal is Doña Juana landfill, where waste from the city of Bogotá and the capital district arrives.

According to *Decreto 1077 de 2015* (2015) A landfill is a place strategically selected, built, and operated for the controlled management of waste without causing risk to public health and minimizing environmental impacts, this is through engineering techniques such as confinement and isolation of waste so that they reduce their volume to the minimum and coverage thereof, seeking to control gases and leachates. However, in real life this system is not working as explained in this definition.

Superservicios explained that the management and renovation of the country's landfills is full of problems, the communities do not want a garbage disposal site in their territory, and their useful life is running out. For instance, Doña Juana is in critical condition since it has less than three years of operation. The solution to continuing the expansion of its territory is not viable, since the implementation of a public exploitation policy has not been effective. Therefore, it is necessary to promote waste minimization so that fewer tons reach landfills every day, through the implementation of new solid waste management alternatives that are based on environmentally and community-friendly technologies (Superservicios, 2023).

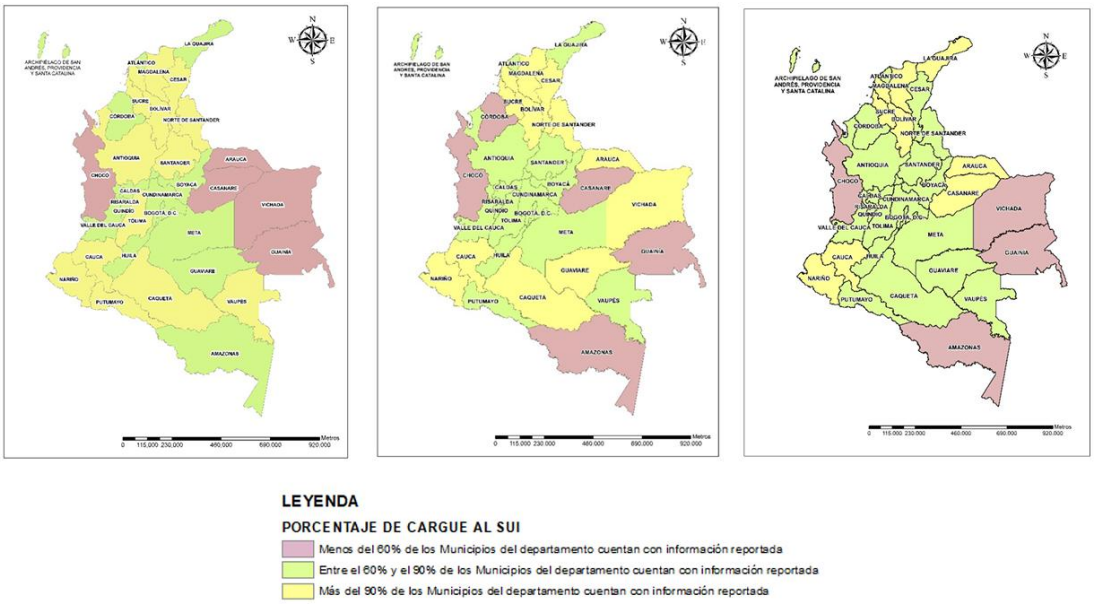
2.1.1. Limitation: Reliability and traceability of the information.

The best way to measure progress in policy implementation is through statistical data. This allows for comparison and easy understanding by the general public. However, in the case of Colombia, different sources of information are used to consolidate data related to Integrated Solid Waste Management. In addition to this, the data received has problems of quality and availability (Superintendencia de Servicios Públicos Domiciliarios, 2023c). Also, some municipalities (especially in surrounding areas and those with difficult access) do not report or have some kind of control over the disposal of their waste.

Additionally, much of this information is not presented clearly and concisely. Instead, it is done through long reports that most citizens never read. On the other hand, it is also problematic because experts struggle in the decision-making process to propose plans for improving waste management. So, citizens do not receive this data, or when they do, they may not understand it. As a result, awareness of this crisis is very low or almost non-existent.

But what is the country doing to solve this problem? The government decreed the Single Information System (SUI, operated by Superservicios) as the main entity in charge of collecting and processing the information. It is also in charge of making annual reports. Superservicios subsequently categorized the other sources and organized them according to the relevance of the data they provided. Thanks to this, there was a 0,25% reduction in data imputation between 2021 and 2022. Still, there are still gaps in the uploading of information to SUI by the country's municipalities, as can be seen in Figure 2.

Figure 2 *Level of information reporting to SUI by departments in force 2020, 2021, 2022*



Note: The translation of the conventions is as follows

- Pink: less than 60% of the municipalities have reported information.
- Green: between 60% and 90% of the municipalities have reported information.
- Yellow: more than 90% of the municipalities have reported information.

Source: Superintendencia de Servicios Públicos Domiciliarios, 2023c.

In this map, there is an improvement for 2022 concerning previous years as there are fewer departments in pink color. However, the variability of the reports is evident, as there is no clear pattern of improvement, but each year the map is completely transformed. According to Superintendencia de Servicios Públicos Domiciliarios (2023c) " The low percentage in the information report could be related to the lack of instruments for measuring or estimating waste disposed of on-site and, (...) the internet connectivity conditions".

2.1.2. Final disposal system of solid waste in Bogota: Doña Juana Landfill

Every day approximately 6,500 tons of waste arrive at Doña Juana Landfill, which is the product of all the waste generated by the Colombian capital and 7 surrounding municipalities. Throughout its more than 30 years of operation, this landfill has generated different types of environmental and social problems, the surrounding communities have had to be evacuated, and it is blamed for the incubation of diseases in the inhabitants near the area, the emission of gases and leachate liquids has not been managed in general in the best way. As a result, in 1997 there was an explosion at the landfill, which left an environmental and social footprint that continues to this day. Despite, the correct preventive measures were not taken after that date, and in recent years landslides have continued to occur, in 2015 there was a landslide of 550 thousand cubic meters of garbage (Cubillos Pineda, 2021).

Once the landfill was created in 1988, the original plan stated that the closure date would be for the year 2000, and beneath all the garbage there was going to be a green area that the inhabitants of the zone could enjoy. However, reality is far away from theory, and this landfill is still functioning nowadays, actually, it is estimated that it has more than 50 million buried garbage in an area of 600 hectares. Clearly, there is nothing green about it. On the contrary, this supposed optimal solution (due to the technological advances of the moment and the economic expenses) for garbage management has only become a toxic urban landscape. (Camargo, 2019)

One of the big mistakes that were made at the beginning of the landfill management was that it was thought that it was not necessary to make a separate collection of garbage and that the

landfill was capable of decomposing any type of waste. Nevertheless, several engineers did not share this opinion and explained that the accumulation of garbage in this way was highly risky, but this position was disregarded. As a consequence, the 1997 catastrophe described above occurred, which not only affected the urban population (more than half a million), but also infected the waters of the Tunjuelo river. After the disaster, a German firm was hired to reorient the waste management system, which developed a master plan based on three pillars: 1) greater citizen participation regarding the reduction of waste produced at the household level, 2) the importance of recycling and recyclers, and 3) the limit of Doña Juana's useful life was 2003. But once again this plan was not fulfilled and was simply detailed in writing in an official document (Camargo, 2019).

Given the above, there is a major flaw in the approach, development and execution of strategies and/or programs to improve recycling in the city. Although each mandate presents innovative policies, which on paper sound like the ideal solution, in reality, these are never completed. Either because they are not even developed, or because they are done poorly, or because during execution they realize that they are not affordable for the municipality. Therefore, there is no relevant and significant change in terms of the classification and disposal system.

Considering the above about the poor management that this disposal system has had, and as stated by (Vargas, 2021) 80% of the 6.500 tons of residues that arrive every day in the landfill have potential for exploitation or reuse. Therefore, the city mayor's office, together with the Special Administrative Unit of Public Services, is focusing on Bogota residents achieving a reduction in the waste they generate through the promotion of the culture of recycling and circular economy principles. Still, it is important to propose new models and strategies to really engage the community and make it easier for them.

2.2.Classification of solid waste in Colombia

According to El (Departamento Nacional de Planeación, 2022) there are two types of solid waste

1. Ordinary solid waste: which is made up of three main categories: non-usable, organic, and usable, which includes cardboard and paper, metals, plastic, glass, wood, and textile.
2. Solid waste with differentiated management: this is divided into two
    a. With post-consumption programs such as used tires, used batteries, expired medications, computers and electronic devices, fluorescent light bulbs, lead acid batteries and pesticide containers.
    b. Others: Waste, electrical and electronic equipment, construction and demolition waste.[3]

In resolution 2184 of 2019 of the Ministries of Environment and Sustainable Development together with the Ministry of Housing, City and Territory, the National Color Code was adopted as a method for separating waste at the source, which consists of the following:

- Reusable waste must go in the white bag.

[3] Considering that this degree work focuses on household waste, this type of waste will not be considered within the analysis and the proposal of suggestions for improvement.

    - Paper and cardboard They must be clean and dry, free of staples, tapes, and wrinkles as much as possible. They should be folded so that they take up minimal space.
    - Plastic: they must also be free of food or drink residue, any other element that is not plastic must be removed.
    - Glass: all contents must be emptied but it is not necessary to wash it. All glass must be separated into a cardboard box, sealed, and marked.
    - Metal: clean and dry, it should not have any type of residue or impurities
- Reusable organic waste such as food and garden waste should go in the green bag[4].
- Unusable waste must go in the black bag.

It is mandatory at least to separate the white and black bags, the green one comes into operation if there is a collection route and subsequent treatment in the municipality. If this route does not exist, the waste from the green bag must be put in the black bag. In the case of Bogota, the citizens must use the three bags.

The recycling chain in Bogotá consists of 7 phases: generation, retrieval, collection and transport, storage, pre-transformation, transformation, and reuse (Padilla & Trujillo, 2018). Although there are problems in each of the phases, this work will focus on the first segment, seeking the correct disposition of resources when they are generated in homes.

[4] Food waste (FW) must be segregated from other solid waste since according to Thi et al., (2015) “FW is currently an environmental issue because it is not segregated well from Municipal Solid Waste (MSW), which contributed to increasing greenhouse gas (GHG) emissions in landfills”.

2.3.Why is there such a low recycling culture in Bogota?

Of the more than 6.000 tons of waste that the landfill receives, 43% are materials that can be recycled, belonging to the usable characteristic. This is the product of several factors such as the lack of management of material with recyclable potential since the system is based on the disposal of waste and not on its use. Additionally, most policies are focused on the development of a linear economy. Especially the lack of a more deeply rooted culture among Bogotá residents of carrying out separation at the source, despite the education and awareness efforts that local governments have carried out (Sepúlveda & Andrés, 2020).

After an analysis carried out by the same authors, the main reasons why the population of the capital does not recycle are:

> There is no knowledge about what recycling and separation at the source are, and there is a great lack of culture, as reflected in the current garbage panorama in Bogotá and the world, there is a lack of precise and pedagogical environmental policies on the part of the local and national government. , that involve all interested parties, and that regulate strict compliance with separation at the source and the adequate collection of waste by the companies in charge. (Sepúlveda & Andrés, 2020)

In a survey carried out by the Colombian newspaper EL Espectador, the result was that Bogota residents do not recycle mainly due to the lack of help from other members of the household in the separation and correct disposal of waste. The second reason is the lack of bins available for recycling. The third argument is that they do not know what materials can be recycled and which ones not (Espectador, 2023). Although there are pedagogical and monetary

sanctions for taking out garbage at unauthorized times, incorrect use of containers to deposit waste, scattering the contents of the bags in public areas, and leaving garbage outside the containers once the separation has been carried out. Recycling figures still do not show significant increases, with only 17% of waste being used (Mora, 2023).

After a study conducted by Muñoz et al., (2021) they concluded that “it is key to massify awareness campaigns about the importance of separating materials in the source and the proper use of containers and colored plastic bags so that citizens generate a change of attitude. Likewise, the change in cultural values must be worked harder through environmental education” (p.15). Therefore, it is necessary to create a policy with strategies that really reach out to the community and change their behaviors, raising awareness about the negative environmental impacts of poor waste management and the importance of source separation.

Citizens do not know all the norms related to the topic like the prohibition of bags smaller than 30x30cm, the sanctions established in the new National Police Code, and, the lack of knowledge of where are located the recycling stations (Sánchez-Muñoz et al., 2019). Another factor that leads to confusion among inhabitants is the lack of alignment between municipalities and national waste management policy (Franceschi et al., 2022).

Another of the strategies proposed by the city to recover at least 50% of all usable waste that ends up in landfills was the installation of big garbage containers and bins throughout the city. The aim was to improve the presentation of waste, reduce its accumulation, and generally facilitate its management. A total of 10.746 containers were located in the city, of which 5.373 were for unusable material and 5.373 for usable material (Holguin Aguirre et al., 2022).

