**Zürich University of Applied Science**
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Bachelor of Science in Business Administration

# Bachelor Thesis

# Comparison of E-waste Management System in Switzerland and Italy: An Analysis of Citizens' Awareness Levels

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# Management Summary

The exponential growth of e-waste streams worldwide has raised significant concerns among governments on a global scale. While Switzerland is successfully managing its e-waste system, South European countries, Italy included, are facing challenges in achieving comparable success.
An effective e-waste management system relies on the correct disposal of appliances and devices by consumers, emphasizing the important role of citizens' awareness about existing legal frameworks and correct disposal behavior. However, there is still a gap in the awareness level of households in this regard.

This study aimed to address the mentioned issue by presenting a comparative analysis of the e-waste management systems of Switzerland and Italy, with a focus on assessing the level of citizens' awareness on WEEE, in order to determine whether there are differences among Swiss and Italian residents.
To address the research question, secondary data was collected to deliver an understanding of the current e-waste management sectors of both countries. Successively, due to limited data on citizens' awareness on e-waste in Italy and Switzerland, a quantitative survey was conducted amongst the two nations. A total of 149 individuals were interviewed using a closed-ended questionnaire.

Based on the research results, significant differences could be observed in consumers' awareness level between the two countries. Italian citizens demonstrated an insufficient awareness of local policy frameworks, suggesting lack of knowledge in specific guidelines regarding e-waste management. Moreover, a divergence was identified in the perception of individual responsibility as a citizen, indicating a greater awareness among Swiss residents of personal responsibility in addressing e-waste issues.
However, as both countries showed a comparable level of awareness concerning environmental and human health risks associated to e-waste, no significant differences were identified in the general understanding of e-waste harm between the two populations. Lastly, the majority of the public expressed the potential for changing their disposal behavior if access to better awareness and information regarding e-waste is handled.

The thesis' findings suggest that there is still area for improvement in terms of citizens' awareness in the context of e-waste in both countries. Strengthening public consciousness of rules and regulations is crucial not only in Italy, but also in Switzerland.

In conclusion, it can be assumed that increased awareness has the potential to influence individuals' performance toward recycling, encouraging them to adopt a more responsible and sustainable e-waste disposal behavior. Italy should additionally focus on emphasizing individuals' responsibility, underscoring the importance of citizens' contribution to address this issue, while implemented frameworks should be promoted at a national level.

Overall, this thesis underscores the importance of citizens' awareness in the field of e-waste and reveals variations in the awareness level between the two populations.

# Table of Contents

I List of Figures ..... V

II List of Tables ..... V

III List of Abbreviations ..... VI

**1. Introduction** ..... 1

1.1 Problem Statement and Scope ..... 2

1.2 Research Question ..... 3

1.3 State of Search and Research Gap ..... 4

1.4 Practical and Academic Relevance ..... 5

1.5 Structure of the Thesis ..... 5

**2. Theoretical Background** ..... 7

2.1 Circular Economy Approach for E-Waste ..... 7

2.2 The E-Waste Management System ..... 9

2.3 Rules, Regulations, and Infrastructure ..... 10

2.3.1 Italy ..... 10

2.3.1.1 European Union: the WEEE Directive ..... 10

2.3.1.2 Implementation in Italy ..... 12

2.3.2 Switzerland ..... 15

2.4 Comparison of the E-Waste Systems of the Two Countries ..... 17

2.5 Citizens' Awareness ..... 21

2.5.1 Citizens' Awareness Around the World ..... 22

**3. Methodology** ..... 25

3.1 Secondary Research ..... 25

3.2 Primary Research ..... 25

3.2.1 Survey Outlining and Administration ..... 26

3.2.2 Structure and Content of the Questionnaire ..... 27

3.2.3 Data Analysis ..... 28

3.2.4 Sampling Design ..... 29
**4. Results** ..... 30
4.1 Socio-Demographic Data ..... 30
4.2 Questionnaire Results ..... 32
4.2.1 General Awareness on E-Waste Recycling ..... 32
4.2.2 Awareness on Rules, Regulation, and Infrastructure ..... 34
4.2.3 Awareness of E-Waste Consequences ..... 35
4.2.4 Awareness of Citizens Responsibility ..... 36
4.2.5 Possible Measures ..... 36
**5. Discussion** ..... 38
5.1 Awareness on E-Waste and Associated Rules, Regulations, and Infrastructure ..... 38
5.2 Awareness of E-Waste Consequences ..... 39
5.3 Awareness of Citizens Responsibility ..... 40
5.4 Possible Measures ..... 41
5.5 Answering the Research Question ..... 42
**6. Conclusion** ..... 44
6.1 Summary of Thesis ..... 44
6.2 Recommendations ..... 45
6.3 Limitations ..... 45
6.4 Suggestion for Further Research ..... 46
**7. References** ..... 47
**8. Appendix** ..... 56
8.1 Questionnaire for the Quantitative Data Collection ..... 56

# I List of Figures

Figure 1: City and regions of residence of survey participants ..... 32
Figure 2: Participants' awareness of equipment classified as e-waste ..... 33
Figure 3: Participants' knowledge of the local collection points for WEEE ..... 35
Figure 4: Possible measures to increase awareness on e-waste ..... 37

# II List of Tables

Table 1: Comparison of the e-waste systems of Italy and Switzerland. ..... 21
Table 2: Socio-demographic information of survey participants ..... 30
Table 3: Participants' general awareness of e-waste recycling ..... 33
Table 4: Participants' awareness of local rules, regulations, and infrastructure ..... 34
Table 5: Participants' awareness of e-waste consequences ..... 35
Table 6: Participants' awareness of their personal responsibility as citizens ..... 36
Table 7: Increased awareness outcomes ..... 36

# III List of Abbreviations

| | |
|---|---|
| CdC | Coordination Centre |
| D.Lgs. | Legislative Decree |
| EEE | Electrical and Electronic Equipment |
| EMF | Ellen MacArthur Foundation |
| EPR | Extended Producer Responsibility |
| EU | European Union |
| GDP | Gross Domestic Product |
| ICT | Information and Communication Technology |
| Inh | Inhabitants |
| Kg | Kilogram |
| $Km^2$ | Square kilometers |
| Mt | Metric Tonnes |
| ORDEE | Ordinance on the Return, Taking Back and Disposal of Electric and Electronic Equipment |
| PROs | Producer Responsibility Organizations |
| RAEE | Rifiuti apparecchiature elettriche ed elettroniche |
| RoHS | Restriction of hazardous substances |
| SENS | Swiss Foundation for Waste Management |
| SFOE | Swiss Federal Office for the Environment |
| SLRS | Systemverantwortung für Leuchten und Leuchtmittel |
| Swico | Swiss Association for Information, Communication and Organization Technology |
| WEEE | Waste of Electrical and Electronic Equipment |
| WEF | World Economic Forum |

# 1. Introduction

Electrical and electronic equipment (EEE) has become an indispensable element of daily life, transforming the way society lives and interacts (Namias, 2013). Industrialization, economic growth, progress in technological development and better living standards are some of the factors that have contributed to humans' reliance on EEE devices (Ratuela et al., 2021). These trends, together with products' short life cycles, as well as non-convenient or limited repair options, have encouraged people to buy newer technological devices while discarding the outdated ones (Baldé et al., 2017). According to statistical data, nowadays a person in Western Europe owns an average number of 9.4 devices, while in 2018 the figure was little more than half of that number (Taylor, 2023).

As EEE production and consumption are exponentially increasing, the equipment's disposal is also rising proportionally. According to Forti et al. (2020), 53.6 Mt of e-waste was generated worldwide in 2019, the equivalent to 7.3 kg per capita. This figure is expected to increase to 74.7 Mt by 2030 (Forti et al., 2020). With 16.2 kg of e-waste production per capita, Europe ranks as the continent with the highest e-waste generation rate (Statista, 2023a).

The waste of electric and electronic equipment (WEEE) is an essential topic for both the waste treatment itself, as well as for the recovery of valuable resources (Cui & Forssberg, 2003). EEE can contain precious metals, such as gold, silver, copper, etc., or harmful elements, e.g., mercury (Forti et al., 2020). If recycled correctly, the valuable metals can be extracted, recycled, and reused in the form of a circular economy, while hazardous substances can be treated properly (Forti et al., 2020). Toxic chemicals, if abandoned in landfills, are released into the atmosphere. Thus, their entry into the drinking water system or into the food supply chain is facilitated, representing a threat to the environment as well as to human health (Forti et al., 2020).

To address the challenges of growing e-waste streams and maximize the recovery and recycling of valuable materials, governments have introduced rules and regulations on recycling and built up related infrastructure. However, for these efforts to be effective, it is necessary for the citizens to be aware of such regulatory frameworks (Islam et al., 2016). Also, a strong civic dedication to preserving the environment is one of the key

factors in determining the success of the WEEE recovery system (Ylä-Mellaa et al., 2014).

Despite regulations being in place, from a global perspective, still only one fifth of the generated e-waste is recycled, precisely 17,4% in 2019 (Forti et al., 2020).
Among European countries, the figure is spread differently. In 2019, for example, the Southern European countries, including Italy, had a recycling rate of approximately 34%, while in the Northern European countries, like Sweden and Norway, the figure of e-waste collected and properly recycled was around 59% (Forti et al., 2020). Switzerland outperformed all other countries, hitting an e-waste recycling rate of 75% in that same year (Spencer, 2019). In fact, Switzerland is a pioneer in this field, as the country had already implemented a successful collection and recycling scheme before the introduction of the WEEE Directive in European countries (Islam et al., 2018).
Italy, the fourth largest economy on the continent in terms of GDP and a country that complies with the guidelines set by the European Union (EU), is facing challenges in implementing an effective system for managing e-waste (Statista, 2023b). In addition to the country's relatively low recycling rate, hurdles are intensified by the presence of internal discrepancies among the various regions (Di Foggia & Beccarello, 2021).

## 1.1 Problem Statement and Scope

As presented above, an effective management of the e-waste system plays a crucial role in promoting recovery and recycling of materials, thereby enabling the successful implementation of a circular economy.
According to Mmereki et al. (2016), the management of e-waste is strongly influenced by several factors, such as lack of required organizational structure, weak infrastructure, inadequate definition of stakeholders and institutions' roles, as well as citizens' lack of awareness regarding the impact of e-waste and their recycling behavior.
In order to address issues related to management practices and support the implementation of governmental policies, it is essential to understand the state of awareness citizens have associated with e-waste (Ramzan et al., 2019). Public consciousness and active civic contribution are crucial for the efficacy of e-waste management practices (Sinha-Khetriwal et al., 2009; Borthakur & Govind, 2017). Moreover, recent studies have further emphasized that citizens' awareness is a key factor

in achieving a successful e-waste management system (Islam et al., 2021; Borthakur & Singh, 2021; Ramzan et al., 2019).
However, despite citizens being considered an integral part of the e-waste management system, Borthakur and Govind (2017) have demonstrated that awareness, familiarity of citizens with the national frameworks and their recycling behavior have been long neglected in research.