However, one of the factors that led to the project not being as successful as expected is the lack of culture on the part of the people and of training processes aimed at citizens. Since there is a lack of knowledge about the nature of waste (citizens do not know which are usable and which are not), this causes possible usable waste to be contaminated by other waste. Another problem was related to the cleaning and maintenance of the containers; some were quickly damaged, had no lid, and had bad odors (Holguin Aguirre et al., 2022).

On the other hand, awareness campaigns on proper waste management are massive, but not very effective in bringing about a real change in the consumption and recycling decisions of the inhabitants (Sánchez-Muñoz et al., 2019). It was also found that these prevention campaigns are mainly promoted by the private sector, so the public sector must become more involved.

Furthermore, by 2015 in Bogota, more than 6 resolutions were proposed (Rodríguez Peñaranda & Contreras Caparroso, 2016), which had the objective of addressing an issue that needed a solution or needed to be recognized, regarding the separation of waste. But at the implementation phase, there have been some issues.

One of the principal strategies was the GTC 24 (by its acronym in Spanish, Guía técnica colombiana (colombian technical guide)) from 2009, the purpose was to give guidance for the separation of non-hazardous, hazardous, and special waste. The ICONTEC (By its acronym in Spanish, Instituto Colombiano de Normas Técnicas y Certificación), recommended the following as a code of color regarding the source of waste:

- Domestic sector:
    - White: usable waste.
    - Black: unusable waste.

  - Green: organic waste.

- Industrial sector:
  - Gray container: cardboard.
  - Blue container: plastic.
  - White container: glass.
  - Cream container: Organic.
  - Dark brown container: metals.
  - Orange container: wood.
  - Green container: ordinary.

The information was extremely confusing, in consequence, an update was necessary, in that way, Resolution No. 2184 of 2019 was introduced. This policy will govern from 2021. It was an attempt to simplify waste management, and it stated the following (Minambiente, 2019):

Figure 3 *Color coding for source separation at the national level.*

Note: translation of the image

Title: Color coding for waste separation at the national level

- Usable waste (white): plastic, cardboard, glass, paper, metals and metals.
- Usable organic waste (green): food waste, agricultural waste
- Non-usable waste (black): Toilet paper, napkins, food-contaminated paper and cardboard, metalized paper.

Source: (Minambiente, 2019)

Although the resolutions were an effort to increase the amount of material that is recycled in the city, the percentage of material remains minimal. The fact that the norm has changed so many times also has immediate consequences on the way materials are disposed of and categorized officially in Bogotá, which affects the whole recycling chain process it's prone to get disorganized, less effective, and unstable in an execution sense.

The complexity and implications of a regulatory framework in constant modification can be many, going from misinformation to the fact that it is going to be more difficult to communicate and educate civilians about every change. This makes it harder for the population to adapt their behavior according to the information and processes that imply carrying out new and correct procedures to recycle. It also implies a higher cost for the city government, as it must change the city's containers, invest in new promotional and marketing campaigns, and propose innovative educational and awareness programs.

2.3.1. Willingness of households to recycle.

Recycling is a world that has gained a lot of popularity in recent years. It refers to the transformative process of waste materials into new products, materials, and inputs to fulfill the

original purpose or a new one. It is the most recognized and used resource utilization technique around the world within the Solid Waste Management (SWM) policy and has proven to be highly effective due to its reduction in environmental impact, in addition to the fact that it can generate revenue. For example, when recycled aluminum is used to produce a new can, the energy use of the production process is reduced by 75%. In short, recycling saves resources (Kassim, 2012).

However, each material has a different recycling process, and this is why it is crucial to implement policies that guide households to correctly separate waste in their homes. Since this is a crucial step so that the resource can be used, and its life cycle can be extended. If everything is put in the same bag, or for example, the packaging is not cleaned and dried, the other materials will be contaminated, which will make the recycling process impossible.

Therefore, it is necessary that the government not only promote recycling but also the policies they establish for SWM are aimed at easy implementation for users. Kassim, (2012) explains the plan that should be carried out to identify the most appropriate program to ensure true use of resources. This has three general steps, 1) Evaluate the country or region's propensity to recycle. 2) Identify viable recycling program alternatives that can be incorporated and accepted by the population of the country or region 3) Select the most appropriate strategies. This methodology is being followed for the present graduating project.

Another important variable to ensure a good recycling program is the willingness of residents and businesses to participate in it. This tendency can be improved if governments understand the behavior, the challenges, and the perceptions of citizens and stakeholders towards the current recycling policies. It is crucial to have feedback on issues such as the level of knowledge and understanding of the two/three-bag separation system implemented in the country, what challenges may arise in the application of these policies, and their tendency to cooperate in the

creation and implementation of new ones. Gathering that key information can translate into a significant change in the city's SWM and a reduction in the amount of garbage reaching the landfill can be achieved. Since Kassim, (2012) mentions "The efficient recovery of large volumes of high-quality recyclable materials depends on citizen involvement" (p.6).

For the case of Bogota, the willingness of households to recycle is directly correlated with the socioeconomic class, therefore (Padilla & Trujillo, 2018) found that the higher the socioeconomic class the higher the probability of the household to do the source-separated recycling. Padilla & Trujillo, (2018) stated that “intent to recycle increases if community members are compensated by the government for recycling” (p.3).

Padilla & Trujillo (2018) performed a survey about the factors that shape attitudes towards source-separated recycling in Bogota and they found that when residents have access to the internet and new information technologies they recycle more, therefore they conclude that a possible solution for improving source-separation is “facilitating access to new information technologies, such as the Internet, as well as the implementation of campaigns to care for the environment from the earliest years of school are measures that should be part of the local environmental policy, with a focus on the households of lowest SECs” (p.12).

2.4.What is sustainability in solid waste management?

It refers to a triple impact on economic, social, and environmental factors that can become leverage for citizens to live better and an opportunity for growth in these areas. If it is done correctly it can be an element for improving the conditions of cities, traducing positive repercussions, especially at social and economic levels, because It can help reduce unemployment and poverty (Muñoz et al., 2021).

The perception of waste has been transformed over the years, it was just perceived as a pollutant and non-usable element, but now it is considered reusable, recoverable, a useful source for recycling, and also an energy source. Therefore, according to Anuardo et al., (2022), "The goals of WM[5] are to protect people and the environment, increase the life span of products, and reduce the use of energy and space. These actions contribute to the reduction of negative impacts on the environment that occur because of human activities" (p.1).

This concept is aligned with Sustainable Development Objective 12 (UN, n.d.), Responsible Consumption and Production, especially target 12.4, Responsible Management of Chemicals and Waste which seeks to reduce the sustainable negative impacts of these residues and, target 12.5 Substantially reduce waste generation respectively, through prevention, reduction, recycling, and reuse. Also, with goal 11- Sustainable Cities and Communities, since it is a basic human right and a utility service. If the urban area has good waste management, the public space will be clean, the spread of pests will be reduced, the city will have a better image, etc. Goal 13- climate action and Goal 14- life below water, as already explained, the different disposal methods are highly polluting for the environment, generating greenhouse gases and contaminating water sources.

[5] WM: Waste Management

In the case of Colombia, the government in its National Development Plan 2022-2026 proposes the creation of the Zero Waste program (Basura Cero in Spanish), which is stated in Article 227 of Law 2294 of 2023. This seeks to take the Colombian waste management system towards a circular economy model, guaranteeing the participation of citizens, recyclers, and organizations. Through two main axes, recycling and the definition of a strategic plan for the definitive closure of open-air dumps and transitory cells. Through the implementation of technological and environmental parks. In general, it is a program that sounds quite attractive and positive in mitigating this environmental crisis in the country. However, it is necessary to wait to know its regulations and guidelines to be later able to analyze its viability, challenges, and difficulties (*Ley 2294 de 2023 Congreso de La República de Colombia*, 2023).

The entity in charge of developing it is the Ministry of Housing, City, and Territory within a maximum of one year from the entry into force (May 19, 2023) of the aforementioned law. However, as of September 2024, the program has not yet been formulated and created. This once again demonstrates the low priority given to SWM in the country.

Batista et al., (2021) identified that to achieve sustainable solid waste management, it is necessary to develop a system with three main conditions, it has to be integrated (alignment among stakeholders), market-oriented (regarding the recyclability and usability of garbage), and flexible (always leaving room for improvement. These three axes must be aligned with economically, socially, and environmentally sustainable objectives that are consistent with the country's current context and situation.

2.4.1. Challenges of Waste Management

In the paper *Toward a Cleaner and More Sustainable World: A Framework to Develop and Improve Waste Management Through Organizations, governments, and Academia* by (Anuardo et al., 2022), the main challenges of WM were identified and correspond to the following ones:

Unreliable information: this is a problem in the case of Bogota since there are very few academic articles or even informative sources that explain the topic in detail, the rules around it are not clear, and the projects are never put into practice or, if they are, they do not resemble what was originally proposed. There is no clear framework, and there is a lack of data, making it very difficult to make decisions in favor of a better system.

Deficient Budget and Urban Structure: related to operative issues that lead to the lack of policies for separation, recollection, and control of residues. Thi et al., (2015) found out that a lot of developing countries have poor WM for various reasons, incomplete legislative frameworks in their recycling system programs, lack of participation among inhabitants, and weak educational programs to understand the strategies. However, the main reason identified is limited government funding. As is the case of Colombia, where in its 2024 investment budget the sector that received the most resources was transportation with 13.9%, then social inclusion and reconciliation with 13%, while in last place is statistical information with 1.4% and in second to last the environment and sustainable development sector with 1.5% (DNP, 2023). Consequently, the Ministry of Environment and Sustainable Development Minister has stated that the resources are insufficient to deploy projects in favor of sustainability.

Low alignment among stakeholders: there is no synergy in the participation and proposal of the different parties involved regarding waste management policies. Therefore, the execution phase takes much more time because it has to be reviewed and approved multiple times. Also, in the case of Bogota, each major comes with a new proposal, usually, this one does not align with the one it is ongoing.

Lack of regulation applied to waste: In the case of Colombia, the regulations surrounding waste regulation are quite incomplete and difficult to access. During the research, it was very difficult to find detailed rules and decrees that described the times of fines and regulations on waste. Additionally, for WM in homes, only one economic sanction is mentioned in numeral 2 of article 94 of Law 1801 of 2016, but there are no concrete figures on how many fines have been imposed in these years, or whether the measure has been effective or not. On the other hand, in Article 111 of the national police code, Behaviors contrary to the cleaning and collection of waste and debris and bad housing practices are stated, but the nature of the sanction is not specified in detail. It is unclear whether it will be educational, economic, or criminal. In addition, most of these sanctions are focused on public spaces and organizations.

In contrast, as an example, in France, the information related to the regulations on waste was easy to find on pages like *France Public* or on government websites, the rules and the respective sanctions for non-compliance were explained, as well as infographics (as it is shown in Figure 3). This allows citizens to receive information and effectively comply with the rules for separating waste.

Figure 4 *Fine for leaving waste in a public way in France*

Translation of the infographic[6]

Source: (*Existe-Il Une Amende Pour Abandon de Déchets Dans La Rue ? - Abandon de Déchets | Service-Public.Fr*, 2024)

Another challenge is the negative environmental impacts: As explained above, improper disposal of garbage can lead to environmental, social, and public health problems. In the case of Colombia, there have been several accidents in landfills and other forms of final disposal, which have generated high levels of contamination and even diseases in the surrounding communities. Also, according to figures from the Ministerio de Vivienda, (2022), "Approximately 61% of the waste generated in Colombia is organic and is directly related to the generation of Greenhouse Gases".

[6] Leaving waste on the street. Is a fine of 135 euros to be paid within 45 days. Beyond this deadline, the fine increases to 375 euros. If you do not pay, the judge can set the fine at a maximum of 750 euros (or up to 1500 euros) with confiscation of the vehicle, if you used it to transport the waste.

One barrier that interferes with achieving correct solid waste management is the country's economic, social, cultural, and political development. As Batista et al., (2021) found,

> Developed countries, which enjoy a higher level of economic development, reach a high level of public awareness, adopting preventive approaches to waste more easily; while developing countries, where populations are more focused on short-term gain or survival, resort to less expensive low-tech approaches. (p.2)

European countries tend to focus their strategies on the real solution to the problem, reducing the tons of waste produced. And how to get the most out of that waste. LCA (Life cycle assessment) is taken into account, aiming to make the product more sustainable throughout its useful life, including end-of-use and waste treatment and recovery. In contrast, countries such as Colombia focus their strategies on temporary and quick solutions to the problem. For example, continuing to expand and build sanitary landfills. Also, the "lack of updated methods, technical and economic resources, a decision support tool for long-term contractual adjustments, as well as the lack of resources and qualified labor are factors that contribute to the use of dumps in the sky and landfills" (Batista et al., 2021, p.4).

2.5.European Union Circular Economy

Considering today's important sustainability challenges and the urgency of adopting a change in the current consumption and production patterns of the world's economies, the European

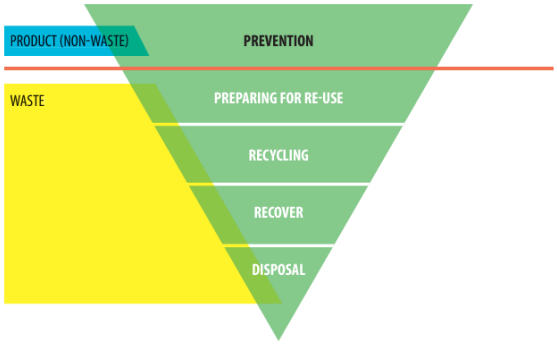
Union announced in 2019 the European Green Deal program, which aims to make Europe the first climate-neutral continent by 2050, transforming this conglomerate into an efficient, modern, and competitive economy within circularity.

In alignment with Sustainable Development Goal 12, Responsible Consumption and Production. It is the concept of the circular economy the EU wants to achieve, where they shift from a throw-away system to a sustainable one based on the principles of recycling, reusing, remaking, and sharing. Therefore, the waste management system in Europe must change to fit into this new objective, seeing it as a resource, changing the mentality that it is simply something we must get rid of to using it as a resource (Weghmann, 2023).

One of the pillars of the European Green Deal is the new circular economy action plan (CEAP), adopted in March 2020. It proposes improvement initiatives for each stage of the product life cycle. The aim is to reduce the number of products that are created and therefore the volume of tons of waste. It also introduces legislative and non-legislative measures such as material footprint resource productivity, and consumption footprint. The aim is to make products sustainable and to give more relevance to consumer demands in terms of greener products and ways of production (European Commission, 2023).

Considering the above premise, these initiatives seek to break with the linearity of the production chain, where the resource was extracted, manufactured, distributed, used, and finally discarded. To move to a cyclical model, which includes these same phases. However, there is a new waste approach, as seen in Figure 5, *European Union Waste Hierarchy*. As proposed by the European Public Service Union, waste avoidance should be prioritized, and the product's useful life extended as much as possible.

Figure 5 *European Union Waste Hierarchy*



Source: (Weghmann, 2023)

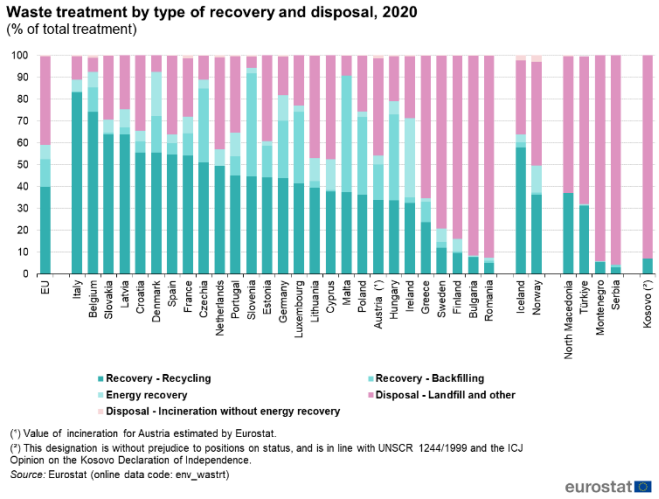
However, according to Popa & Negulescu, (2024), there are some challenges with this new model of seeing waste which the EU is working on. Like the following "the complexity of legislation that leads companies to treat production waste as waste, rather than recover it, to reintroduce it into production cycles, to avoid penalties related to its reuse". Since there is no incentive to use materials that come with the circular model, and they are not actually cheaper, so in a business and financial point of view they do not represent any additional value or advantage to the company.

2.6.Waste Treatment in the European Union

As stated by figures from Eurostat, (2020), the total Waste Generation in the EU for that year was 2.135 million tons[7], which represents approximately 4.815 kg per capita. Of this global value, 9,4% corresponds to households, being the 5th most representative activity after construction, mining and quarrying, wastewater, and manufacturing. Nevertheless, just 776 million tons were produced excluding major mineral waste, and for this case, households produced 196 million tons.

But how did the EU deal with this waste? During the period 2004-2020, the two main categories of treatment were recovery and disposal, as shown in Figure 6. The first category includes activities such as recycling, backfilling and energy recovery. This led to the treatment of more than half of the waste (59.1%) in 2020. And for disposal, the main method is the use of landfills.

Figure 6 *Waste treatment by type of recovery and disposal in the EU*



Source: (Eurostat, 2020)

[7] This amount includes all the economic activities that generate waste and not just household waste

Recalling the EU's waste hierarchy, disposal is the least preferable option and therefore in this case landfilling should be reduced year after year and used only for the minimum necessary. Given that, despite the incorporation of best treatment practices, the group recognizes the environmental and human health effects that this type of waste treatment generates. Such as the generation of leachate that contaminates the groundwater, and methane production, among others (European Commission, 2020).

In consequence, a key goal of the group is to cut the amount of waste that is sent to this disposal method. Based on figures from the European Environmental Agency, (2024) between 2010 and 2020 landfill rates decreased by 7%, passing from 23% to 16%, although the total amount of waste has increased during the same period. This has been achieved thanks to the Landfill Directive, a set of rules and requirements to protect the environment and human health.

To achieve this objective some of the proceedings established by this document are the following: by 2035 only 10% of the share of municipal waste can be landfilled, by 2030 there are restrictions on the type of waste that can be landfilled in these disposal centers. Warning reports should be made 3 years in advance of the center's expiration date to identify shortcomings. Countries should implement internal strategies to reduce the amount of biodegradable waste sent to landfills (European Commission, 2020).

In addition, only waste that has been treated can be taken to a landfill, and these sites can be classified according to the type of waste they receive (hazardous, non-hazardous, and inert waste). Better waste management is achieved, facilitating waste treatment, and reducing environmental impact. Thanks to the development of more specialized technologies. An example of this is the Centre de tri de collectes sélectives – operated by Veolia in Amiens, France. Here,

cardboard, paper, and different types of plastics are treated separately, and then compacted. Many of these materials are sold for reuse.

2.6.1. Recovery or recycling in the European Union

The other waste treatment category is recovery, also understood as recycling. In Figure 6 *Waste treatment by type of recovery and disposal in the EU* it can be seen that for 2020 almost 40% of the waste was recycled. The leading country was Germany with a rate that passed 60%. Meanwhile, Bogota's rate does not even reach the barrier of 20%. This demonstrates the urgency of improving the situation in Bogota. However, it should be clarified that no system is perfect, waste management still has many challenges and implications worldwide. For example, countries like Germany, which has superior management compared to the rest of the world, exports a proportion of its recyclable waste, losing control over the final use of these.

The important thing here, and part of what this work of degree seeks, is to change the mentality of the citizens of Bogota. To begin to see garbage as something else that supposedly already fulfilled its cycle and has no other use, more of a waste disposal overview, rather than waste management. Instead, they should start adopting the mindset that these countries propose of recursion and use of these wastes to generate raw materials, give them a second life, energy recover, etc. This is supported by Popa & Negulescu,

> The shift to circular economy production cannot be separated from the innovation economy, understood at all levels: product, process, and system. Therefore, only innovation can become the engine of transition to a new development environment, to closing cycles and efficient use of resources, but before innovating products and processes, a change of mentality is needed. (2024)

2.7. European Union strategies for improving household waste management in Bogotá.

In this section, it will be mentioned and explained some strategies applied by the European Union (EU) to improve household waste management. First, why was this group chosen? Because they have stood out as a world leader in the field. Thanks to its circular economy policy, which is promoted from the public and private sphere, also because they have been pioneers in innovative technologies for the use of waste. It promotes the involvement of the scientific sphere, researchers are constantly identifying gaps and proposing solutions to these problems (Gabor et al., 2023).

Considering that this geopolitical entity currently comprises 27 countries, not all the techniques applied in the region will be described. This degree work will focus on those that could provide solutions to the main challenges that Bogota presents in its solid waste management and that could be incorporated into the city's strategic plan, considering an understanding of the user, cultural, economic, and social factors. This goes in alignment with

what (Gabor et al., 2023) affirm “Identifying and analyzing the factors that generate the alarming increase in waste worldwide are more important for finding solutions to reduce them”.

Based on the first part of this literature review, the main problems with household waste management in Bogota:

- Educational, cultural, and social issues: This category includes the lack of knowledge and the low willingness to recycle that citizens have regarding waste separation policies. Also, the low effectiveness of awareness campaigns, which although designed to have a massive reach, cannot generate a real recall in the inhabitants. Finally, there are constant changes in regulations and the functioning of the waste separation system in the city. All this leads to confusion and doubt in households, which is why they often mix all the garbage in the same place.

Ferraresi et al., (2023) conclude that “households surrounded by individuals with good recycling habits are more likely to adopt the same behavior because they feel part of a virtuous community, and vice versa for households sur-rounded by individuals with bad recycling habits”. In that sense. If we can change the habits of decision-makers in each locality, neighborhood, and residential complex in Bogota, this behavior will spread among the neighbors.

- Infrastructure and operational: This axis is mainly related to containers, here there are two major issues. The first is that there is not enough infrastructure in terms of bins (citizens are the ones who must buy them) and big street containers (provided by the mayor's office for public use and to help the collection process) to meet all the demands of households in the capital. The second is the condition and maintenance of these containers.

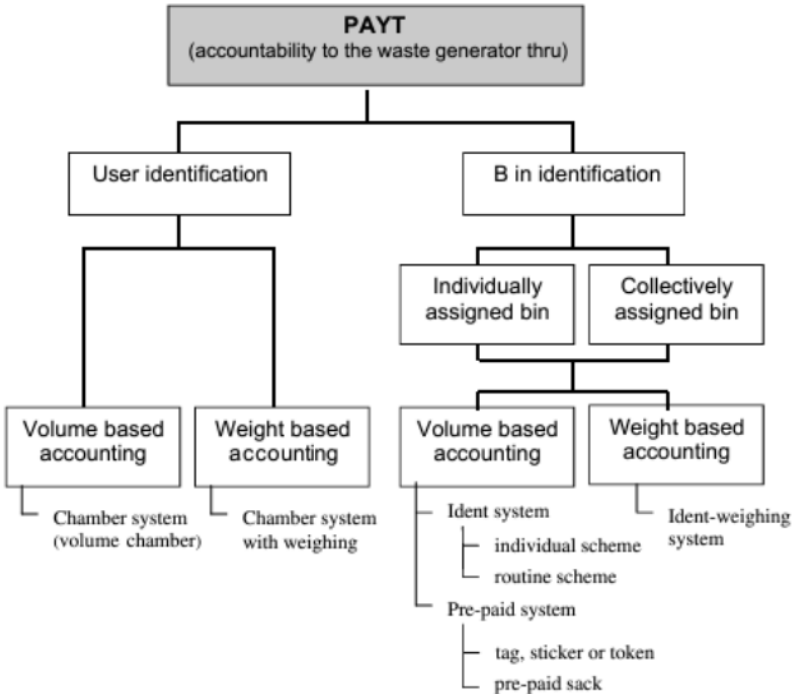
- Policy and governance shortcomings include a lack of clarity in national and local policies, a low budget, and low resources. This makes it impossible to generate a good incentive system around proper waste management.

This leads to an inefficient system with low recycling rates and a high percentage of recyclable materials ending the landfills that already reached their capacity. In the following sections, the strategies will be explained.

2.7.1. Pay as You Throw System

This is a worldwide-known system that every year more local governments are incorporating. It is used in some French municipalities, the Netherlands, Belgium, Luxemburg, Austria, etc. It consists of citizens paying waste fees according to the amount of mixed waste they generate and put into the waste management system, as well as other public services, like gas, water, or electricity. Figure 7 shows an illustrative diagram of some of the alternatives for the implementation of this system. It can be implemented in different formats: volume, sack, weight, or frequency-based schemes, and also some of these can be mixed. The system can likewise focus on charging fees not only for residual waste but also for separated streams (European Commission, n.d.).

Figure 7 *Some alternatives for implementation of PAYT*



Source: (Reichenbach, 2008)

If citizens fail to pay their taxes, the fixed fee for collecting waste will increase. Furthermore, recycling is free, but citizens must pay an additional fee (which is included in the cost of the bag) for the solid waste that is eventually rejected and taken to the incinerator facility (Sánchez-Muñoz et al., 2019). The European Commission mentioned that:

> In a well-functioning PAYT system, waste fees to users are based on a fixed plus variable fee component, to reflect the cost structure of waste management and align incentives for users (i.e. lower fee when less waste is produced) and waste collectors (i.e. revenue stability from the fixed fee component). (n.d.)

The European Commission (n.d.) identified 4 key success elements for this program, it is necessary to be able to identify users individually and to have a user-level measurement. This

should be done from the time of garbage collection. The establishment of a consistent charging rate that is realistic and drives change. Finally, the involvement of citizens so that they understand the characteristics of the system and are committed to it. Regardless of where the system is adopted or what format is used, it is key that the municipality has a user-friendly collection infrastructure that is aligned to the model and effective.