To address the research gap regarding citizens' awareness in the context of e-waste, the aim of this study is to analyze the current level of consumers' awareness in Italy and Switzerland.
As a comparative case study, Italy is chosen as a representative European Member country with a relatively low recycling rate, and Switzerland because of its success in handling e-waste. By assessing to what extent citizens in both nations are aware of e-waste and its associated issues, this thesis aims to identify whether there are key differences in terms of citizens' awareness between the two countries.
In the first part, the comparative analysis between Switzerland and Italy aims to deliver a general understanding of both countries` current management systems in the field of e-waste, highlighting the strengths and weaknesses of their respective approaches. Thereafter, the survey will specifically aim to assess whether there are any notable differences between the two countries in the context of e-waste and propose potential measures for improvement to address these disparities.

## 1.2 Research Question

The research question that will guide the thesis is the following:

*What are key differences, if any, in the level of citizens' awareness regarding e-waste between Italy and Switzerland?*

This thesis focuses on citizens' awareness level, without exploring the households' willingness to contribute to e-waste or their associated behavior. Moreover, no differentiation between the various categories of EEE will be made.

## 1.3 State of Search and Research Gap

The existing literature regarding the e-waste system in Italy emphasizes that a successful e-waste management system is necessary to meet circular economy goals, enabling the recycling and recovery of precious components (Tisserant et al., 2017). Recent literature has confirmed a difference in the collection systems between Southern and Northern Italian regions, also mentioning the different levels of industrialization of the regions (Di Foggia & Beccarello, 2021). Moreover, a correlation between the collection rate and the available number of collection points within one region was established (Favot & Grassetti, 2017). Furthermore, studies emphasize the critical role of consumers' awareness regarding the importance of correct recycling behavior and its consequences, as their active participation in these programs is crucial to achieve successful targets (Vicente & Reis, 2008).
However, there is limited literature on understanding consumers' awareness concerning e-waste not only in Italy but also on a global scale, including Switzerland (Sinha-Khetriwal et al., 2009; Borthakur & Govind, 2017; Islam et al., 2021).

Research on Switzerland's e-waste management system emphasizes its effectiveness, by underlining the decades of experience the country has in handling e-waste (Sinha-Khetriwal et al., 2005; Debnath et al., 2014; Islam et al., 2018). Existing literature emphasizes the participation of all stakeholders involved in the system, underlying the awareness of sustainability issues among citizens and government (Islam et al., 2018).

A study published by Borthakur and Govind (2017) identified that although there is a growing body of studies on e-waste management and recycling frameworks, a limited number of research is specifically addressing citizens' awareness and their disposal behavior in the context of e-waste. The authors conducted an analysis of publications focused on the term "e-waste" and discovered that from the over 3'000 publications covering a period of 20 years from 1994 to 2014 worldwide, only 52 studies adequately addressed the topic of public awareness and disposal behavior in different countries.
Thus, a scarcity of sufficient research towards consumers' awareness and behavior in comparison to other aspects related to e-waste was determined (Borthakur & Govind, 2017). Also, Sinha-Khetriwal et al. (2009) emphasized that there is a lack in understanding how the citizen's awareness level affects the e-waste practices of a country.

In conclusion, to the author's knowledge, this thesis is the first attempt to comprehensively review consumers' awareness in relation to e-waste in Italy and in Switzerland. Therefore, this paper seeks to contribute to the limited existing research of citizens' awareness in the e-waste management system in both countries.

## 1.4 Practical and Academic Relevance

As previously mentioned, civic contribution to e-waste is crucial to achieve a successful working e-waste system within a country. To enable households to actively contribute, it is necessary that they are aware of regulations, infrastructure, material value and all other factors related to e-waste (Islam et al., 2016). Awareness helps individuals to understand the threats to the environment and health risks associated with improper e-waste management and motivates them to adopt more responsible and sustainable practices (Park & Ha, 2014).

Based on the current state of citizens' awareness, this study aims to address areas where additional research is needed.

The comparison of Italy with a successful e-waste management system of another country, such as Switzerland, serves to determine the level of awareness in each nation and identify significant differences which affect the e-waste management system of the countries. This comparative analysis highlights the disparities present in awareness level and suggests which are areas for improvement that can be beneficial for Italy as well as for other European countries. The insights gained from this paper can be useful for future strategies to promote responsible e-waste management practices to increase citizens' awareness, emphasizing the obligations for each individual to contribute to reduce negative environmental and health impacts associated with e-waste disposal.

## 1.5 Structure of the Thesis

This thesis consists of six main chapters.

The first chapter serves as an introduction, emphasizing the importance of addressing e-waste as an increasingly pressing environmental issue. Moreover, the purpose of the study is presented, together with the research gap that the study aims to fill and the research question which will guide the research.

The subsequent chapter consists of the theoretical framework. This section includes a literature review and the examination of relevant sources, to deliver an overview of the e-

waste legislation and the associated infrastructure in both countries, establishing the theoretical foundation for the survey and setting the stage for the subsequent chapters.

Chapter three focuses on the methodology employed in the study. Both methods utilized, secondary and primary research, are presented. For the primary research, the survey conducted is described in detail.

The fourth chapter presents the results obtained using tables and other visual graphics to facilitate comprehension.

In chapter five the results are interpreted and discussed, allowing a deeper analysis of the findings. Possible conclusions are drawn based on the collected data.

Lastly, in the sixth and final chapter, the key findings of the thesis are summarized, and recommendations are provided. This section acknowledges the limitations of the research and proposes potential areas for further research.

# 2. Theoretical Background

The aim of this chapter is to provide a review of the available literature on e-waste recycling, highlighting the purpose of the research question and the scope of the thesis. The theoretical framework begins with the investigation of the circular economy approach and the crucial role a successful e-waste management system plays in today's society.

The various factors that influence the e-waste management system, namely rules and regulations, infrastructure and, with a particular focus, public awareness are presented separately for both Italy and Switzerland.

By delivering an overview of the current e-waste management systems in both countries, this review delivers insights that enable a better understanding of the main discrepancies between the two nations. In conclusion, the identified research gap will be highlighted, establishing the foundation for the subsequent chapter.

## 2.1 Circular Economy Approach for E-Waste

Since the Industrial Revolution the linear economic system, also known as *take-make-dispose model*, has held a dominant position in society and it persists to these days (Esposito et al., 2018). This model incentivizes consumers to buy, use and discard products, rising consumerism and therefore the demand for short-cycle goods (European Environment Agency, 2021). As a consequence of the high reliance on resource consumption, the linear economy not only contributes to resource scarcity but also results in a significant increase in waste streams (Pan et al., 2022).

Traditional waste treatment practices are also oriented towards the linear economy and have therefore focused on the management of resources sent to landfills, without considering the recycling and recovery of materials (Hockerts & Weaver, 2002). Hence, these measures have not helped in reducing waste volumes nor in mitigating the problem of resource scarcity (Geisendorf & Pietrulla, 2018). Furthermore, incorrect handling of waste in landfills poses risks to both the environment and human health, and it also intensifies the challenges posed by climate change, pushing the physical boundaries of the planet (World Economic Forum (WEF), 2023). Compared to other types of waste, e-waste is considered to be one of the most hazardous solid waste categories (Kapoor et al,

2021). Moreover, it is one of the fastest growing streams worldwide, with a rate of 3-5% yearly increase (WEF, 2023).
Based on the European Directive on WEEE (2003), the definition of equipment that falls under the category of EEE includes the following:

"(...) *equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and field and designed for use with a voltage rating not exceeding 1´000 volts for alternating current and 1´500 volts for direct current*".

Additionally, following the Directive, EEE ranges from small and large household appliances, IT and telecommunications devices, consumer equipment and photovoltaic panels, lighting equipment, toys and sport equipment, medical devices, monitoring, and control instruments as well as automatic dispensers. In line with the Directive, the term WEEE refers to all EEE that has been classified as waste. It includes all constituent assemblies and sub-components that have been or are about to be abandoned by their owner, without an intention of being reused (Directive 2002/96/EC, 2003).

A closed product life cycle, which supplies the economic system with a cyclical flow, is considered a proper solution for the management of e-waste (Geissdoerfer et al., 2017). With this approach the recycling and recovery of resources are prioritized: resources are reintegrated in the supply chain, maximizing their value, and keeping them in circulation as long as possible. Consequently, the amount of waste disposed of in landfills is minimized (Pajunen & Holuszko. 2022).
The organization Ellen MacArthur Foundation (EMF) promotes the concept of a circular economy across the world and delivers one of the most widely accepted definitions of it (Geisendorf & Pietrulla, 2018). Its definition describes the circular economy as a solution approach to address pressing global issues such as climate change, biodiversity loss, waste, and pollution (EMF, n.d.). According to EMF, the circular economy is driven by three fundamental principles, all guided by design: the elimination of waste and pollution, the promotion of product and material circulation and the revitalization of nature.
The foundation also assists businesses and organizations in their journey towards adopting circular economy principles (European Union, n.d.). In fact, the closed loop economy has emerged as a new business model, creating economic markets and entrepreneurial opportunities for companies globally (Ghisellini et al., 2016).

While the circular economy model is an effective solution for managing e-waste, its success relies heavily on the establishment of a robust recycling system. The logistic operations concerned with the collecting, recycling, and reuse of WEEE are crucial for shifting to a closed loop economy (Cui and Zhang, 2008). Also, consumers' awareness and behavior help to achieve suitable approaches to achieve a circular economy (Islam et al., 2021).

## 2.2 The E-Waste Management System

Decades before the introduction of a circular economy, governments worldwide had already introduced measures to improve the management of the e-waste sector.

In the mid-1990s, the majority of WEEE disposal was uncontrolled. In fact, over 90% of the material was burned, landfilled, and recovered without any prior treatment (Ylä-Mella et al., 2014). Moreover, a significant number of hazardous compounds were discovered in municipal garbage streams (Ylä-Mella et al., 2014).

To address the expanding WEEE environmental impacts like the increasing amount of abandoned electronics worldwide, governments in Europe, Asia and America have implemented e-waste management systems, sharing the common goal of collecting and properly disposing of electronic waste (Gurauskiené, 2008).

The involvement of different key players such as producers, recyclers and governmental organizations is crucial to tackle the e-waste problem. However, the generation and the handling of e-waste is also strongly linked to the consumers of electronic products (Gurauskiené, 2008). According to Ylä-Mella et al. (2014), the effectiveness of the WEEE recovery system is significantly influenced by both consumers' awareness of the importance of separate WEEE collections and their commitment to returning end-of-life devices to designated collection points. Kidee et al. (2013), stated that all involved parties need to collaborate and complement each other, as one party alone is not sufficient to succeed. Therefore, as indicated by Lee and Sundin (2012), it is crucial to involve all stakeholders with clearly defined responsibilities and effective means of collaboration. This entails creating awareness and ensuring satisfaction among all parties involved, citizens included.

Subsequently, the involved actors will be examined, starting with the government and its regulatory framework, along with the associated infrastructure. Delegated responsibilities

placed on producers and retailers will also be considered. Finally, the role of consumers and their awareness will be discussed.

## 2.3 Rules, Regulations, and Infrastructure

As earlier mentioned, due to emerging WEEE environmental impacts such as the increasing amount of abandoned electronics in the EU, governments were forced to introduce sound management practices (Mihai & Gnoni, 2016).
In the following chapters, the regulatory framework will be presented for both Italy and Switzerland, providing an overview of the measures and guidelines in place.