Romano & Masserini conducted a study in Italian municipalities to test the effectiveness of this system application in decreasing waste generation and boosting separate waste collection in terms of quantity and quality. They concluded that

> Municipalities that adopted PAYTT show a higher separate collection rate than others, with an average difference of 10%. This means that through PAYTT, municipalities are better able to encourage citizens to separate source household waste, thanks to the economic incentive linked to tariff reduction. Moreover, separate collection of individual waste fractions is seen as a precondition for fostering high-quality recycling and increased recycling rates (2023).

An example of some of the innovations that have been made in favor of smart waste metering. The Suez group in France launched an electronic chip in the waste container given to each household. As soon as the chip makes contact with the waste collector, the household knows the exact amount of waste it has deposited, thanks to a phone application. This is intended to develop awareness in the inhabitants so that they can become aware of their progress or setbacks in waste generation (Canas, 2023).

While this system is highly effective in reducing the amount of waste generated by households, it is recommended that it be combined with other strategies, such as having specific organic waste collections. But it also has its limitations, it can be costly to implement, it needs a

lot of support from local governments, both in terms of funding and awareness campaigns. Citizens, in fear of being charged more, could end up throwing away part of their garbage in the streets, parks, or public spaces.

2.7.2. Pfand System – Bottle Return System in Germany.

This system was introduced in Germany in the 2000s, one of the world's leading countries in terms of recycling. According to Kwon et al., (2023), the plastic recycling rate of PET (polyethylene terephthalate) bottles is 97,4%. The Pfand system (also known as DPG (Deutsche Pfandsystem GmbH)) functions as follows, every time a user buys a bottle, whether a glass, plastic or aluminum can, he/she must pay a deposit (Pfand). This varies between 8 and 25 cents. It is returned to the users when they return the empty containers to the *Pfandautomat* (bottle return machines) for recycling or reusing.

The DPG system aims to reduce single-use disposables, and waste and promote recycling. It was launched with the slogan: *less waste, fewer disposable.* It was quite a visionary project at the time. For example, in Colombia until this year (2024) the first phase of Law 2232 of 2022 was implemented, through which the progressive elimination of single-use plastics is sought. In this case, Germany is more than 20 years ahead of the country in this area.

It is important to clarify that not all bottle types are part of the *pfand* system. Therefore, specific symbols were invented to identify them, as can be seen in Figure 8. Usually, the bottles

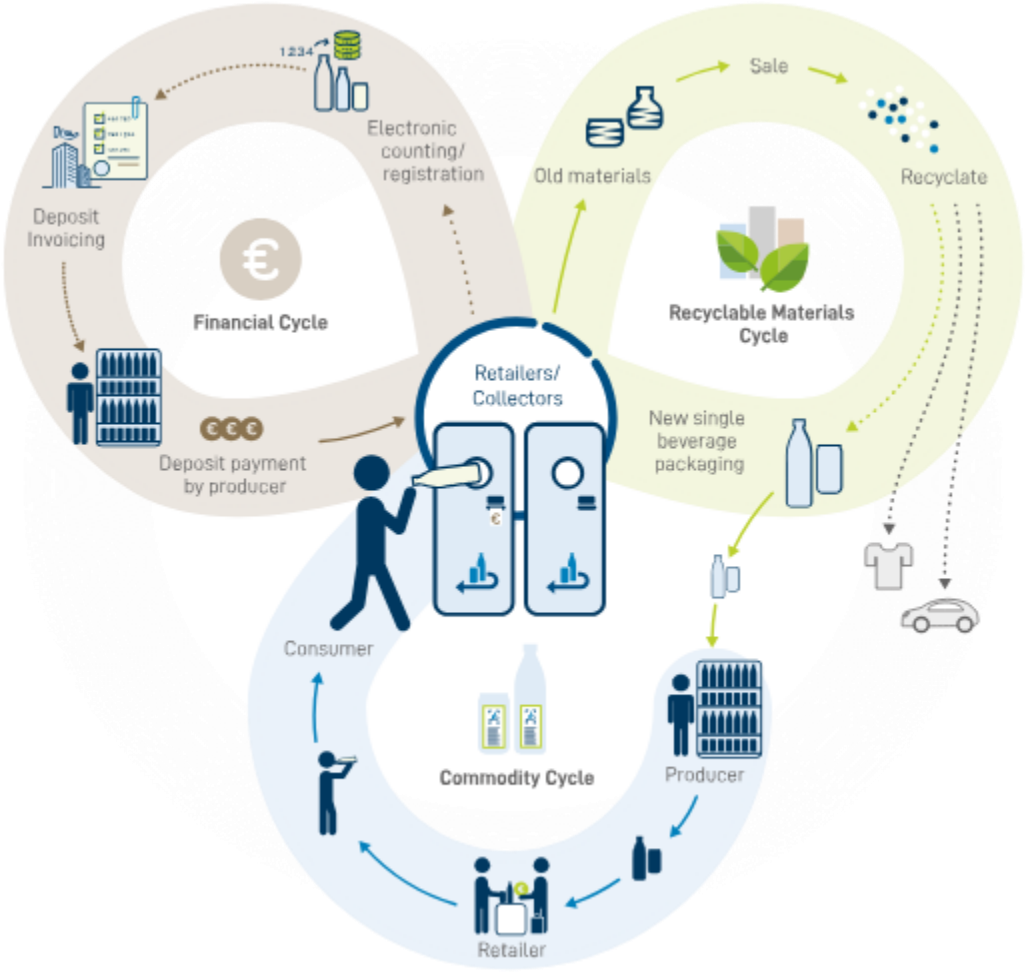
that fall into this system are beer bottles, aluminum cans, single-use and multiple-use plastic bottles, Landliebe yogurt containers, and some wine bottles. Each has a different disposal value (Bouliane, 2024).

Figure 8 *Pfand symbols for recognizing bottles that have a deposit*

Source (Bouliane, 2024)

One of the successful factors of the Pfand program is the classification of containers according to their type: single-use (Einweg) or multiple-use (Mehrweg). Each category must be deposited in a specific container designed for that purpose. The bottles must be returned in good condition: not crushed, broken or damaged, and with their labels. Collection points, known as "Pfandautomaten", are conveniently located in most supermarkets, making it easy for consumers to participate in this efficient and sustainable recycling system. Figure 9 illustrates the containers, how the system works, and its alignment with the circular economy initiative of the EU (*Pfand in Germany – A Guide to the Bottle Return System*, 2024).

Figure 9 *The DPG deposit process*



Source: (*DPG Deutsche Pfandsystem GmbH - The DPG Deposit Process*, 2024)

The trajectory of this policy demonstrates both temporal and strategic consistency, where one can perceive slight changes. Still, the essence of the strategy remains, where robustness is established in the sense of accurate communication to the public, clarity in information to generate simple actions that the population can adapt in daily life. In addition to the above, the Pfand system has lasted for more than two decades, which allows development with greater experience and understanding of the field in which it operates.

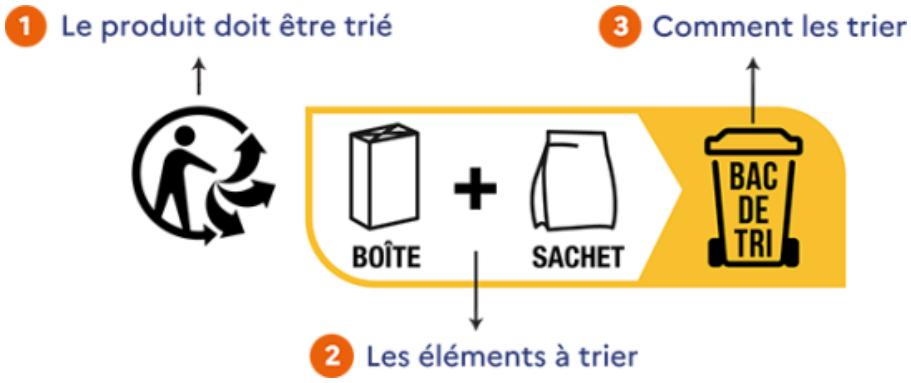
2.7.3. Use of a graphical helps, the Triman-logo – Example of France

This strategy is based on the use of a logo that is the Triman, which indicates that this product is recycled, if it does not appear it is because the product should go in the ordinary trash. Next to the Triman, there will be a graphic guide (Info-Tri logos) for the user on how to dispose of each of the parts of the product that has just been consumed. In this way, the constant doubt of citizens as to whether this material should go in the recycling container or not is resolved, and a better waste separation process is ensured.

The French Decree No. 2014-1577 aims to promote the recycling of consumer products among citizens through the Triman and Info-Tri logos. Since 2022, this standard has been implemented for most of the products marketed in the country. In alignment with *La responsabilité élargie des producteurs* (REP), in English Extended Producer Responsibility. ADEME, explains this concept,

> The aim of the Extended Producer Responsibility (EPR) scheme is to act on the entire life cycle of products, to build a more sustainable economy. In particular, it focuses on product eco-design, waste prevention, extended useful life (through reuse and repair), and end-of-life management. It implies that each economic player is responsible for the entire life cycle of the products it puts on the market, in accordance with the polluter-pays principle. (2022)

Figure 10 shows an example of these graphic resources, firstly the Triman logo, which indicates that the product should be recycled. In step two, the elements of the product are shown. In step three, where these elements should be deposited. In the case of this example, it is in the yellow container, where cardboard, paper, and plastic go.



Note: translation of the image

1. The product must be sorted
2. Items to be sorted
3. How to sort them

Source : (*Avec l'Info-tri, trier devient plus simple | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l'Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine*, 2024)

2.7.4. Separate containers for glass recycling.

Currently, at least 15 of the 27 European Union countries use separate containers for glass recycling. In the case of Colombia, for example, glass is placed in the same bag with cardboard,

metal, and plastic. However, this is not very efficient in using glass, since this material can be recycled infinitely. Being mixed with these other elements, in addition to making the separation more tedious, can also cause it to be contaminated or its quality to be compromised, which subsequently makes the recycling process more complicated (Hsieh & Tsai, 2023).

The recyclability of glass is perfectly aligned with the European Green Deal program and the new circular economy plan. It also fits the new WM model, the hierarchy of waste. By having specific containers for this material, the recovery and treatment of glass becomes much simpler besides having the advantage that it is a material that is recycled in the same production system without suffering any alteration at the chemical or physical properties level.

Considering the broad application of this strategy, this project will focus on one country, France. Which, according to Messad (2023) has a recycling rate of 85% for glass. However, it is important to clarify that the operation of this strategy is the same for almost all countries. People must drop off their glass containers at specific collection points. These are located throughout the city, for example in Paris, there is a website where people can search for the nearest container to their residence. Once they reach it, they can see which types of containers are allowed to be deposited there, thanks to an illustration. An example of this is shown in Figure 10.

Figure 10 *Example of a dedicated container for glass containers in Villejuif, France.*

Source: photograph taken by the author of the document.

3. Methodology

3.1.Hypothesis and variables

The hypotheses of this degree work were formulated thanks to the collection of previous information. The first hypothesis (H1) is based on analyzing the current situation in Bogota regarding household waste management and its main challenges. And the second one (H2), with the review of successful strategies implemented in other contexts, particularly in the European Union. Both seek to identify the key factors that influence the low recycling rates in Bogota and explore possible solutions inspired by international practices.

The verification or refutation of H1 and H2 will be carried out through an empirical study, a survey of a representative sample of Bogota households. The results obtained will serve to evaluate the validity of the hypotheses and will provide valuable information to make recommendations on possible strategies that can be included in the waste management plan in the Colombian capital. The following chart provides the hypothesis with its variables.

Table 1 *Hypothesis and variables of the study*

Hypothesis	Independent Variable(s)	Dependent variable(s)
H1: The lack of a clear understanding or knowledge of waste separation systems among Bogota's households is the main	• The understanding of waste separation systems among Bogota's households	• Recycling rates in Bogota.

factor contributing to the city's low recycling rates.		
H2: The implementation of a combination of EU-inspired strategies such as: having separate containers for glass recycling, the use of illustrations about how the product must be recycled, a bottle return system similar to Germany's *Pfand* system, and the pay-as-you-throw system would significantly increase recycling rates and improve overall household waste management in Bogota.	• Separate containers for glass recycling. • Use of illustrations as a guide for recycling the product. • The bottle return system is similar to Germany's *Pfand* system. • Pay-as-you-throw system.	• Recycling rates in Bogota.

Source: own elaboration.

3.2.Research Design

This graduating project aims to identify how implementing European strategies related to household waste management can improve the recycling rate among Bogota citizens. To achieve

this, exploratory research was carried out. Taking into account that there are very few studies on this topic. It is important to clarify that at the research level, there are several articles on the environmental emergency of the landfill, the social implications of the landfill, and how the waste from the landfill could be used. Comparative studies on household waste management systems have also been conducted between Colombia and other countries. However, no papers were found that specifically discussed the impact of the application of strategies used in EU countries.

This type of research allows the gathering of preliminary information that will allow to identify insights for future research. For this specific case, for example, if the validity of the stages is demonstrated, papers could be developed focusing on the implementation of each of the strategies and their local impact, level of acceptance, and measure of results.

A mixed methodology of primary and secondary sources will be used. As a primary source – data collected from the data source-, a quantitative survey is going to be carried out. To measure and analyze the relationship between the dependent and independent variables.

As a secondary source, academic articles, reports, conventions, conventions, webpages, and other sources were used to learn about recycling strategies in EU countries such as France, Germany, and the Netherlands in particular. This information was condensed in the literature review and will be used again to conclude, once the survey data is obtained.

Regarding the dimension of the research design in terms of time horizon, this is a cross-sectional study. The data will be collected at one simple point in time, providing a snapshot of the current understanding of waste separation systems among households and their attitudes towards proposed recycling strategies.

3.3.Research Question

How can household waste management strategies from European Union countries be adopted and implemented effectively in Bogota D.C, Colombia, to improve recycling rates and mitigate the negative impact of solid waste on the environment?

3.4.Data collection

For data collection, a structured survey will be conducted with 13 mandatory questions and 3 additional questions that vary according to the participants' answers. Some of the question formats that are going to be used are multiple-choice, dichotomous, rating scale, and demographic questions. The survey will be conducted online and only for people who reside and have a home in Bogota.

3.4.1. Survey.

The survey was conducted in Spanish (Appendix A) since it is focused only on people living in Bogota, Colombia, where the official language is Spanish. Considering the above, for analysis purposes, later in this section we will translate each of the parts and questions of the survey.

Divided into 5 sections:

Section 1: Personal data processing policy. As soon as the participants open the survey, they will find the following paragraph on the protection of personal data and the use that will be given to them for academic purposes.

In Spanish (original version):

En conformidad con la expedición de la ley estatutaria 1581 de dos mil doce (2012) por la "cual se dictan disposiciones generales para la protección de datos personales" y el Decreto reglamentario número 1377 de dos mil trece (2013) por el "cual se reglamenta parcialmente la ley 1581 de dos mil doce (2012)", autorizo a emplear y tratar para fines estadísticos de análisis y de registro. Los datos recolectados en esta encuesta se mantendrán confidenciales y unicamente se usarán con fines académicos, con el objetivo de realizar un estudio de mercado sobre el nivel de reciclaje en los hogares bogotanos.
De antemano, ¡gracias por participar!

Traduction in english

Under the issuance of statutory law 1581 of two thousand twelve (2012) "which dictates general provisions for the protection of personal data" and the regulatory Decree number 1377 of two thousand thirteen (2013) "which partially regulates the law 1581 of two thousand and twelve (2012)", I authorize to use and treat for statistical purposes of analysis and registration. The data

collected in this survey will be kept confidential and will only be used for academic purposes, to conduct a market study on the level of recycling in Bogota households.

Thank you in advance for your participation!

Subsequently, people are asked “Do you agree with the personal data policy?” with a yes-no answer. If the person answers no, the form is automatically sent.

The second question in this part is: Do you live in Bogota? Also, there is a possibility of a yes-no answer, and if the person answers no, the form is automatically sent. This question would prove that the survey is conducted just with people who are currently living in Bogota.

Section 2: Demographic information. This section contains two questions: What gender do you identify with? with the following response options: Female, Male, Other, I prefer not to say. How old are you? It is an open question that only accepts numerical values.

Section 3: Knowledge about waste separation and *Section 4:* Color Code for Waste Separation. Both sections seek to know the level of knowledge or understanding among the citizens of Bogota regarding the waste separation policies applied in the city. Also, the main obstacles to recycling.

Section 5: Application of European Union strategies to improve waste separation in Bogota's households. Focus on asking how viable they see the implementation of the waste management strategies used in EU countries to improve their knowledge and intention to correctly separate waste. And therefore, the recycling rate of the city. To better understand the proposed strategies, images were included in the questions regarding the *triman* logo and glass containers.

In the table of Appendix B*, the Survey questions and the hypothesis they are addressing* show each of the questions in the original language, their translation, and to which hypothesis, H1 or H2 they are related.

3.4.2. Description of the sample

Population: Colombian people of all ages, genders, and races living in the city of Bogotá. According to the last census conducted by the DANE (National Administrative Department of Statistics, for its acronym in Spanish) in 2018, there were 7,412,566 inhabitants in the city. Regarding the housing distribution of this population, 2,514,482 private households were censused, and 46.7% of these are occupied by two or three people. (DANE, 2018)

Sample: The survey was diffused through social networks in order to have the highest possible visibility. One of the limitations is that it could not be distributed in mass consumption platforms such as newspapers or mayoral websites due to a lack of resources, which made it impossible to reach the entire population.

Therefore 220 persons answered the questionnaire, where, 11 people did not accept the personal data treatment policy and 15 responded that they do not live in Bogota. Therefore, the sample for this study is 196 inhabitants of the city of Bogota.

Comparing the population with the sample, the sample may not be very representative. However, it is important to clarify that the scope of the study is to give recommendations on

strategies that can be implemented in the capital to improve waste management, but not to ask whether one agrees or disagrees with an already elaborated draft law on the subject.For the latter, it is necessary to have a census of almost the entire population. Also, this sample allows to identify some behavioural patterns for the population.

Additionally, it was a completely random sampling, which makes the data organic and there is no bias in the answers. Neither was a socioeconomic division made in the data collection or filtering of the data since this work does not seek to deepen the relationship that exists in the willingness to recycle according to the level of household income. Previous studies have already proven this relationship, and in Bogota, a whole work could be done around this topic. Also, waste collection in the city is not done by localities, but 5 companies are in charge of this process. A single company can easily cover up to 8 localities (Ramírez, 2018). For this reason, the sample was not delimited according to the geographic location of the place.

Considering the above, the sample of 196 is representative of the purpose of this degree work, which is a preliminary study on the current panorama of citizens regarding their sustainable practices related to recycling. It also allows the identification of specific trends and patterns on the likelihood of implementing strategies from other countries to improve these practices.

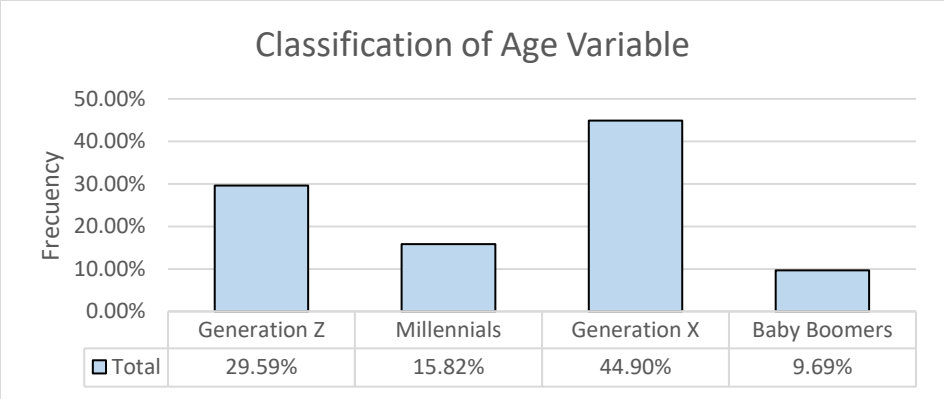
3.4.3. Data Analysis

Once the responses were collected, the database was cleaned. Respondents who did not accept the data processing policy and those who did not live in Bogotá were removed. Regarding the first section of the survey, demographic data. It was obtained that 69,4% of the sample identify as women, followed by 30,6% men and 0% for the other categories (other, prefer not to say). On the other hand, the average age was 40,91 years, with a minimum value of 17 years and a maximum of 85 years, the mode (the most repeated data) was 22 years, with 22 responses for this value.

Taking into account the above and considering the generational table proposed by Brunjes, (2019) the following division was made for the age variable:

- 17-25 years: Generation Z
- 26-41 years: Millennials
- 42-57 years: Generation X
- 58 years and more: Baby Boomers

Figure 11 *Generational Classification and relevance for the Age variable*



Source: own elaboration

Excel was used to generate graphs and simple statistical analyses to perform data analysis. Google Forms were also useful for performing the frequency analysis, which allows patterns to be identified. SPSS software was also used to support descriptive and inferential analysis, which allows for an overview of the data.

The first thing that was done in SPSS was the categorization of the variables, as can be seen in Table 2.

- Nominal: also known as categorical, is a variable that has two or more categories but there is no specific order or hierarchy between them. (Chetty, 2015) For example, for gender, there were 4 response options but no intrinsic order between them.
- Ordinal: in this case, the values do have an intrinsic ranking between them. For example, the questions related to the implementation of European Union strategies measure the level of motivation in recycling on a scale of 1 to 5, where higher values mean higher motivation.
- Scale: Numerical values are used but they do not have any level of hierarchy or linkage between them. There is no specific order. For example, age.

Table 2 *Characterization of the variables*

Variable	**Type**	**Measure**
Gender	String	Nominal
Age	Numeric	Scale
Level of knowledge about the waste separation policy in Bogota	Numeric	Ordinal

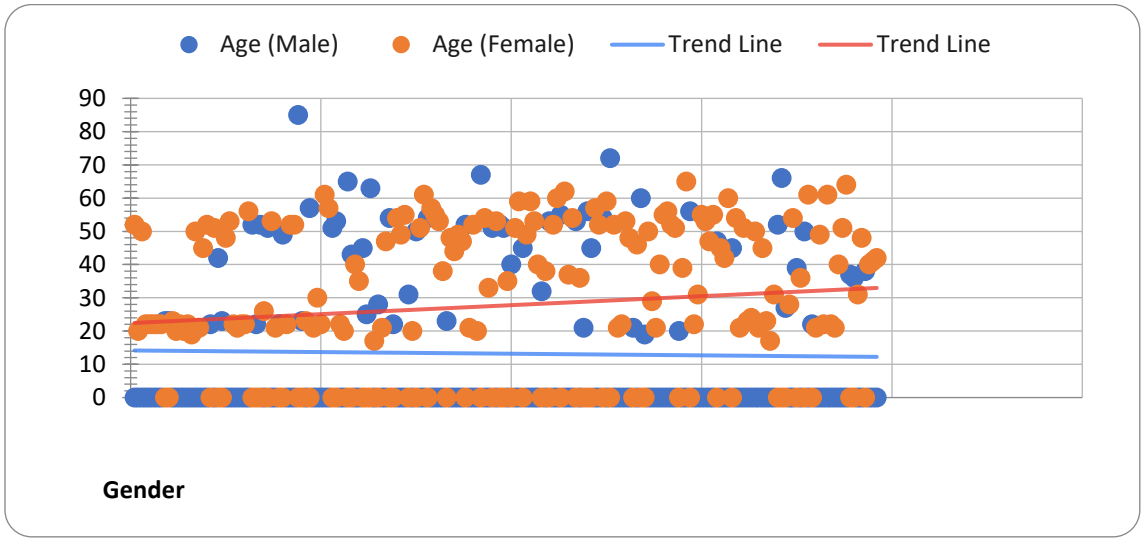
Number of Garbage containers	Numeric	Scale
Frequency of waste sorting	Numeric	Ordinal
Obstacles for recycling	String	Nominal
Knowledge about the colored code for waste separation.	String	Nominal
White bag	String	Nominal
Black bag	String	Nominal
Green bag	String	Nominal
EU strategy, glass containers	Numeric	Ordinal
EU strategy, Triman logo	Numeric	Ordinal
EU strategy, Pfand system	Numeric	Ordinal
EU strategy, PAYT system	Numeric	Ordinal

Source: Own elaboration

Figure 12 is a scatter plot showing the age distribution by gender; from this, it can be inferred that there is a significant dispersion in the data for men and women concerning age. They cover a wide range of ages between 17 and almost 90 years. But more important than this, the average is around 40 years for both genders which is good as it indicates that the data is not accumulated at specific ages, but that there is a good age distribution for both genders. This allows us to conclude that the survey captured a wide range of ages, representing diversity in the data collected, which is key for statistical analysis. On the other hand, it can also be observed that there is a slight overrepresentation of women.

However, it is important to clarify that, although the survey was randomly distributed. Without any kind of categorization by socioeconomic level, membership of cultural groups, ethnicity, etc., the survey was open to any kind of respondents. Nevertheless, due to the limited resources for dissemination and time constraints, it was not possible to ensure that it effectively reached all types of groups of the population. This represents a probable statistical bias.

Figure 12 *Age Distribution by Gender with Trend Lines*



Source: Own elaboration using Excel

4. Results and analysis

4.1.Descriptive Analysis

Through these analyses, an overview of the findings of the survey will be given. The information will be summarized and interpreted, making connections with the hypotheses. An analysis of mean, mode, and standard deviation was performed for the ordinal variables. These findings and their interpretation can be seen in Table 3. The median and range were not considered since most of these questions used a Likert scale, these values are always the same and do not provide any conclusive result.