### 2.3.1 Italy

As a member of the European Union, Italy implements legislation mandated by the European Commission. Therefore, in the following section, firstly the Directive introduced by the EU will be presented. Consequently, an overview of its implementation in Italy will be provided.

#### 2.3.1.1 European Union: the WEEE Directive

Within the EU, several treaties have been adopted, increasing the EU's legal and political authority in the field of e-waste (Selin & VanDeveer, 2006). The introduction of the WEEE Directive aimed to standardize e-waste management strategies in the different European member countries, to prevent individual and different national strategies, which could hamper the efficacy of recycling approaches (Ylä-Mella et al., 2014). The Directive has been revised multiple times throughout the years. Each revision aimed to improve and upgrade the management system of e-waste. The latest versions have added stricter restrictions and broadened the range of items covered compared to the previous ones (Ylä-Mella et al., 2014).
Below the evolution of the Directive will be chronologically presented.

WEEE Directive 2002/96/EC

The first Directive, known as Directive 2002/96/EU and introduced in 2002, was legally binding for all member states and regulated the collection of WEEE (European Commission, 2005). Its aim was to boost WEEE recycling, reuse, and recovery, to cut down waste disposal (Directive 2002/96/EC, 2003). Moreover, it attempted to enhance

the environmental practices of all parties engaged in the life cycle of EEE, including manufacturers, distributors, and consumers (Directive 2002/96/EC, 2003). The Directive also placed a particular focus on parties directly involved in the handling of e-waste. The collection target set in 2002 required each member state to achieve a collection rate of 45% by 2006 (Forti et al., 2020). The EEE were categorized in 10 different groups, ranging from big and small household appliances to medical devices (Directive 2002/96/EC, 2003).

Two important elements introduced by the WEEE Directive are the one-to-one policy, enabling consumers to return their WEEE free of charge when buying a comparable EEE, and the ERP (Extended Producer Responsibility) policy (Berežni et al., 2021). Through the ERP approach, the responsibility of the products is shifted from the public administration (whether governmental, provincial/regional, or municipal) to the producers for every step of the products' life cycle, including its disposal even after it has been passed on to the end consumer (WEEE Forum, 2020). The concept should encourage environmentally conscious design and production of EEE generating products easy to repair, upgrade, reuse, disassemble and recycle (Directive 2002/96/EC, 2003). This idea was first introduced by Lindhqvist in 1990 as a motivator for manufacturers to take environmental factors into consideration during the design of the product to reduce WEEE ecological impact (Lindhqvist, 1990).

Furthermore, according to the Directive, producers must oversee the financing for the creation of affordable and suitable processes so that the return of WEEE and the recovery is uncomplicated and free of charge for private households (Ylä-Mela et al., 2014). However, manufacturers are free to decide whether they would like to meet this responsibility on an individual basis or by joining a collective scheme (Directive 2002/96/EC, 2003).

In addition, the mandate highlights the necessity of citizens' active participation in the disposal and collection of e-waste (Directive 2002/96/EC, 2003). Therefore, they should be motivated to return their WEEE through accessible facilities, e.g., public collection points, where private households can dispose of their waste without charge (Directive 2002/96/EC, 2003). Following the guidelines, the responsibility of providing end consumers with information about the content materials to incentivize correct disposal behavior lies also with the producers (Ylä-Mellaa et al., 2014).

By August 2004, the Directive had to be incorporated into the respective national legislation of EU member states (Directive 2002/96/EC, 2003).

Contemporaneously, to restrict the use of hazardous materials, the Restriction of Hazardous Substances Directive (RoHS) was introduced (Ylä-Mella, 2014). This requirement aims to bring legislation of the member states regarding restrictions on the use of hazardous substances in electrical and electronic equipment closer together (Directive 2011/65/EU, 2011). The substitution or restriction of WEEE´s hazardous materials such as mercury and cadmium, is the most effective method to contribute to the protection of human health and the environment (Directive 2011/65/EU, 2011).

WEEE Directive 2012/19/EU

In 2012, the Directive 2012/19/EU replaced the original one. The reviewed mandate, which came into force two years later, aims to improve e-waste separate collection, treatment, and recycling strategies by setting ambitious and suitable collection rates for each member state (Ylä-Mella, 2015). As for the collection rates, member states have the possibility to set their collection targets in two different ways, choosing between a percentage of the annual average weight of EEE placed on the market in the last three years (new 65% instead of 45%), or as a percentage of the amount of WEEE generated within their borders (in this case 85%) (Magalini et al., 2012).

The Directive also differentiates two kinds of WEEE to avoid market exploitation: WEEE from private households, known as 'consumer-to-business', and WEEE from users other than private households, known as 'business-to-business' (Magalini et al., 2012). Another additional objective is to simplify the registration and reporting requirements for new equipment placed on the market, thereby reducing administrative constraints within the internal market (Ylä-Mella, 2015). Moreover, the classification of the products has changed, categorizing them into six new groups, instead of 10. The range of goods covered is broadened, including the group of solar panels (Salhofer et al., 2016).

The revised policy is addressing again to all stakeholders, government, producers, and consumers, as well as to the recycling industry (Directive 2012/19/EU, 2012). Article 14 reiterates the importance of providing households with essential information regarding the collection of WEEE to avoid incorrect disposal of materials, like discarding EEE in unsorted municipal garbage (Directive 2012/19/EU, 2012).

#### 2.3.1.2 Implementation in Italy

As a member of the EU, Italy implemented the WEEE Directive under the Legislative Decree (D.Lgs.) n. 151/2005 in 2005, one year after the deadline set by the European

Commission (Magalini et al., 2012). The system became operational in the Italian territory only in November 2007, after having priorly passed financial responsibility to producers. A couple of months later, in 2008, all municipalities completed their registration with the national clearing house, which enabled organizations to engage in WEEE take-back operations (Favot et al., 2016).

The first target set was to ensure the achievement of a collection rate from households of at least 4 kg on average per inhabitant per year by the end of 2008 (D.Lgs. n. 151, 2005). To achieve this goal, Art. 6 of the Decree, which focuses on separate collection, addresses municipal districts, distributors, and producers. According to the Decree, the first ones should ensure the functionality and accessibility of separate collection systems from households. Distributors, on the other hand, ensure private households the free take-back of a used equipment when buying a new electrical or electronic device of the same type. Lastly, producers should organize and manage the collection system for household's EEE on an individual or collective basis, bearing related costs (D.Lgs. n. 151, 2005).

In Art. 10, the costs the producer is responsible for are reported, namely the financing of treatment, recovery, and environmentally compatible disposal operations of waste originated from households for all EEE placed on the market after August 13, 2005 (D. Lgs. n. 151, 2005).

Concerning responsibility of citizens' information, the Italian Decree follows the guidelines of the European WEEE Directive. Also in Italy, the producers are in charge of providing instruction for use of the equipment, give citizens adequate information concerning the obligation not to dispose of WEEE as municipal waste and to carry out separate collection (D.Lgs. n. 151, 2005). Furthermore, producers have the duty of informing citizens about WEEE collection systems and the potential effects of e-waste on the environment and human health (D.Lgs. n. 151, 2005).

The Decree was replaced in 2014 by the Legislative Decree n. 49/2014. This update considers the modifications made by the revised WEEE Directive, including the raised collection targets (D.Lgs. n. 49, 2014).

Italy presents a slightly different classification system of EEE, as the six categories of the latest WEEE directive are divided into five waste streams in the Italian country (Magalini et al., 2012).

Italian System Operation

According to the Decree, the transport, treatment, and recycling of WEEE across the whole country, is managed by the producer responsibility organizations (PROs).

PROs are third-party organizations that support producers in implementing the EPR schemes, thereby sharing the responsibility (Winternitz et al., 2019). These entities are required to create and provide funding for the national clearing house, the Coordination Centre (CdC) for WEEE (Favot et al., 2016).

As described by Berežni et al. (2021), the CdC is the centralized national entity that acts as regulatory authority for all WEEE flows in Italy. The authors explained that the tasks of this institution include ensuring the collection of WEEE from designated centers, gathering and reporting statistics on the collection and handling of EEE, monitoring WEEE flows by category and verifying the accuracy of information with data provided by producers. Moreover, the CdC receives data on the quantities of EEE put on the market by the members of the PROs.

Thereafter, based on these quantities, each municipal collection point will be assigned to one or more of the PROs on an annual basis (Favot et al., 2016). If the assigned PRO does not handle all five categories of WEEE, another collective system is responsible for collecting the remaining groups of WEEE (Favot et al., 2016). Consequently, the analysis is not feasible at a regional or local level, as it needs to be conducted at a national one (Favot et al., 2016).

Meanwhile, municipalities are given the responsibility of ensuring that WEEE collection systems from households are efficient and adequate, as well as guaranteeing the accessibility to the assigned collection centers, whereas each collective system's task is to provide for a functioning take-back of WEEE from municipal collection centers across the whole country, as provided by the CdC's guideline (Berežni et al., 2021). Consumers bear the responsibility to deliver WEEE to municipal collection sites or retailers (Magalini et al., 2012).

Italy, in its 302'000 $km^2$ territory, has 4'279 municipal collection centers and 628 retailer collection points, the latter including both individual and collective schemes (Istat, 2013; RAEE, 2022).

As per 2018, Italy had a total of 37 PROs, among which the biggest one held a market share of 70%, followed by the second largest with 20%, while the remaining 35 PROs shared the last 10% (Winternitz et al., 2019).

According to the latest data referring to the year 2022, the average of collected waste pro capita in the Italian territory was 6.12 kg (RAEE, 2023).

### 2.3.2 Switzerland

Switzerland was the first nation worldwide in which e-waste management regulations came into force (Islam et al., 2018). In 1998, before the European Directive on WEEE was developed, the Swiss Federal Office for the Environment (SFOE) introduced the Ordinance on the Return, the Taking Back and Disposal of Electric and Electronic Equipment (ORDEE) (The Federal Council, 2022b).

As outlined by The Federal Council (2022b), the principal objectives imposed by SFOE's Directive are to ensure that EEE is not discarded in municipal waste and that it is disposed of through an environmentally safe approach. Moreover, it also dictates rules of conduct for private households, retailers, producers, and importers:

- Individuals who want to discard EEE must return it to a dealer, manufacturer, or a disposal company. Another option is for them to bring the product to public collection points.
- Retailers are required to accept the return of equipment free of charge. This applies only for end-users and for equipment within their product range.
- Manufacturers and importers are also obligated to take back appliances of their respective brands, free of charge.

However, years before these guidelines came into force, two PROs were already operating in the nation's e-waste industry: the Swiss Association for Information, Communication and Organization Technology (Swico) and the Swiss Foundation for Waste Management (SENS) (Sina-Khetriwal et al., 2005). Both organizations are non-profit oriented and based on an ERP system.

Swico focuses on the management of electronic waste originating from fields of information technology, entertainment, office, graphic industry, medical technology etc., while SENS is responsible for small and big household equipment, gardening appliances, hobby equipment as well as for toys (Ott, 2022).