Table 3 *Descriptive analysis for ordinal variables*

Variable	Mean	Standard Deviation	Mode	Analysis
Level of knowledge of the waste separation policy in Bogota	3,046	0,9989	3	The value of the mean and the mode (with 44,9% of people answering 3) indicates that respondents perceive a moderate level of knowledge about the separation policy. The standard deviation measures the variation or dispersion of the data to the average. In this case, it is low (since it is less than 1), which indicates that most of the responses are close to the mean, with little dispersion.

Frequency of waste sorting	3,811	1,207	5	37,8% indicate that they always separate their waste, which is the value 5 of the mode. However, the mean value indicates that respondents frequently separate their waste, but not absolutely. In addition, the deviation is high, which indicates that there is greater variability in the responses.
EU strategy, glass container	3,811	1,219	5	The averages of the EU strategies are between 3,81 and 4,342; indicating that respondents have a positive attitude towards the improvement that the implementation of these measures could represent in the recycling rate and their household waste management practices, which supports the H2 (The implementation of a combination of EU-inspired strategies such as: having separate containers for glass recycling, the use of illustrations about how the product must be recycled, a bottle return system similar to Germany's *Pfand* system, and the pay-as-you-throw system would significantly increase recycling rates and improve overall household waste management in Bogota). Adding to this, the mode of all these variables is 5, again demonstrating the acceptance level. However, only the triman logo strategy presents a low dispersion in
EU strategy, Triman logo	4,342	0,917	5	
EU strategy, Pfand system	3,934	1,062	5	
EU strategy, PAYT system	3,857	1,132	5	

the data. For the others, these standard deviation values suggest different levels of acceptance. Finally, the strategy with the best results is the triman logo, having the highest average but also the lowest variability.

Source: Own elaboration with SPSS calculations.

There were 6 questions in the survey that did not have a Likert answer but were yes or no questions or multiple choice. Therefore, for analysis, frequencies and percentages will be calculated.

Regarding the question How many bin containers are used at your home? More than half of people (53,1%) use two containers to separate their waste, which can refer to the basic separation of household waste, recyclable and non-recyclable. The second highest percentage of the population, 32,7%, uses three containers, a number that corresponds to that stipulated by the Color Code for Waste Separation at the National Level.

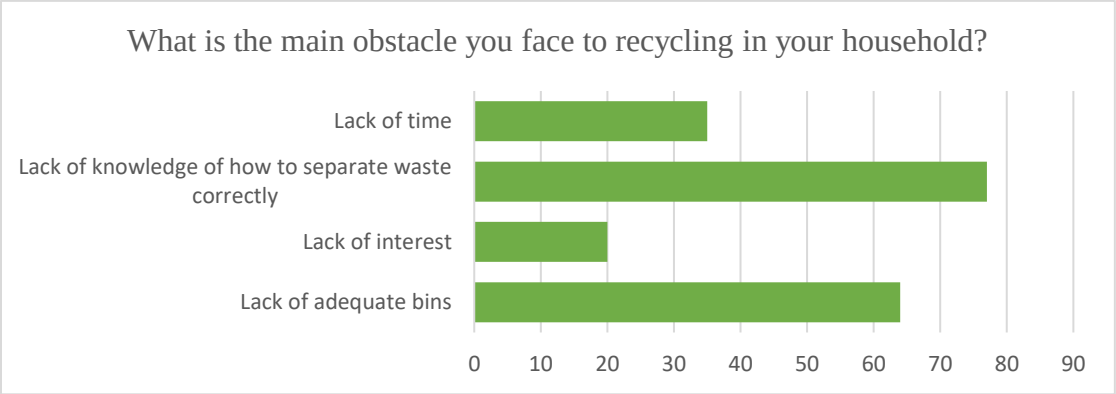
> Intending to promote citizen culture regarding waste separation throughout the country, and take into account the experiences and progress of some cities in the country such as Bogotá, Bucaramanga, or Pereira, Minambiente issued Resolution No. 2184 of 2019, through which the white, black, and green color code for the separation of waste at source will begin to apply in 2021. (Minambiente, 2019)

10,2% of the respondents use only one container, which means that no recycling or waste separation action is carried out in these people's households. This is alarming, given that it contributes to the city's low recycling rate. In addition, on a macro level, it generates pollution of

the air, soil, water, etc. And, in general, it contributes to the increase of our negative environmental footprint on the planet. Finally, 4.1% use 4 containers, probably this fraction is following the GTC-24 standard, which guided the sorting process before 2021.

Although 89,9% of respondents sort their waste, only 32,7% do so correctly and follow national guidelines. However, the question here is why this percentage is so low. The literature review identified some key problems that lead to bad household waste management in Bogota: Lack of knowledge of how to separate waste correctly, Lack of adequate containers, Lack of time, and Lack of interest. These were used as response options to the question: What is the main obstacle you face when recycling at home?

Figure 13 *Survey Question What is the main obstacle you face to recycling in your household? Results*



Source: own elaboration using Excel.

Figure 12 shows that the main obstacle described by respondents is the lack of knowledge of how to correctly separate waste, represented by 39.3%. This aligns with the fact that more than the majority of the sample, 59.2% expressed not knowing the Color Code for Waste Separation at the national level (the official and most important document regarding this topic). The above

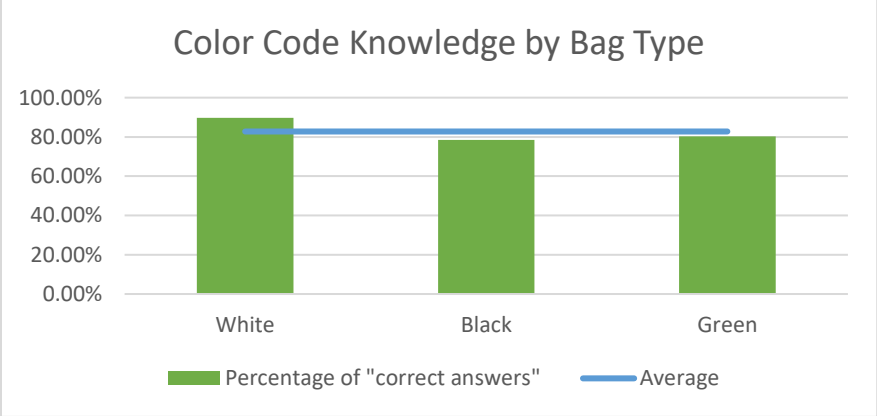
supports H1 (The lack of a clear understanding or knowledge of waste separation systems among Bogota's households is the main factor contributing to the city's low recycling rates). This result underlines that the central problem lies in insufficient environmental education. The second most representative value, with 32.7%, refers to the lack of adequate bins, which is related to one of the main problems with household waste management in Bogota described in the literature review: the lack of infrastructure. To address both challenges, it is necessary to make improvements at both the individual and institutional levels.

On the other hand, the third most recurrent obstacle among the respondents is lack of time with 17,9%. And with 10,2% there is a lack of interest. These last two are aligned with more intrinsic motivations. Although this percentage is lower, it is still of concern as there is still a segment of the population that does not perceive waste separation as an essential practice to mitigate the city's environmental crisis. This finding suggests that current communication and education initiatives may not effectively reach all population segments. These practices have failed to become part of household routines. Demonstrating the importance of innovating in the strategies used to disseminate this information.

Regarding section 4 of the survey on knowledge of the color code for waste separation, 59,2% stated that they are aware of this system. However, to test this information, 3 questions were asked about the type of waste that should go in each bag, with one correct answer. In general, the results were positive, with percentages of assertiveness above 78% for the three questions. The bag that generated the most confusion among the respondents was the black bag, where non-organic waste should go. On the other hand, the best understood was the white bag, which contains usable waste.

Figure 13 shows in the columns the percentage that correctly answered the type of waste that should go in each bag: In addition, the blue line represents the overall average knowledge, which is 82,8%. This indicates a good level in general, but there are opportunities for improvement. Starting with 1) increasing the percentage of people who know the code and 2) for those who say they know the code; the answers should be much closer to 100% or even 100%. Since this is the only way to ensure that a good separation process is being carried out at home and therefore the recycling rate can be increased.

Figure 14 *Color Code Knowledge by Bag Type*



Source: Own elaboration using Excel.

4.2.Inferential Analysis

4.2.1. Spearman correlation

A Spearman correlation analysis was performed in SPSS (results in Table X) in order to measure the strength and direction of the relationship between the variables, knowledge of the study separation system, and the frequency of separation. This statistical measure was used since both variables are of ordinal category, a normal distribution of the data cannot be assumed, and the relationship of the data is not strictly linear. This coefficient varies between -1 and 1, where -1 indicates a strong negative relationship, 0 is no relationship and 1 is a strong positive relationship.

Table 4 *Spearman's Correlation between Variables*

Variables	Correlation coefficient (ρ)	p Value	N
Knowledge of the waste separation policy in Bogota Frequency of waste sorting	0,448	<0,01	196
Knowledge of the waste separation policy in Bogota Number of bin containers used at home for waste separation	0,369	<0,01	196
Number of bin containers used at home for waste separation Frequency of waste sorting	0,521	<0,01	196

Source: own elaboration using SPSS software

Regarding the results of the relationship between Knowledge of the waste separation policy in Bogota and the Frequency of waste sorting, it can be concluded that the ρ value is 0,448.

Which indicates a moderate positive correlation. This means that the greater the knowledge, the greater the tendency to separate waste more frequently. In summary, this information supports H1, since it suggests that the lack of knowledge may be an important factor in the low recycling rates in Bogota if we assume that the greater the knowledge, the greater the separation and, therefore, the better the recycling.

Analyzing the 0,369 indicates that there is a slight to moderate positive correlation, which implies that there is a slight tendency for people who have more knowledge about the waste separation system to use more garbage containers in their homes for recycling.

On the other hand, the strongest relationship is between the number of containers and the frequency of sorting with 0,521, this implies that the more containers there are in the home, the better the waste separation. This suggests the importance of proper infrastructure as a factor in encouraging recycling.

For the three cases the p-value <0,01 indicates that the correlation is statistically significant. And the N refers to the number of cases, which is 196 since it corresponds to the number of valid responses. And although all the correlations are positive, none is very strong, this hints that other factors also influence the city's low recycling rate and poor waste management in households.

4.2.2. T-test of a sample

This statistical test determines if the population means differs significantly from a specific value. In this case, it was 3 because it is the neutral value since we were dealing with scales from 1 to 5. This test was applied in the 4 EU country strategies to assess whether the respondents' perceptions were significantly positive, greater than neutral.

Table 5 *t-test for EU Waste Management Strategies*

Strategies	t	df	p-value	Mean difference	Cohen's d
Glass Containers	9,313	195	<0,01	0,811	0,665
Triman logo	20,478	195	<0,01	1,342	1,463
Pfand system	12,302	195	<0,01	0,934	0,879
PAYT system	10,598	195	<0,01	0,857	0,757

Source. Own elaboration using SPSS

Considering the information on the table. df: refers to the degrees of freedom, the formula is n-1, where n=196, which is the sample size. P-value is used as a measure of the strength of the evidence of the data, indicating the level of probability of having obtained results by chance. A value of >,001 indicates high statistical significance and that the values are not random. Cohen's d is the measure of the effect size of the difference between two means, while a p-value measures the existence of an effect, and Cohen's d measures how large that effect is. The rule of thumb indicates that a value of 0,2 is a small effect, 0,5 medium effect, and 0,8 is a large effect (Statistics how to, 2024).

Therefore, all t-values are positive and large, suggesting that the sample means are significantly above the test value, 3. Additionally, the strategies are close to or greater than the

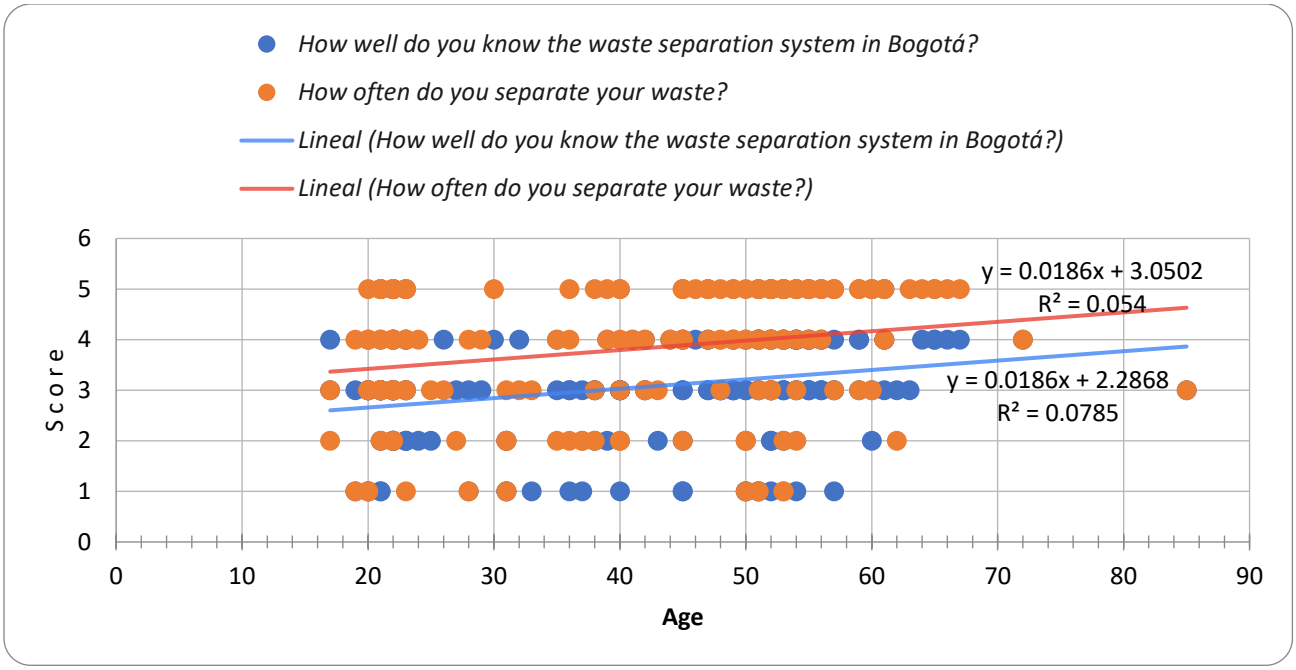
0,8 Cohen's d value, indicating that they have a large effect size and that all 4 proposals would have a significant impact on recycling practices. The positive perception of the respondents regarding the implementation of these strategies is not only significant but also relevant.