Swico was founded in Switzerland in 1994 as one of the oldest national systems for waste management (Fredholm et al., 2008). Swico's aim is to recover raw materials and recycle pollutants in an ecologically sustainable manner (Swico, SENS, SLRS, 2021). The organization operates in close collaboration with various entities including retailers, private and public collection points, logistic companies, environmental agencies, and auditors (Swico, n.d). Due to its successful take-back system, Swico Recycling has established a reputation for being a highly effective and reliable provider of e-waste management solutions (Sinha-Khetriwal et al., 2005). Its success can be attributed to notable achievements in terms of high rates of collection and recycling, its stringent processing guidelines, and the rigorous quality inspections (Sinha-Khetriwal et al., 2005). SENS was founded in 1990 and it focuses on the collection, recycling, and disposal of EEE (Swico, SENS, SLRS, 2021). One of its main scopes is also to foster ecological management practices throughout Switzerland (Sens-city, n.d).

Swiss System Operation

Streicher-Porte (2006) described in detail how the e-waste system in Switzerland operates.

According to the author, both PROs groups, to ensure proper recycling of EEE, require an advanced recycling fee (ARF) from producers and importers. These fees are then passed through to distributors, retailers and lastly to end-users, who pay the fee upon purchasing an electronic device. As a result, customers can return their outdated EEE for free to specific collecting points or retail stores. Swico or SENS, depending on the geographical location, invite recyclers to bid and then assess the costs for reimbursement per kilogram of recycled materials (Streicher-Porte, 2006). The author further stated that while Swico and SENS are both non-profit organizations and make sure to transport WEEE only to certified recycling firms in compliance with environmental laws, the recycling and transport companies operate for profit. They generate revenue from material recovery and from the received reimbursement from Swico/SENS for the recycled amount of WEEE (Streicher-Porte, 2006).

In Switzerland, all stakeholders involved, including producers, importers, retailers/distributors, recyclers, and especially customers, participate in the collection and recycling of e-waste (Islam et al., 2018). Through the deployment of the EPR, manufacturers and importers bear both the financial and physical obligation for the

ecologically appropriate disposal of end-of-life electronics (Debnath et al., 2014). Meanwhile, the responsibility for operating and managing the system on behalf of their member producers lies entirely within the two PROs (Debnath et al., 2014). Therefore, roles and responsibilities are clearly defined. This establishes a healthy relationship between all involved parts in the e-waste management industry (Islam et al., 2018).

Switzerland, which extends on a territory of 41'285 $km^2$, has 591 collection points from Swico, plus almost 7'000 options for return in retail centers (The Federal Council, 2023; Swico, 2021).
As per 2019, Switzerland had a total of four PROs, with Swico and Sens being the two largest ones (Doan et al., 2019).
Data from 2021 demonstrated that in that year, Switzerland recorded a collection of 15 kg of WEEE per capita (Swico, 2022).

## 2.4 Comparison of the E-Waste Systems of the Two Countries

As mentioned in chapter 2.3.2, Switzerland has had an efficient and successful e-waste management system since 1994, before the European Directive was even developed (Wäger et al., 2011). Already in 2003, one year before the WEEE Directive set by the EU imposed an e-waste collection target of 4 kg/capita for European countries, Switzerland had already reached a collection target of 9 kg/capita (Sinha-Khetriwal et al., 2005).
Italy instead, failed to meet the initial collection target set by the first Directive, which had to be achieved within 2006. The target was set at 45%, yet Italy managed to achieve a collection rate of 34% in 2019 (Forti et al., 2020). Moreover, according to the latest RAEE report, Italy is still significantly off from achieving the new collection targets set by the updated WEEE Directive, in both available measurement methods (RAEE, 2023). In fact, maintaining a consistent level of collected e-waste at 6 kg/inh over the past three years, Italy is still circa 8.8 kg/inh distant from reaching the 85% target for WEEE generated and 3.5 kg/inh distant in reaching the 65% target for EEE put on the market (Baldé et al., 2020).

Rules and Regulations

Baldé et al. (2020), states that one of the factors that has a significant impact on the collection targets of e-waste is the implementation of WEEE legislation at a national

level. According to the authors, countries implementing an "all actors" strategy in the e-waste industry and compulsory handover of WEEE, typically have greater collection rates compared to those without such an approach.

While in Switzerland the entire waste management industry is under multi-level monitoring and control, in Italy a poor control system incentivizes the emergence of unofficial flows, allowing WEEE to be collected by informal actors or even by authorized collectors (Islam et al., 2018; Baldé et al., 2020). The latter, although formally engaged in e-waste collection, sell later the collected e-waste to informal treatment operators due to financial advantages (Baldé et al., 2020). Thus, the illegal sector has a significant role in waste management in the country, mostly in the southern regions, where criminal organizations have influence over landfills (Germani et al. 2015; Buclet, 2002).

Furthermore, an investigation conducted by members of Ecodom in 2019, who covertly placed GPS trackers in big, discarded households' appliances in Italy, reported that 35% of the produced e-waste never reached the authorized facilities (Baldé et al., 2020). Baldé et al. (2020) reported that some appliances landed in Slovenia in non-authorized plants, other arrived in parking lots, anonymous houses, private houses or reached second-hand markets of EEE. However, in this investigation, the majority of WEEE were originated in the Northern regions of Italy. Therefore, the authors claimed that the informal sector of the country exceeds the 39% of the total e-waste produced (Baldé et al., 2020).

Thus, a strong control system at a national level is necessary, since due to its enormous economic and resource value, the e-waste industry is frequently a target for illegal trafficking (Vagliasindi et al., 2015).

In contrast, in Switzerland, tighter control over downstream inventories prevents free-riding and ensures compliance with environmental standards for recycling and proper disposal (Islam et al., 2018).

As mentioned in paragraph 2.3.1.2 for Italy and in 2.3.2 for Switzerland, retailers in the Switzerland offer consumers the possibility to bring back a device for free, while in Italy customers can return their device for free only if a new product of the same category is acquired.

As for the producers, the degree of responsibility they have can be financial or organizational, and it is set by regulations at a national level (Magalini et al., 2021).

The ERP scheme in Italy, which was introduced in 2011, is both financial and

organizational (Winternitz et al., 2019). Specifically, Italy has adopted a fully organizational responsibility, which stipulates that producers are completely responsible for the collection and treatment of e-waste ((Winternitz et al., 2019).

By contrast, in Switzerland, the producers bear only the financial responsibility, while the whole operational responsibility lies with the two biggest PROs, Swico and SENS, (Sinha-Khetriwal et al., 2005).

As earlier reported, Italy has 36 PROs, whilst Switzerland has a total of four. Winternitz et al. (2019), argued that the existence of multiple PROs represents challenges to ensure a proper supervision within a nation. This issue, in Italy, has been confirmed by episodes of material leakage, as reported by the authors.

Infrastructure

A study conducted by Gamberini et al., (2010), researched which are the elements included in the infrastructure that affect the e-waste functioning of a country. The authors (2010), identified the following ones:

- treatment facility where WEEE is processed and recycling takes place,
- the municipal WEEE collection points where outdated appliances are disposed,
- available resources, such as number of collection vehicles, capacity of vehicles used, and working days,
- collections routes which need to be covered on a regular basis.

Di Foggia and Beccarello (2021) observed that two of the mentioned factors are quite latent: waste management facilities and the collection points are not equally distributed across the country. According to the authors, the percentage of sorted waste varies among Italian regions, ranging from 29.55% to 73.95%.

Studies conducted in the Scandinavian countries have confirmed that lengthy transportation distances represent obstacles to a proper management of the WEEE recovery system (Ylä-Mellaa et al., 2014). Additionally, a study conducted by Massarutto (2010), proved that the system of waste management infrastructure in northern areas is more advanced compared to the southern one. The author claimed that Southern Italy and the islands fall short of their goals because of their undeveloped waste management system.

Based on a study carried out by Hobohm et al. (2017), which compared citizens' behavior in waste disposal in Italy and Germany, it was observed that Italy demonstrates a good

performance in collecting large household appliances since their oversized dimensions occupy significant space and also because the country offers a pick-up collection service for free. However, small equipment is very commonly stocked in Italian households. The authors argued that a possible explanation for the disparity in e-waste collection between large and small equipment could be attributed to the shortage of bins allocated in Italian cities specifically designed for e-waste. In comparison, German cities have a large number of bins strategically placed in close proximity to retail establishments or in neighborhoods, facilitating waste disposal for citizens (Hobohm et al., 2017). Again, this study, emphasizes the latent infrastructure in Italy.

In Table 1, all points reviewed and discussed in chapters 2 to 2.3 are summarized.

| | | **Switzerland** | **Italy** |
|---|---|---|---|
| **Collection rates (2021)** | | 15.0 kg/capita | 6.1 kg/capita |
| **Rules and regulations** | **Jurisdiction** | Ordinance on the Return, the Taking Back and Disposal of Electric and Electronic Equipment (ORDEE) | Legislative Decree n. 49/2014 |
| | **Monitoring** | Multi-level monitoring and tighter control over downstream inventories | ▪ Less monitoring and control of collecting and treatment facilities.<br>▪ Undocumented WEEE flows.<br>▪ Illegal sector accounts 1/3 of the WEEE produced. |
| | **Responsibilities** | Producers are responsible only for financing the correct disposal of e-waste, while operational responsibility and management of the system lies mainly with the two largest PROs.<br>Total of 4 PROs<br>Including two large PROs with clearly defined responsibilities. | Producers bear the financial and full operational responsibility.<br>Total of 36 PROs<br>The presence of 36 PROs in the country challenges the supervision at a national level. |

| | | | |
|---|---|---|---|
| | **Retail policy** | Zero-to-one policy: Retailers offer the possibility to bring back a device for free. | One-to-one policy: Retailers offer the possibility to bring back a device for free, only if a new comparable device of the same category is bought. |
| **Infra-structure** | **Collection network** | ▪ 591 Swico collection points (0.014 per $km^2$)<br>▪ 7'000 retailers (0.169 per $km^2$)<br><br>Collecting network of e-waste is well established throughout the whole country. | ▪ 4'279 municipal collection points (0.014 per $km^2$)<br>▪ 628 retailers (0.002 per $km^2$)<br><br>WEEE collecting network is less accessible in some areas, mostly in the Southern regions of the country due to latent infrastructure. |

*Table 1: Comparison of the e-waste systems of Italy and Switzerland.*
*Own representation based on literature review of sections 2-2.3.*

## 2.5 Citizens' Awareness

For both Italy and Switzerland, no data on citizens' awareness in the field of e-waste could be found so far. However, since e-waste is mostly generated by households, examining consumers' awareness of e-products can reveal crucial patterns in the waste production (Nguyen, 2019). Therefore, it is essential to have an understanding of the level of citizens' awareness and their attitude towards e-waste collection and recycling (Nguyen, 2019). Awareness is defined by Rousseau and Venter (1992) as the level of consciousness and understanding that individuals have regarding their rights and responsibilities within the marketplace. Among these rights, the authors (1992) state that "the right to be informed, the right to choose from alternatives, the right to be heard (ie. to redress), the right to safety and health in the consumption and the right to clean environment" are included.

However, there is a considerable gap across households regarding WEEE and their access to information (Islam et al., 2016). To address this issue, there has been an increasing interest in recent years in measuring the level of citizens' awareness of e-waste through studies conducted worldwide.

In the subsequent paragraph, some of the studies concerning public awareness on a global scale will be reported.

### 2.5.1 Citizens' Awareness Around the World

India, which recycles only 5% to 10% of the total e-waste generated, has been subject of various studies in the last decades, with the objective to understand the obstacles to proper e-waste handling (Sengupta et al., 2022).