The triman logo is the most promising strategy as it has the highest significance value, being 1,463. The participants believe that this idea will be particularly effective. It is followed by the Pfand system. On the other hand, the PAYT system has the least impact among the 4 options but is still in the medium to a large range. In summary, the results of this t-test provide strong support for hypothesis 2 of this paper, as they indicate that the implementation of the 4 EU recycling strategies would significantly improve the recycling rate in Bogota.

4.2.3. Lineal regression

Figure 15 shows a scatter plot along with its linear regression lines. It contrasts an independent variable, age vs. two dependent variables which are the lack of knowledge of the waste separation system in Bogota and the frequency of waste sorting.

Figure 15 Relationship between Age, Level of Knowledge of Waste Separation System, and Frequency of Waste Sorting in Bogota



Source: own elaboration.

It can be concluded from the blue line, having a slightly positive slope, is an indicator that as people's age increases their knowledge about waste separation also increases slightly, a baseline knowledge is located at 2,29. On the other hand, the value of R, as it is low, implies that it does not represent a strong correlation between age and knowledge, although there is a slight 7,8% change in recycling knowledge with increasing age. In the case of the orange line that refers to the frequency of separation, the slope is also positive and with a base of 3,05. Taking into account that 1 is never doing garbage separation and 5 always does it, it can be said that the majority of respondents perform at least moderate garbage separation. There is a large scatter of points around both lines which reinforces that there is not a very strong relationship between the independent and dependent variables. Therefore, other factors are more likely to influence these variables.

5. Conclusions

5.1.Current scenario

The waste management system in Colombia is still very unsustainable. Although the National Development Plan 2022-2026 proposes the creation of a Zero Waste program, the reality is far from this objective. This development plan seeks to orient the system towards a circular economy model, such as the one used in the European Union and several countries around the world. However, the current 7-phase recycling model (generation, retrieval, collection and transport, storage, pre-transformation, transformation, and reuse) is completely misaligned with this idea. Therefore, a restructuring of this model is necessary, taking as inspiration the EU waste hierarchy. Which seeks to reduce waste generation as much as possible, and then reuse, recycle, recover, and as a last and least desirable option, discard.

It is clear that there is a lack of recycling culture among the residents of Bogota, which translates into poor household waste management. Through the implementation of the EU country strategies described in this paper, this problem can be addressed and the willingness to recycle can be increased.

The public sector must implement and promote a policy of extended producer responsibility. The proposed strategies should not only focus on the inhabitants but also require companies to use less polluting production methods. With a much more innovative and far-reaching vision. Since it must be recognized that this has already begun to be done, for example, in the law that

regulates and prohibits single-use plastic packaging. The problem with this is that this type of legislation has already been incorporated in other countries for several years or even decades.

To achieve an improvement in the waste management system not only in Bogota but also in the country, it is necessary that policymakers promote strategies that last over time. Constantly changing the color code for waste sorting generates a lot of confusion among the inhabitants. Even if they intend to recycle, the main obstacle is the lack of clarity and knowledge regarding the national guidelines.

Institutional entities should strive to improve the information available on the recycling policies that are in place in the city and country. First, it was very difficult to find official documents that explained in detail how the policies work. Second, these documents were excessively long and did not really address their target audience, Colombians or the inhabitants of Bogota. The message is not clear and straightforward. This explains the high level of confusion in people's minds.

5.2.Main Challenges

There is no official data on the city's recycling rate, nor its measurement year after year to analyze its progress or setback. In order to measure the impact of these recommendations or existing policies in general, it is necessary to collect information on the recycling rate and related

data, including it in the annual reports of results at both national and local levels. This is the only way to measure progress and whether or not the strategies are effective.

The State continues to fail to prioritize sustainability, as evidenced by the low budget received by the Ministry of the Environment. This makes it impossible to implement projects that promote circularity in the economy. In addition, the lack of adequate infrastructure for waste separation is also an obstacle.

In fact, the State should provide waste garbage cans to households to solve one of the problems identified: the lack of resources to buy bins and garbage bags. This is related to the fact that a part of the population does not have sufficient resources to purchase those items. In this way, a standardization model could also be put in place that would adapt the collection trucks to lift and collect the same type of garbage cans, which would save time and resources.

5.3.Factors that contribute to a low recycling rate

The results of the survey support what was stated in hypothesis 1, so it can be concluded that the main factor contributing to the low recycling rates in Bogotá is the lack of information or knowledge about the waste separation policy. However, other relevant factors must also be considered in order to achieve a comprehensive and lasting solution to the waste management problem. These include a lack of infrastructure and a lack of interest.

To address these challenges, it is necessary to improve environmental education and awareness at the individual level. This is achieved through institutional actions related to infrastructure improvement, policy clarity, and reformulation of current communication initiatives. This is necessary, as such initiatives do not reach all segments of the population. In this way, obstacles related to intrinsic motivations could also be overcome.

5.4.Recommendation to implement EU strategies to improve Bogota's recycling rate

According to the survey results, hypothesis 2 was validated, and the inhabitants of Bogota consider that implementing these strategies (use of exclusive containers for glass, triman logo, Pfand system, and PAYT) could improve their behaviors around waste separation at home.

It is also important that there is consistency in implementation. Citizens need to understand the why behind each strategy and the impact of their actions. This can be achieved through eye-catching and impactful marketing campaigns. Changing a bit the current scope appeals much more to the massification and use of a very generic and boring promotion. One way to achieve this is to gradually implement the strategies, starting with the one with the highest acceptance, in this case, the French triman logo, followed by the *pfand*, then the glass containers, and finally the PAYT.

Each of the strategies must be adapted to the local context of Bogota in order to maximize their effectiveness. Aligned with the implementation of these campaigns should be a multifaceted

approach that also addresses education, infrastructure, and the drafting of clear and consistent policies.

6. Recommendations & Future Approaches

While it is essential to recommend local campaigns to reduce waste generation to tackle the solid waste management environmental crisis in Bogotá, the rest of the city's recycling chain should not be neglected. It is of no use for the inhabitants to change their behavior patterns if, for example, the companies in charge of waste collection do not have good management of their operations. This degree project offers some frameworks for this first step, which, in order to be effective, must be applied across the board with the support of the public and private spheres.

At the governmental level, it is necessary that the city mayor's office, the Ministry of Environment, congressmen, etc., start to truly prioritize sustainability in their proposals and policies. And yes, although many of these already talk about green projects or initiatives aligned with the Sustainable Development Goals, most of them remain on paper. When an in-depth analysis is carried out, very little of what was described has been put into practice. This is the case of Doña Juana Landfill. It was originally planned as a short-term project, which would later become a green space. But today it continues to receive tons of waste every day. Without real pressure from this axis of power, there will be no results that will last and be adopted by the majority of the population.

At the business level, companies also have a key role to play as leaders and agents of change. They must take responsibility for their environmental footprint and strike a balance between social, profit, and environment. For example, if they use LCA analysis and guidelines such as the triman logo in the creation of their products, they will contribute significantly to the improvement of recycling, not only in Bogotá but throughout the country.

If it is decided to implement the strategies described in this graduating project, it is necessary to conduct a more in-depth study to gather information on cultural and social factors, especially on citizens' motivations for adopting policies such as these. For example, if it is identified that the inhabitants comply better with the rules when there is a reward or punishment system in place. Each of the initiatives can be tailored to have such a component.

In link to what was mentioned before, a cost-benefit analysis can be carried out, in which the economic feasibility of implementing these strategies in Bogota is investigated. From the idea approach, the adaptation process, and the testing; to the implementation and maintenance over time.

In addition, this degree work can serve as an inspiration for future research on the adoption of policies that have been effective in other countries to improve the other links in the waste management chain in the city. In this way, a much more effective and far-reaching proposal that includes all the actors involved in this process could be achieved, especially for the two mentioned above.

Studies that prove a relation between the socioeconomic level of the people with the level of recycling were cited in this paper. In which a positive correlation between the variables is described, the higher the income level, the better the level of recycling. This is an issue that could also be analyzed in Bogota and that complements very well the findings of this paper. It serves as a tool to understand the social context and motivations to recycle or not. With these insights, a better adaptation of the proposed strategies of EU countries could be made, to tackle all the population of the city. And thus, achieve highly effective communication campaigns.

Considering the lack of an official city recycling rate. It is necessary to carry out a statistical study that involves collecting data on the three axes: institutional, business, and population. In this way, annual reports can be generated on the improvement or detriment of recycling in the city, with detailed and updated data. These reports can be shared with citizens so that they can become involved and understand better the problem.

7. Limitations and Assumptions

It is important to clarify that this degree work does not seek to impose or create any type of law or decree for waste management policy in Bogota or Colombia. However, a study was conducted on the feasibility of the application of EU strategies to improve recycling levels among the citizens of the city.

Taking into account the above and considering the findings, the sample of the population used considers that the application of these 4 selected and described strategies could improve their waste sorting patterns. However, a more extensive study with a much larger sample is recommended if it is decided to incorporate these strategies into the current waste management plan. Given that a limitation of this research work was the resources available for disseminating the survey since there was no authorization to use mass media that would truly reach a large part of the population.

In the event that this line of research and the implementation of the modification for the adoption of any or all of these strategies is continued. A possible limitation is the budget to carry out the implementation process. Given that, as described in the literature review, the Ministry of the Environment currently has one of the lowest annual budgets, and this figure is not likely to increase, but rather to be cut.

Another limitation of this work was that although the sampling process was completely random, it is not known for sure if all types of population groups were included. In addition, only residents of Bogota were considered. This could present bias in the case of extrapolating this proposal to a regional or even national level. Future research should attempt to include a larger

geographically and culturally diverse sample. The survey should be conducted to include more demographic questions. In order to analyze other variables such as socioeconomics.

This is a cross-sectional study, in which the data collection is static and is done at a certain moment in time. This implies that it is not possible to analyze how people's behavior and attitudes change over time. A longitudinal study would be very useful in case it is decided to implement these strategies since it would allow measuring the level of commitment on the part of the inhabitants. And the impact on the recycling rate over time.

It is clear that other factors influence waste separation decisions. This assumption explains why the first hypothesis mentions lack of knowledge as the main factor, but not the only one. However, to identify in detail all the factors involved, a more extensive study is needed. Including a qualitative approach with experts in the field in the country to obtain valuable insights. In order to have a much more complex vision and to be able to articulate tactics to solve each of the obstacles identified. In fact, this would also be very valuable for the possible implementation of any of the strategies.

A major obstacle that arose throughout the research process of this work was the lack of information about waste management not only in Bogota but also in Colombia. This represented a limitation in terms of quantity and quality of research. Since many of the sources came from unofficial pages or were outdated information. This represents a limitation in the work as it is impossible to ensure the figures' transparency and traceability. In addition, responses to recycling behavior are based on self-reports, which may be subject to bias. In order to determine the level of recycling at the city level, access to government databases is required.

Regarding the selection of EU strategies, as the group of countries is so large, there may be other relevant strategies that have not been considered and that may also be applicable to the scope of the project.