A survey on citizens' awareness conducted in Bangalore by Awasthi and Li (2018), revealed that 69% of the participants were not aware of local e-waste rules and regulations. Most participants, however, expressed their willingness to increase their awareness of environmental issues caused by e-waste, in order to assist in mitigating them. The authors, therefore, emphasize the importance in understanding the present level of awareness among citizens regarding e-waste, environmental concerns, and its influence on human health. In a study performed in Delhi, Kwatra et al. (2014), confirm the importance of societal awareness in tackling e-waste. The authors found that a considerable proportion of the middle-class is still unaware of e-waste. As a consequence, due to lack of knowledge on effective recycling and disposal procedures, many households and institutions dispose of their e-waste in regular bins (Kwatra et al., 2014). Sivathanu's research (2016) on e-waste knowledge and attitudes in India, found a clear association between consumers' awareness and readiness to recycle e-waste, emphasizing again the crucial role awareness plays in ensuring efficient e-waste management. Moreover, the study revealed that education and income levels of awareness are significantly associated with their awareness of e-waste, respectively the first ones being 94.87% and the second 88.03% of the participants. By contrast, a study conducted in Nigeria did not find any significant relationship between respondent's degree of awareness and knowledge about e-waste management and their socio-demographic characteristics (Miner et al., 2020). On the other hand, the same study revealed that most Nigerians would be willing to participate in WEEE, if they are provided with the necessary information about the safe disposal and recycling procedures (Miner et al., 2020).

Poll data from another study carried out in Bangladesh (Islam et al., 2016), showed that households demonstrate a low level of awareness regarding environmental issues, making WEEE management particularly challenging for them. The survey indicated that only a

small percentage of households (9%) was aware of WEEE and of its harmful influence on health and environment (Islam et al., 2016). Moreover, it was observed that only 3% of households were aware of valuable elements that can be extracted from WEEE through proper recycling (Islam et al., 2016). By contrast, a study in Northwest China (Ramzan et al., 2019) indicated that respondents had a strong environmental consciousness, however, they exhibited an insufficient awareness on e-waste related laws, regulations, and recycling programs.

In Jordan, the results of an awareness questionnaire demonstrated that individuals who were aware of the presence of valuable components in e-waste, also showed a higher level of overall knowledge on the topic (Tarawneh & Saidan, 2013).

Perez-Belis et al. (2015), instead, investigated consumer behavior in the context of waste originated from electrical and electronic toys in Spain. The authors (2015) found out that 67% of individuals discard the toys in their domestic bins, mainly due to insufficient awareness of proper e-waste disposal. Islam et al. (2021) in a study conducted in Sydney, highlighted that knowledge of local collection points and understanding of recycling schemes is fundamental to avoid incorrect disposal behavior.

As for comparative analysis conducted between two countries, Islam et al. (2018) compared the Australian e-waste management system to the Swiss one. The results of the survey on public awareness of e-waste and collection points conducted in Australia, showed that 90% of the participants weren't aware of the local recycling scheme, while 60% were unfamiliar with permanent collection points (Islam et al., 2018).

These studies arrive at the same key finding that increasing awareness of e-waste can lead to improved recycling behavior. While some research place emphasis on the importance of citizens` awareness regarding the environmental and human health impacts of e-waste, others stress the importance of households being aware and informed about regulatory frameworks.

The finding is further supported by Bamberg and Möser (2007), who, however, reinforce the concept by emphasizing the importance of individual responsibility. The authors state that individuals face challenges in feeling a sense of responsibility towards performing a certain behavior if they lack awareness of the potential consequences of their own actions. In contrast, when consumers have an understanding of environmental issues and are aware that recycling plays a significant role in mitigating them, they tend to feel incentivized to engage in recycling (Bamberg & Möser, 2007). Decades ago, Fishbein and Ajzen (1975) argued that people who are aware of the benefits of recycling, such as

reduced pollution, less depletion of natural resources, and a better environment for future generations, and who highly value these outcomes, are more likely to favor recycling. Schwartz (1977) also claimed that when individuals have a greater understanding of the consequences of recycling, they become more conscious of the impact their actions have on others and on the environment. According to the author (1977) awareness of consequences refers to a person's inclination to link their behavior to the wellbeing of others and the ascription of responsibility is the individual's personal sense of accountability for the outcomes of their actions.

As a result, it is assumed that also awareness of the outcomes of recycling will play a critical role in shaping attitudes toward recycling (Bamberg & Möser, 2007).

# 3. Methodology

To address the research question outlined in section 1.2, a combination of primary and secondary data has been used.
This chapter delivers an overview of all methods employed, starting with the secondary research, which was used in the first part in the form of a literature review (see chapter 2), then moving forward describing the collection of primary data through a quantitative online survey.

## 3.1 Secondary Research

Data collection is a necessary aspect for conducting research. The method of gathering data is selected based on the research goals and its appropriateness for the specific type of analysis to be conducted (Mazhar et al., 2021). Two types of data, primary and secondary, can be utilized (Mazhar et al., 2021).
Secondary Data refers to data which have previously been collected by another party and have already undergone the statistical process (Hox & Boeije, 2005; Mazhar et al., 2021). Since someone else has collected the data, secondary analysis offers advantages in terms of cost-effectiveness and convenience (Mwita, 2022). This research methodology consists in the technique the researcher uses to gather, examine, and evaluate existing collected data specifically for its own study (Creswell, 2007). It also serves as a primary step to acquire relevant information and contextualize the research topic within existing literature (Puch, 2003).
The conduction of a thorough literature search of available information on the investigated topic enables the identification of potential gaps that require further exploration and can be addressed through the collection of primary data (Creswell, 2007).
In this study, secondary research was used in the form of a literature review to provide an overview of the e-waste recycling systems of Switzerland and Italy and their distinctive differences. For this section, the following sources were utilized: reviews, published books, journal articles, governmental and companies reports as well as legislations.

## 3.2 Primary Research

Primary data refers to data gathered for the first time (Mazhar et al., 2021). This type of data is collected using methods that are best suited for a specific research problem (Hox

& Boeije, 2005). To date, the level of public awareness in Italy and Switzerland in e-waste has not been researched. Therefore, to answer the research question, quantitative research was employed in this thesis.

Saunders et al., (2009) noted that the approaches employed to gather primary data are observation, interviews, questionnaires, and database analysis. The authors claimed that the questionnaire is the most popular data collection method used, as it provides an effective way to gather meaningful data from a sample as each participant is asked the same set of questions. According to Robson (2002) standardized questions ensure that all participants have all the same interpretation, resulting in accurate findings.

In this thesis, the conduction of a quantitative survey aimed at Swiss and Italian citizens allowed for an in-depth exploration of citizen awareness in the context of e-waste recycling in both countries.

The subsequent paragraphs will provide an overview of the survey administration, its structure, and content. Thereafter, the data analysis process will be shown, followed by the presentation of the sampling design to conclude the methodology chapter.

### 3.2.1 Survey Outlining and Administration

The questionnaire utilized in this study was developed based on a combination of prior research on e-waste awareness conducted in countries worldwide. Studies discussed and literature reviewed in section 2.5 were considered during the questionnaire development. Moreover, for the creation of the survey, part of the design proposed by Nguyen (2019) for research on consumers' awareness was taken into account.

Data collection began on Monday 01. May 2023 and was concluded on Tuesday 09. May 2023. To guarantee that the questionnaire was understandable to all participants, two steps were previously taken. Firstly, the survey was also translated into the Italian language. Secondly, a pretest was conducted prior to the survey. For this, the two language versions of the questionnaire were reviewed by four individuals from Switzerland and Italy in their respective languages.

After being reviewed, the questionnaire was set up using the online survey tool Qualtrics (https://www.qualtrics.com). The participation was limited to individuals currently residing in Italy or Switzerland. Given the anonymity of the survey, the location of residence was verified by using two questions on the current place of living ("In which country do you live?", "In which city do you live?").

### 3.2.2 Structure and Content of the Questionnaire

The questionnaire consisted of a total of 19 questions, including five focusing on demographic information (see Appendix 1).

The majority of the questions in the survey, twelve, utilized a rating scale. Among these, eight questions required participants to provide a numeric rating on a 10-point scale to assess their level of awareness on a specific topic, with 1 representing very low awareness and 10 indicating a very high one. The last three questions utilized the Likert-style rating scale for agreement or disagreement about a statement, with 1 indicating "I strongly disagree", and 10 "I strongly agree".

In order to prevent confusion among the participants, questions were all presented in straight lines. Moreover, the same order of response categories was kept (Dillman, 2007).

One question allowed open-ended responses, enabling participants to specify their city of residence. In addition, there were five single-choice and one multiple-choice question.

As for the structure, the questionnaire was divided into an introduction section and the questionnaire section itself.

The introduction section of the questionnaire provided an overview of the study's purpose and emphasized the importance of providing truthful answers to ensure accurate results. The introduction assured respondents that their personal information will remain anonymous and confidential.

The questionnaire was divided into five blocks: (1) Demographic information, (2) General e-waste awareness, (3) Rules, regulations, and infrastructure awareness, (4) Awareness of e-waste composition and consequences, (5) Awareness of responsibility, (6) Possible measures.

The first section collected socio-demographic information on participants' age range, educational attainment, annual income brackets, and place of living.

The following section assessed the respondents' awareness of the topic of e-waste in general and their knowledge on the definition of e-waste.

The third block measured the awareness citizens have about e-waste rules and regulations, as well as the infrastructure of their own region.

The succeeding consequences section explored the awareness citizens have about the materials e-waste contains and the consequences released materials might have on the environment and on human health.

The responsibility part investigated to which extent participants are aware of their obligations in the field of e-waste as citizens.
Lastly, in the final section, participants were asked about outcomes of increased awareness and their perspective on the most effective way to ensure that necessary information reaches all people in the future.

### 3.2.3 Data Analysis

As raw quantitative data lacks meaningful interpretation, it is essential to process and analyze these data in order to make them valuable and to transform them into useful information (Saunders et al., 2009). Graphs, charts, diagrams, and statics facilitate the presentation and description of relationships and trends obtained from quantitative analysis. Moreover, thanks to statistical measures, comparisons can be made (Saunders et al., 2009).
There are two types of quantitative data: "categorical data", which consists of non-numerical values and "numerical data", also known as "quantifiable data" (Brown et al., 2008). In this survey, the data collected is mainly "numerical data", which can be measured or counted numerically as quantities (Brown et al., 2008). Compared to "categorical data", "numerical data" is considered to be more precise, as it offers greater accuracy since each data value can be assigned a position on a numerical scale (Saunders et al., 2009). "Categorical data" was used only in a few questions, mainly in the demographic section and in the measures block.
After entering data, individual answers were reviewed and controlled, to identify potential errors (Saunders et al., 2009). Although for all questions it was mandatory to select an answer, two responses were incomplete. In these two particular cases, the survey was partially shown to the participants, which did not enable them to entirely view and complete the survey. The two invalid responses were therefore excluded and not considered in the data analysis.
The following step was to start the analysis process of the answers. To provide valuable insights for analysis based on the responses received from participants, a range of descriptive statistics were used. To assess the statistical significance of differences in feedback between the two groups, namely Italian and Swiss citizens, t-tests, chi-square tests and Fisher's exact tests were employed.

The independent t-test was used to assess differences between the mean of the two given samples for variables measured with 1-10 scales. The chi-square test (if both variables only have two groups) and Fisher's exact test (more than two groups) were used to compare categorical variables respectively.
Using the tests, a p-value was calculated to assess the statistical significance (using p-value <.05).

### 3.2.4 Sampling Design

According to Saunders et al., (2009), in survey-based research methodology, representative sampling has the potential to generate findings that are representative of the entire population. Collecting data from a sample of the population enables researchers to address the research questions or achieve specific goals.
The size of the total inhabitants is approximately 59.1 million for Italy (The World Bank, 2022a) and around 8.7 million for Switzerland (The World Bank, 2022b).
Therefore, in this study, the necessary sample sizes were calculated using the adjusted formula for very large population sizes, as proposed by Bartlett et al. (2001):

$$n = \frac{t^2 * p(1-p)}{d^2}$$

For the calculation, the following criteria were considered: a standard deviation (p-value) of 0.5 and a margin of error (d-value) of 10%. As for the confidence level, a margin of 90% was selected, which results in a t-value of 1.65.
Based on these calculations, a minimum sample size of 68 individuals per country was determined. Since 71 individuals participated for Italy and 78 for Switzerland, this requirement for representativeness is satisfied.
The sampling technique used in this research is a non-probability sampling, precisely a self-selection sampling. This approach allows individuals to voluntarily participate, based on their interest in the research subject and their willingness to engage (Thornhill et al., 1997). For this thesis, to reach a high number of possible participants in both countries, the questionnaire was promoted on various social media, with the request to further share the survey with contacts. Individuals were invited to participate by clicking on a link, which redirected them to the online questionnaire.

# 4. Results

In this chapter, the results of the quantitative online survey are presented in two main blocks: the first focuses on the socio-demographic profile of the participants whilst the second describes the questionnaire results.

In the socio-demographic paragraph, all five questions of the block will be presented, while in the questionnaire section, the results of each survey block will be individually shown in detail in a correspondent subsection. The responses are presented in tables and graphs, reporting the results for each country.

## 4.1 Socio-Demographic Data

Table 2 presents socio-demographic data for all 149 participants, 78 residing in Switzerland and 71 in Italy. The table provides a detailed breakdown of the participants' profiles from both countries, including characteristics such as age category, educational attainment, and income.

| | Switzerland n | Switzerland % | Italy n | Italy % | Total n | Total % | p-value |
|---|---|---|---|---|---|---|---|
| Country of residence | | | | | | | - |
| Switzerland | 78 | 100% | 0 | 0% | 78 | 52.3% | |
| Italy | 0 | 0% | 71 | 100% | 71 | 47.7% | |
| Age | | | | | | | .698 |
| < 20 | 1 | 1.3% | 2 | 2.8% | 3 | 2.0% | |
| 20-30 | 37 | 47.4% | 31 | 43.7% | 68 | 45.6% | |
| 31-40 | 25 | 32.0% | 25 | 35.2% | 50 | 33.6% | |
| 41-55 | 14 | 18.0% | 10 | 14.1% | 24 | 16.1% | |
| >55 | 1 | 1.3% | 3 | 4.2% | 4 | 2.7% | |
| Highest degree | | | | | | | **<.001** |
| No degree | 0 | 0.0% | 7 | 9.9% | 7 | 4.7% | |
| High School | 20 | 25.6% | 27 | 38.0% | 47 | 31.5% | |
| Bachelor | 31 | 39.7% | 12 | 16.9% | 43 | 28.9% | |
| Graduate | 19 | 24.4% | 22 | 31.0% | 41 | 27.5% | |
| Other | 8 | 10.3% | 3 | 4.2% | 11 | 7.4% | |
| Yearly income | | | | | | | **<.001** |
| <25'000 | 6 | 7.7% | 49 | 69.0% | 55 | 36.9% | |
| 25'000-49'999 | 12 | 15.4% | 15 | 21.1% | 27 | 18.1% | |
| 50'000-100'000 | 34 | 43.6% | 5 | 7.0% | 39 | 26.2% | |
| >100'000 | 26 | 33.3% | 2 | 2.8% | 28 | 18.8% | |

*Bold items are significant at p<.05 level.*

*Table 2: Socio-demographic information of survey participants (n=149)*

Age range

In the survey, the two least represented categories were the youngest and the oldest blocks. Precisely those below 20 years old, were represented by 1 respondent from Switzerland and 2 from Italy, while individuals above 55 years old, were 1 respondent from Switzerland, and 3 from Italy.

In both countries, the greatest number of responses received fell into the category of 20-30 years old, with 47.4% in Switzerland and 43.7% in Italy.

The next two age groups were those between 31-40 years old, with 32% survey takers for Switzerland and 35.2% for Italy, and those between 41-55 years old, with 18% respondents for Switzerland and 14.1% for Italy.

There were, however, no significant differences in the age distribution between the two country samples ($p = .698$).

Educational attainment

Among Swiss participants, the most prevalent category of education was the bachelor's degree group, accounting for 39.7% of the respondents, followed by high school degrees at 25.6% and graduate degrees at 24.4%.

By contrast, in Italy, high school degrees were the most predominant category, representing 38%. Graduate degrees ranked second with 31% and bachelor's degrees third with 16.9%.

For both countries, the least represented categories were the ones with no degrees and other degrees.

The survey results showed significant differences in the highest degree earned ($p < .001$) between the two countries.

Income

While in Italy most of the participants, 69%, reported a yearly income below EUR 25'000, making it the predominant category, in Switzerland only 7.7% of the participants fell into this income category.

The most prevalent income category among Swiss participants was the range of EUR 50'000-100'000, which accounted for 43.6% of the responses. By contrast, in Italy, this category was represented by only 7% of survey takers.

In Switzerland, approximately one-third of the participants belonged to the category of

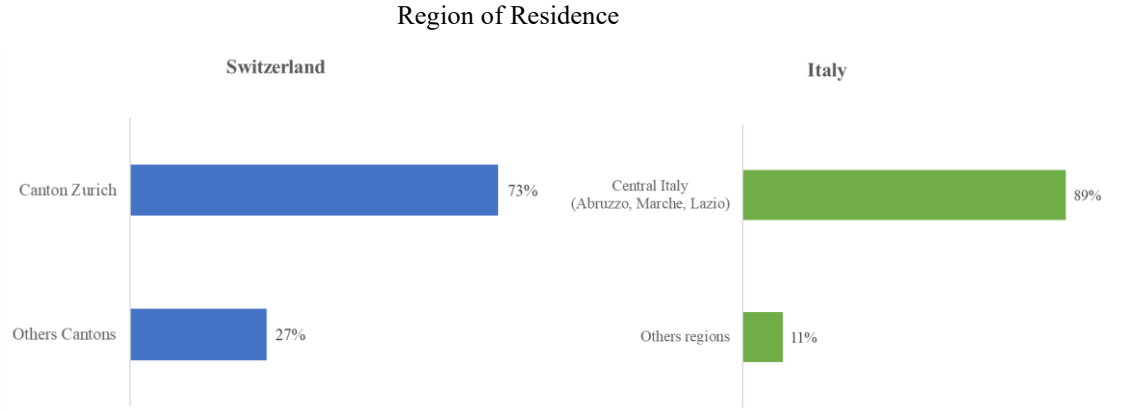
an annual salary above EUR 100'000, whereas in Italy the category was represented by only 2.8% of the participants.

The results indicated a statistically significant difference between the two countries with $p < .001$.

City of Residence

Figure 1 illustrates that 73% of survey takers in Switzerland resided in the region of Zürich, with 58% living in the city itself and 15% in other cities within the Canton. The remaining 27% stated to live in other regions of the country.

In Italy, 89% of the participants are located in Central Italy, with 49% specifically residing in the region of Marche, 35% in Abruzzo and 4% in Lazio. The remainder (11%), stated to live in different regions outside the central area.




*n=149*

*Figure 1: City and regions of residence of survey participants*

## 4.2 Questionnaire Results

After having analyzed the demographic information of the participants, this section will present the results of the five questionnaire blocks.

### 4.2.1 General Awareness on E-Waste Recycling

The table below (Table 3) presents the participants' responses to the first question regarding their general awareness of e-waste recycling.

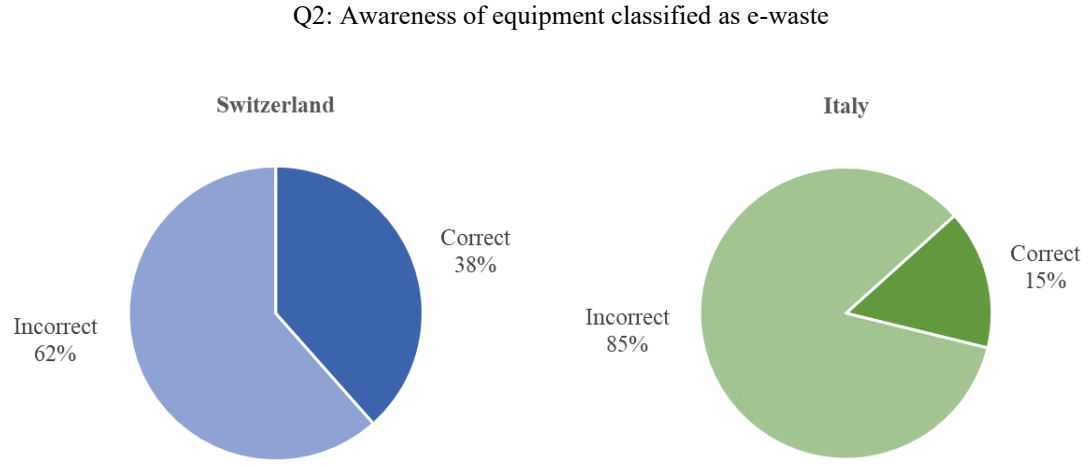
| | Switzerland mean | Italy mean | Total mean | p-value |
|---|---|---|---|---|
| **General awareness of e-waste** | | | | |
| Q1. General awareness level | 6.01 | 5.03 | 5.54 | **.006** |

*Bold items are significant at p<.05 level; n=149.*

*Table 3: Participants' general awareness of e-waste recycling*

For both countries, the general awareness level of e-waste recycling, measured on a scale from 1 (very low) to 10 (very high), fell around the midpoint, 5.54. The participants' average awareness level in Italy was 5.03, while in Switzerland it was 6.01. As reported in Table 3, the differences between the two means were statistically significant (p = .006).

The observed difference is supported by the follow-up question in which survey takers were asked to select the type of devices which, per definition, are considered e-waste. The question was presented in a multiple-choice format. As illustrated in Figure 2, while 38% of participants in Switzerland identified the correct answers, only 15% of participants in Italy were able to answer it accurately. As the difference also showed statistical significance (p =.002), it further confirmed the contrast of e-waste awareness levels between the two countries.




***p = .002*** *(significant at p<.05 level); n=149*

*Figure 2: Participants' awareness of equipment classified as e-waste*

### 4.2.2 Awareness on Rules, Regulation, and Infrastructure

The third question required participants to assess the extent of their awareness of local rules and regulations in the field of e-waste, while in the fourth question, they were asked to evaluate their information level regarding proper disposal of e-waste.
The respondents' answers are presented in the following Table 4.