8. References

ADEME. (2022). *Les filières à Responsabilité Élargie du Producteur | Filières à Responsabilité Élargie du Producteur*. https://filieres-rep.ademe.fr/

Anuardo, R. G., Espuny, M., Costa, A. C. F., & Oliveira, O. J. (2022). Toward a cleaner and more sustainable world: A framework to develop and improve waste management through organizations, governments and academia. *Heliyon*, *8*(4), e09225. https://doi.org/10.1016/j.heliyon.2022.e09225

Avec l'Info-tri, trier devient plus simple | Ministère du Partenariat avec les territoires et de la Décentralisation Ministère de la Transition écologique, de l'Énergie, du Climat et de la Prévention des risques Ministère du Logement et de la Rénovation urbaine. (2024). https://www.ecologie.gouv.fr/info-tri

Batista, M., Goyannes Gusmão Caiado, R., Gonçalves Quelhas, O. L., Brito Alves Lima, G., Leal Filho, W., & Rocha Yparraguirre, I. T. (2021). A framework for sustainable and integrated municipal solid waste management: Barriers and critical factors to developing countries. *Journal of Cleaner Production*, *312*, 127516. https://doi.org/10.1016/j.jclepro.2021.127516

Bouliane, N. (2024, August 7). *The Pfand system: How to return bottles in Germany*. All About Berlin. https://allaboutberlin.com/guides/pfand-bottles

Brunjes, K. (2019, November 10). *Age Range by Generation—Beresford Research*. https://www.beresfordresearch.com/age-range-by-generation/

Camargo, F. M. (2019). El relleno sanitario Doña Juana en Bogotá: La producción política de un paisaje tóxico, 1988-2019. *Historia Crítica*, *74*, Article 74. https://doi.org/10.7440/histcrit74.2019.06

Canas, N. (2023, December 10). *"Pay-as-you-throw": The microchips conquering Europe's waste bins*. Www.Euractiv.Com. https://www.euractiv.com/section/circular-economy/news/pay-as-you-throw-the-microchips-conquering-europes-waste-bins/

Chetty, P. (2015, January 16). *Nominal, ordinal and scale in SPSS*. Knowledge Tank. https://www.projectguru.in/nominal-ordinal-and-scale-in-spss/

Cubillos Pineda, K. V. (2021). *Doña Juana: Más allá de la basura*. https://doi.org/10.48713/10336_31376

DANE. (2018). *DANE, Departamento de Bogota D.C.* https://sitios.dane.gov.co/cnpv/app/views/informacion/perfiles/11_infografia.pdf

Decreto 1077 de 2015. (2015). https://www.alcaldiabogota.gov.co/sisjur/normas/Norma1.jsp?i=62512

Departamento Nacional de Planeación. (2022). *Guía NACIONAL para la adecuada separación de residuos sólidos*. Departamento Nacional de Planeación; PDF.

DNP. (2023). *Con un crecimiento del 19,4%, el Presupuesto de inversión alcanzará los $99,3 billones en 2024 y será el más alto en la historia del país*. https://www.dnp.gov.co:443/Prensa_/Noticias/Paginas/con-un-crecimiento-del-19-4-el-presupuesto-de-inversion-alcanzara-los-99-3-billones-en-2024-y-sera-el-mas-alto.aspx

DPG Deutsche Pfandsystem GmbH - The DPG deposit process. (2024). https://dpg-pfandsystem.de/en/the-one-way-deposit-system/the-dpg-deposit-process.html

Espectador, E. (2023, July 11). *Bogotá cada día recicla menos: Solo 5 de cada 10 personas lo hacen ¿a qué se debe?* [Text]. ELESPECTADOR.COM. https://www.elespectador.com/bogota/bogota-cada-dia-recicla-menos-solo-5-de-cada-10-personas-lo-hacen-a-que-se-debe/

European Commission. (n.d.). *Pay-as-you-throw | Green Best Practice Community*. Retrieved September 22, 2024, from https://greenbestpractice.jrc.ec.europa.eu/node/7

European Commission. (2020). *Landfill waste—European Commission*. https://environment.ec.europa.eu/topics/waste-and-recycling/landfill-waste_en

European Commission. (2023). *Circular economy action plan—European Commission*. https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

European Environmental Agency. (2024, January 22). *Diversion of waste from landfill in Europe*. https://www.eea.europa.eu/en/analysis/indicators/diversion-of-waste-from-landfill

Eurostat. (2020). *File:Waste treatment by type of recovery and disposal, 2020 (% of total treatment) 25-05-2023.png*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Waste_treatment_by_type_of_recovery_and_disposal,_2020_(%25_of_total_treatment)_25-05-2023.png

Existe-il une amende pour abandon de déchets dans la rue? - Abandon de déchets | Service-Public.fr. (2024). https://www.service-public.fr/particuliers/vosdroits/F36492/0?idFicheParent=F31963

Ferraresi, M., Mazzanti, M., Mazzarano, M., Rizzo, L., & Secomandi, R. (2023). Waste recycling and yardstick competition among Italian provinces after the EU Waste Framework Directive. *Regional Studies*, *57*(8), 1535–1545. https://doi.org/10.1080/00343404.2022.2148643

Franceschi, F. F., Vega, L. T., Sanches-Pereira, A., Cherni, J. A., & Gómez, M. F. (2022). A combined approach to improve municipal solid waste management in upper-middle-income countries: The case of Sabana Centro, Colombia. *Clean Technologies and Environmental Policy*, *24*(8), 2547–2562. https://doi.org/10.1007/s10098-022-02333-x

Gabor, M. R., López–Malest, A., & Panait, M. C. (2023). The transition journey of EU vs. NON-EU countries for waste management. *Environmental Science and Pollution Research*, *30*(21), 60326–60342. https://doi.org/10.1007/s11356-023-26686-y

Greenpeace. (2023). *Greenpeace Colombia realiza un sondeo sobre la problemática del manejo de las basuras en Bogotá*. Greenpeace Colombia. https://www.greenpeace.org/colombia/noticia/issues/contaminacion/greenpeace-colombia-realiza-un-sondeo-sobre-la-problematica-del-manejo-de-las-basuras-en-bogota/

Holguin Aguirre, M. T., Giraldo Uribe, J. J., Sánchez Muñoz, M. del P., & Valencia Aguirre, E. (2022). *Análisis de la actividad de contenerización de residuos sólidos en Bogotá* (edsdia.ART0001573632). Dialnet. https://dialnet.unirioja.es/servlet/oaiart?codigo=8768330

Hsieh, C.-L., & Tsai, W.-H. (2023). Towards Carbon Neutrality and Circular Economy in the Glass Industry by Using the Production Decision Model. *Energies (19961073)*, *16*(22), 7570. https://doi.org/10.3390/en16227570

Jiménez, A. M. B. (2023). Reflexiones frente a los rellenos sanitarios en Colombia: Impacto, tratamiento y pautas para la mitigación de los daños ambientale. *Revista Jurídica Mario Alario D´Filippo*, *15*(30), Article 30. https://doi.org/10.32997/2256-2796-vol.15-num.30-2023-4249

Kassim, S. M. (2012). The Importance of Recycling in Solid Waste Management. *Macromolecular Symposia*, *320*(1), 43–50. https://doi.org/10.1002/masy.201251005

Kwon, S.-Y., Kim, Y.-H., Lee, J.-S., Park, J.-H., Park, J.-W., & Lee, Y.-H. (2023). PT Bottle Classification Function for Pfand Equipment. *2023 8th International Conference on Business and Industrial Research (ICBIR), Business and Industrial Research (ICBIR), 2023 8th International Conference On*, 1124–1127. https://doi.org/10.1109/ICBIR57571.2023.10147720

Ley 2294 de 2023 Congreso de la República de Colombia. (2023). https://www.alcaldiabogota.gov.co/sisjur/normas/Norma1.jsp?i=142257

Messad, P. (2023, June 27). *Glass deposit scheme makes a comeback in France*. Www.Euractiv.Com. https://www.euractiv.com/section/circular-economy/news/glass-and-plastic-deposit-schemes-to-make-a-comeback-in-france/

Minambiente. (2019). *Gobierno unifica el código de colores para la separación de residuos en la fuente a nivel nacional | Ministerio de Ambiente y Desarrollo Sostenible*. https://archivo.minambiente.gov.co/index.php/noticias-minambiente/4595-gobierno-unifica-el-codigo-de-colores-para-la-separacion-de-residuos-en-la-fuente-a-nivel-nacional

Ministerio de Vivienda. (2022). *Basura cero | Minvivienda*. https://www.minvivienda.gov.co/basura-cero

Mora, P. V. R. (2023, July 10). *¿Cuánto vale una multa por sacar la basura a destiempo en Bogotá?* El Tiempo. https://www.eltiempo.com/bogota/bogota-cuanto-vale-una-multa-por-sacar-a-destiempo-la-basura-784846

Muñoz, M. del P. S., Redondo, J. M., Cerón, J. G. C., Ibarra-Vega, D., Cortina, A. D. R., & Catumba-Ruíz, J. (2021). Sustainability of the usable solid waste market in Bogota (Colombia). *Urbe. Revista Brasileira de Gestão Urbana*, *13*, e20200343. https://doi.org/10.1590/2175-3369.013.e20200343

Padilla, A., & Trujillo, J. C. (2018). Waste disposal and households' heterogeneity. Identifying factors shaping attitudes towards source-separated recycling in Bogotá, Colombia. *Waste Management*, *74*, 16-16–33. ScienceDirect. https://doi.org/10.1016/j.wasman.2017.11.052

Pfand in Germany – A Guide to the Bottle Return System. (2024, August 27). How-to-Germany.Com. https://www.how-to-germany.com/pfand-in-germany/

Popa, N. M., & Negulescu, O. H. (2024). THE PLANNING MODEL OF THE EUROPEAN UNION: CIRCULAR ECONOMY STRATEGY. *Review of General Management*, *39*(1), 106–123. https://research.ebsco.com/linkprocessor/plink?id=ba760664-2fa9-3347-9385-7b255f5c93c9

Ramírez, L. (2018). *Horarios de recolección de basuras en las localidades de Bogotá | Bogota.gov.co*. https://bogota.gov.co/mi-ciudad/habitat/horarios-de-recoleccion-de-basuras-en-las-localidades-de-bogota

Reichenbach, J. (2008). Status and prospects of pay-as-you-throw in Europe – A review of pilot research and implementation studies. *Waste Management*, *28*(12), 2809–2814. https://doi.org/10.1016/j.wasman.2008.07.008

Rodríguez Peñaranda, A. M., & Contreras Caparroso, C. S. (2016). *Análisis del reciclaje en la ciudad de Bogotá desde la perspectiva de dinámica de sistemas*. http://hdl.handle.net/1992/53154

Romano, G., & Masserini, L. (2023). Pay-as-you-throw tariff and sustainable urban waste management: An empirical analysis of relevant effects. *Journal of Environmental Management*, *347*, 119211. https://doi.org/10.1016/j.jenvman.2023.119211

Sánchez-Muñoz, M. del P., Cerón, J. G. C., & Uribe, J. J. G. (2019). Análisis de la opinión de los hogares sobre la gestión de los residuos sólidos domiciliarios en Bogotá. *Semestre Económico*, *22*(52), Article 52. https://doi.org/10.22395/seec.v22n52a5

Sepúlveda, L., & Andrés, C. (2020). *Tipos de reciclaje y separación en la fuente, como métodos para disminuir el porcentaje de materiales aprovechables que llegan al relleno sanitario doña Juana en la ciudad de Bogotá*. http://repository.unad.edu.co/handle/10596/37256

Statistics how to. (2024). *Cohen's D: Definition, Examples, Formulas*. Statistics How To. https://www.statisticshowto.com/probability-and-statistics/statistics-definitions/cohens-d/

Superintendencia de Servicios Públicos Domiciliarios. (2023a). *Actividad de aprovechamiento de residuos en el país requiere ajustes: Superservicios | Superintendencia Servicios Públicos Domiciliarios*. https://www.superservicios.gov.co/Sala-de-prensa/noticias/actividad-de-aprovechamiento-de-residuos-en-el-pais-requiere-ajustes-superservicios

Superintendencia de Servicios Públicos Domiciliarios. (2023b). *Informe Nacional de Disposición Final de Residuos Sólidos 2021*.

Superintendencia de Servicios Públicos Domiciliarios. (2023c). *Informe Nacional de Disposición Final de Residuos Sólidos 2022*. Superservicios.

Superservicios. (2023). *Rellenos y rebosados | Superintendencia Servicios Públicos Domiciliarios*. https://www.superservicios.gov.co/Sala-de-prensa/Columnas-de-opinion/Rellenos-rebosados

Thi, N. B. D., Kumar, G., & Lin, C.-Y. (2015). An overview of food waste management in developing countries: Current status and future perspective. *Journal of Environmental Management*, *157*, 220–229. https://doi.org/10.1016/j.jenvman.2015.04.022

UN. (n.d.). *Goal 12: Responsible consumption and production*. The Global Goals. Retrieved March 14, 2024, from https://globalgoals.org/goals/12-responsible-consumption-and-production/

Vargas, C. (2021). *Bogotá pondrá a dieta al relleno sanitario de Doña Juana | Bogota.gov.co*. https://bogota.gov.co/mi-ciudad/habitat/bogota-pondra-dieta-al-relleno-sanitario-de-dona-juana

Weghmann, V. (2023). *Waste Management in Europe*. EPSU (European Public Service Union). https://www.epsu.org/sites/default/files/article/files/Waste%20Management%20in%20Europe_EN.pdf