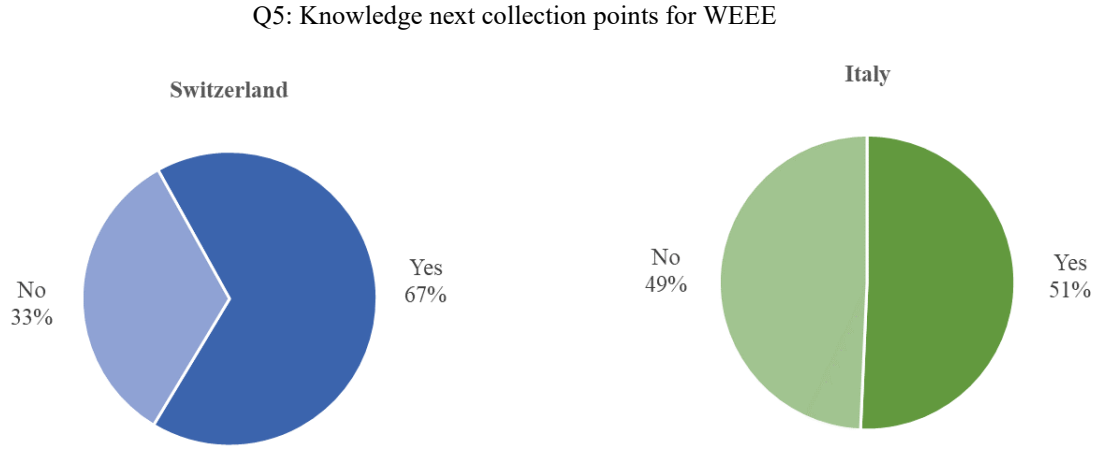
| | Switzerland mean | Italy mean | Total mean | p-value |
|---|---|---|---|---|
| **Awareness of rules, regulations and infrastructure** | | | | |
| Q3. Awareness level of local recycling rules and regulations | 5.12 | 4.17 | 4.66 | **.009** |
| Q4. Information level of proper disposal of e-waste | 5.65 | 4.68 | 5.19 | **.011** |

*Bold items are significant at p<.05 level; n=149.*

*Table 4: Participants' awareness of local rules, regulations, and infrastructure*

As illustrated by the table, the average score for the awareness level of local rules and regulations on e-waste recycling was below the midpoint for both countries (4.66). Switzerland demonstrated an average score of 5.12, while Italy had the lowest average value of the entire survey, with a rating of 4.17 for this question.
The associated p-value at .009 indicated that the difference was statistically significant. Regarding the information level of proper e-waste disposal, the total mean was 5.19, once again below the midpoint. Likewise, with an average of 5.65, Switzerland reached a significantly higher score compared to Italy, which recorded an average score of 4.68.
With a p-value of 0.011, also this difference can be classified as statistically significant.

The results of question four, were verified with a follow-up question. Specifically, in the fifth question, participants were asked if they know where the next collection points close to their homes are. To answer the questions, participants had to select between two options: "yes" or "no".
The 67% "yes" responses for Switzerland and 51% "yes" for Italy (Figure 3), further supported the results of the previous questions but did not indicate statistical significance.




*p = .066 (not significant at p<.05 level); n=149*

*Figure 3: Participants' knowledge of the local collection points for WEEE*

### 4.2.3 Awareness of E-Waste Consequences

Questions six and seven asked participants to rate the extent of their awareness level of the impact e-waste has on the environment and on human health. Questions eight and nine, aimed to assess participants' level of awareness regarding the presence of harmful or precious components in e-waste.

As displayed by the underlying Table 5, for all four questions included in this block no statistical significance between the average scores of the two countries was found.

| | Switzerland mean | Italy mean | Total mean | p-value |
|---|---|---|---|---|
| **Awareness of consequences** | | | | |
| Q6. Awareness of impact e-waste has on the environment | 6.17 | 5.86 | 6.02 | .388 |
| Q7. Awareness of impact e-waste has on human health | 5.64 | 5.63 | 5.64 | .984 |
| Q8. Awareness harmful components of EEE | 5.71 | 5.08 | 5.41 | .090 |
| Q9. Awareness precious components of EEE | 5.72 | 5.39 | 5.56 | .414 |

*Bold items are significant at p<.05 level; n=149.*

*Table 5: Participants' awareness of e-waste consequences*

In this section, Switzerland scored overall slightly higher than Italy. Both Swiss and Italian citizens demonstrated that they were most aware of the environmental impact of e-waste, scoring respectively 6.17 and 5.86.

As for the consequences e-waste has on human health, both countries rated almost the same level, 5.64 for Switzerland and 5.63 for Italy.

In Italy, the lowest level of awareness was represented regarding the harmful components contained in EEE, with a score of 5.08, while Switzerland had a score of 5.71. Finally, the awareness of precious materials contained in EEE was rated 5.72 in Switzerland and 5.39 in Italy.

### 4.2.4 Awareness of Citizens Responsibility

In question 10, citizens were asked to assess their awareness level of personal responsibility as citizens. As demonstrated by the results presented in Table 6, a significant difference was observed.

| | Switzerland mean | Italy mean | Total mean | p-value |
|---|---|---|---|---|
| **Awareness of personal responsibility** | | | | |
| Q.10 Awareness of personal responsibility as a citizen | 6.55 | 5.07 | 5.85 | **<.001** |

*Bold items are significant at p<.05 level; n=149.*

*Table 6: Participants' awareness of their personal responsibility as citizens*

Italian citizens scored an average value of 5.07, whereas Swiss participants demonstrated a substantially higher average of 6.55, the highest deviations in means observed in all questions.

### 4.2.5 Possible Measures

In questions 11 to 13, where the Likert scale was used, participants were requested to rate their agreement or disagreement with the statements provided on a scale of 1 (strongly disagree) to 10 (strongly agree).
The results are represented in the table below (table 7).

| | Switzerland mean | Italy mean | Total mean | p-value |
|---|---|---|---|---|
| **Measures: Impact on recycling behavior** | | | | |
| Q.11 Better awareness of impact of e-waste on the environment | 7.72 | 7.54 | 7.63 | .571 |
| Q.12 Better awareness of local rules and regulations | 7.36 | 7.59 | 7.47 | .468 |
| Q.13 Better awareness of impact of citizens behavior | 7.71 | 7.62 | 7.66 | .796 |

*Bold items are significant at p<.05 level; n=149.*

*Table 7: Increased awareness outcomes*

In question 11, participants were asked to express their level of agreement or disagreement regarding whether increased awareness of the impact e-waste has on the environment would likely affect their recycling behavior. Both countries achieved relatively high scores, with Switzerland having an average of 7.72 and Italy 7.54.

In question 12, respondents had to rate whether better awareness of local rules and regulations would likely affect their recycling behavior. This statement received an average rating of 7.36 from Swiss citizens and 7.59 from Italians.

Question 13 required participants to rate whether a better awareness of the impact a citizen has would influence their recycling behavior. The average rating for this statement was 7.71 for Switzerland and 7.62 for Italy.

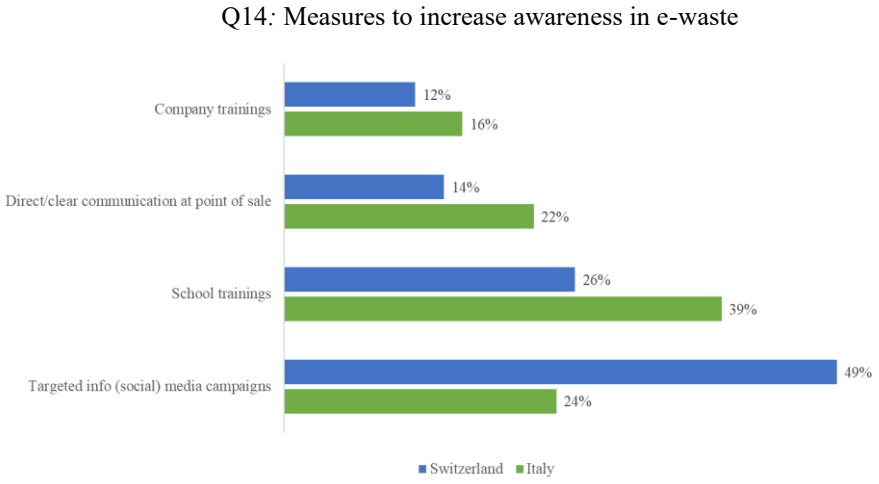
Overall, the total mean for all three statements was relatively high, varying between 7.47 and 7.66. All three questions did not exhibit a significant difference in means between the two countries.

In the last question, represented in Figure 4, participants were asked to select one of the four proposed options to increase awareness among citizens. The results demonstrated a strong orientation of Swiss citizens towards media and social networks campaigns, which ranked first with of 49%, followed by training in schools with 26%.

By contrast, for Italy, the most voted option was training in schools with 39%. The second and third most preferred options were (social) media campaigns with 24% and direct and clear communication in retailer centers with 22%.

For both countries, the least favorite option was training in companies.

The differences in results between the two countries were statistically significant (p=.024).




***p = .024*** *(significant at p<.05 level); n=149*

*Figure 4: Possible measures to increase awareness on e-waste*

# 5. Discussion

Through an analysis of citizen awareness on e-waste and its associated consequences, this bachelor thesis aims to investigate whether there are variations in the degree of awareness between Italian and Swiss citizens within this area.
This chapter deals with the discussion of the obtained results from the quantitative online survey linking them with the theoretical framework of chapter 2. This discussion chapter provides insights to answer the research question.

## 5.1 Awareness on E-Waste and Associated Rules, Regulations, and Infrastructure

The aim of the first two blocks of the survey, respectively questions 1 to 5, was to assess any differences in the level of general awareness between the two populations concerning e-waste, including their knowledge of local regulations and the related infrastructure.
As Swiss citizens are seen as actively engaged in following rules and in returning their appliances to the official collection points or to retailers (Bothakur & Govind, 2017), it is expected that they exhibit a higher level of general awareness regarding e-waste and its recycling scheme compared to Italy.
Moreover, as reported in the literature review in section 2.5.1, research in countries with lower recycling rates such as India, China, Nigeria, or Spain have measured low levels of citizens' awareness regarding e-waste. These studies have emphasized that lack of information on appropriate WEEE disposal among citizens hinders the effectiveness of the recycling system of the country.
The analysis of data shows that Italians generally have a lower level of public awareness in the field of e-waste compared to Switzerland. Moreover, it can be observed that most Italian participants possess limited awareness of the national recycling scheme and official collection points.
In Italy, the detected lower awareness level of regulatory framework could suggest a similar behavior pattern observed among the Spanish and the Indian population, such as disposing of small IT-equipment in municipal bins or hoarding them at home (Perez-Belis et al., 2015; Kwatra et al., 2014). This conclusion was also drawn by Islam et al. (2018) in their comparative study between Switzerland and Australia, as 60% of Australian citizens stated to be unfamiliar with the local collection points. Indeed, the authors pointed

out that missing knowledge regarding the next collection points is a severe drawback for the Australian e-waste recycling efforts.
The results of this thesis show that 49% of Italians and 33% of Swiss citizens also report missing knowledge of their next collection point. This suggests that the Italian government and stakeholders should consider measures to inform citizens on their local recycling infrastructure.

As for Switzerland, the country shows a comparatively higher level of awareness in the field of e-waste regulatory frameworks. However, the average ratings of 5.12 for local regulations and 5.65 for collection points indicate that there is still room for improvement not only in Italy, but also in Switzerland.

## 5.2 Awareness of E-Waste Consequences

The objective of this questionnaire section was to evaluate whether there are discrepancies in the awareness of e-waste consequences between the two countries.
Besides being considered highly diligent when it comes to fulfilling their legal duties, Swiss citizens are also recognized as conscientious about climate change (Islam et al., 2018, Bhotakur & Govind, 2017; Sinha-Khetriwal et al., 2005).
As demonstrated by the findings of the studies of Miner et al. (2020) and Awasthi and Li (2018), individuals tend to engage in recycling when they are aware of environmental issues caused by e-waste. Furthermore, in the ranking of the Environmental Sustainability Index, a tool for measuring a country's environmental performance, Switzerland was placed first in 2018, while Italy 16 (Environmental Performance Index, 2018).
Therefore, also here, it is expected that Swiss citizens exhibit a higher level of environmental consciousness and awareness concerning toxic effects on human health, explaining their higher contribution to e-waste compared to Italians.
However, this expectation is not particularly met. Both groups present a comparable degree of awareness on these two aspects. Similar results are also observed on the awareness about EEE precious and hazardous components.
A comparable pattern was observed in the research conducted by Ramzan et al. (2019) in Northwest China. As reported in paragraph 2.5.1., the respondents, despite showing minimal awareness level on e-waste regulatory frameworks, demonstrated a strong environmental consciousness.

Furthermore, additional explanation could be found by referring to a study conducted by Golob and Kronegger (2019), which investigated environmental consciousness of European consumers. The research revealed that 50% of citizens fell into the groups of moderate to high environmental segments. The remaining half also demonstrated a significant level of environmental consciousness, but with a reduced willingness to make personal sacrifices for the environment. Consequently, it can be concluded that Europe is generally experiencing a positive trend in terms of growing awareness of environmental issues (Golob & Kronegger, 2019).

Thus, based on the findings regarding awareness of consequences related to e-waste it can be concluded that this factor is not the main explanation for the observed awareness variation in the field of e-waste between the two countries in this case study.

## 5.3 Awareness of Citizens Responsibility

As presented in paragraph 4.2.4, a large discrepancy between the two countries was found in the section of awareness of civic responsibility.

The higher score of awareness observed among Swiss citizens could be attributed to the concept of individual responsibility which plays a significant role in the Swiss society, even being prominently mentioned in the Federal Constitution of the Swiss Confederation (The Federal Council, 2022a). Article 6, titled *Individual and collective responsibility*, outlines the following concept:

"*All individuals shall take responsibility for themselves and shall, according to their abilities, contribute to achieving the tasks of the state and society*".

The existence of this clause in the constitution emphasizes the importance placed on individual responsibility and social engagement in the country.

These results align with the concept of individual responsibility highlighted by Bamberg and Möser (2007). As discussed in paragraph 2.5.1, the authors claimed that individuals are more likely to perform a recycling behavior when they feel a sense of responsibility towards performing such behavior.

Concurrently, this idea can be applied to the case of Italy. As individuals do not understand their personal responsibility as citizens in the field of e-waste, it can be assumed that they are also less likely to engage.

Another interpretation can be provided by the research conducted by Rhein and Schmid (2020) on consumers' awareness of plastic packaging in Germany. The study found out

that citizens, even though they were aware of the environmental impact of plastic, tended to not feel personally responsible for addressing this issue. The authors claimed that citizens believed they lacked the ability to influence the current situation, feeling a sense of powerlessness. Moreover, according to the authors, individuals believed that the situation is in the hands of the companies or the government.

These patterns of awareness could be an explanation for the lower level of awareness of personal civic responsibility observed among Italian citizens. Lacking an extensive understanding of the existing framework and regulations concerning e-waste management, Italians rely on the government to take the required measures to tackle the issue.

## 5.4 Possible Measures

The results of the last block show that an increased awareness in three areas, namely impact of e-waste on the environment, rules and regulations as well as consequences of individual behavior, would likely have a significant impact on citizens' recycling behavior.

Hence, the results are in line with other studies that demonstrated consumers' willingness to support sustainable e-waste management practices for the preservation of the environment and human health (Miner et al., 2020; Kwatra et al., 2014). However, in this study, it is observed that Italians already have a relatively high awareness level of the environmental harm related to e-waste, suggesting that awareness of this issue alone might not be sufficient to change behavior. This could imply that clear rules and regulations and citizens' awareness of these rules might be a more important factor for success, followed by the awareness of personal responsibility as a citizen.

As for the favored source of information, the large preference of Swiss citizens for a media campaign could be attributed to the higher level of trust Swiss citizens place in the media compared to Italy. A study performed by Newman et al. (2022) examining how news is consumed across the globe, revealed that 46% of Swiss citizens trust the media, whereas in Italy the figure is only 35%. The report also highlighted that trust has decreased in Italy in the past years. In fact, only 13% of the population think that Italian media is free from political manipulation and only 15% from business influence. While Swiss citizens declared to rely on public broadcasters as well on local and quality newspapers (Newman et al., 2022).

By contrast, Italians exhibit a greater reliance on formal education, implying that they perceive school training as a trustworthy and most effective source of information. In fact, in an annual questionnaire carried out in Italy to assess the level of trust placed in institutions, organizations and social groups, schools have ranked as fourth most trusted category since 2012. Education institutions are placed just behind the police forces, the Pope, and the President of the Republic (Demos, 2022).

## 5.5 Answering the Research Question

The survey findings indicate that there are significant differences in awareness between Italian and Swiss citizens in the field of e-waste, aligning with the statement of Bothakur and Govind (2017), that consumers' awareness regarding e-waste varies across different countries.

One of the most notable discrepancies is found in the level of awareness of local regulatory framework. Indeed, Italians have limited awareness and knowledge concerning e-waste recycling programs and the related infrastructure, despite being conscious about the harm e-waste represents for the environment and human health.

In fact, no substantial disparities are found between the two countries regarding awareness of the environmental and human consequences related to e-waste.

Furthermore, the analysis of data indicates that there is a lower sense of individual responsibility as citizens among Italian participants compared to Swiss.

The higher average scores in Switzerland in terms of both regulatory frameworks and personal responsibility, indicate that these two are the primary areas to focus on for further improvement.

Although both Italian and Swiss citizens demonstrate a potential willingness to adjust their recycling behavior with increased awareness, it is important to recognize that citizens cannot achieve this alone. Instead, there is the need of all actors involved in the e-waste management system to take necessary actions.

As previously cited, the definition of awareness involves the right to access information. This study identifies relevant aspects of citizens' awareness, which should be taken into account by the responsible authorities involved in the promotion of information, ensuring that information effectively reaches the citizens.

While Swiss residents wish information and communication related to e-waste to be promoted via media channels, Italians would prefer the topic to be integrated into the

school system, making it part of formal education in schools. This hints that there is no "one-size-fits-all" concept to raise awareness levels in different countries, but that measures should be tailored to the respective country and its citizens.

# 6. Conclusion

## 6.1 Summary of Thesis

This study aimed to provide an understanding of the current e-waste management system, focusing on citizens' awareness in two specific countries, namely Italy and Switzerland. Over the past decades, the e-waste management system has been facing challenges due to exponentially rising e-waste streams. To address this issue, the circular economy approach has been proposed, which in a cyclical flow reintegrates resources in the supply chain of a business. For a successful implementation of the closed-loop economy, it is crucial for resources and materials to be correctly disposed of, collected, and recycled. To overcome these challenges, governments worldwide have introduced various regulatory frameworks and developed the associated infrastructure.

While Switzerland introduced e-waste regulations in the early 1990s, Italy became operational in the e-waste sector more than a decade later. Today, the two countries have different collection targets, with Switzerland collecting an average of 15 Kg/inh, whereas Italy falls behind with just over 6 Kg/inh.

To understand these variations, studies have investigated the e-waste sector, focusing on a wide range of stakeholders involved, including government, producers, retailers, municipalities, PROs and the recycling facilities, but not on citizens.

Existing literature indicates that Switzerland and Italy have diverse regulations and different distribution of responsibilities among the actors involved. Additionally, the infrastructure varies, with Switzerland having a higher density of collection points per $km^2$ compared to Italy (Table 1). Lastly, in Italy, it was observed that the informal sector plays a significant role in the country's management system.

Nevertheless, if consumers are not aware of correct disposal behavior and of local rules and regulations, the recycling efforts will never meet satisfactory standards.

Bothakur and Govind (2017) claimed that citizens' awareness is the key determinant factor for the long-term success of the e-waste management system. Therefore, understanding the current level of awareness among citizens in a specific country is central (Ramzan et al., 2019).

Thus, through a comparative analysis, this study aimed to assess whether there are differences in the e-waste awareness levels of the two countries.

The findings of this study demonstrate that there are notable variations in the awareness levels between Italy and Switzerland. Two specific areas that require particular attention in terms of citizens' awareness are the local regulatory framework and the awareness of personal responsibility within the society.

Italians indicated a limited level of awareness and knowledge of regulations as well as of the related infrastructure. However, the study demonstrates that citizens would be willing to collaborate if they had a better awareness of these topics.

In conclusion, the study emphasizes the significance of assessing the level of citizens' awareness in order to identify and understand specific areas to focus on for improvement.

## 6.2 Recommendations

Based on this study's findings, Italy should focus on improving awareness of regulatory frameworks and of the individual responsibility within society.

The study identified valuable points that can guide the implementation of measures to increase households' awareness and encourage behavioral change. As emphasized by Miner et al. (2020), the initiation of awareness-promoting campaigns is necessary to encourage responsible e-waste management.

In Italy, the adoption of a proactive educational strategy could ensure that individuals and the next generations are informed about e-waste and understand their obligations. This could motivate citizens to actively engage in the handling of e-waste and contribute to a sustainable future. In addition, the government should make sure that citizens are well informed and aware of their obligations. Italy could learn from the Swiss government's approach, which emphasizes personal responsibility of each citizen in actively contributing to accomplish the objectives of the state and the society.

In contrast, Switzerland should work on improving the awareness level of its citizens specifically regarding e-waste rules and regulations by actively promoting awareness campaign through various media channels.

## 6.3 Limitations

In this section, the limitations of the results presented as well as of the study itself are pointed out.

Firstly, the survey focused only on citizens' awareness on e-waste recycling, without considering individuals' performed behavior. As stated by Rhein and Schmid (2020), awareness alone does not guarantee changes in behavior.

In addition, in Italy, 89% of the participants were located in the central regions of the country. As stated by Di Foggia & Beccarello (2021) the amount of e-waste collected in Italy varies between the northern and southern parts of the country due to differences in infrastructure. Therefore, it would be important to conduct similar studies in other regions of Italy. This could improve the validity and consistency of the results.

Also in Switzerland, since the focus was limited to the Canton of Zürich, the study could be replicated in other parts of the country.

Lastly, this study did not explore possible correlations of awareness with demographic characteristics such as income and academic degree.

## 6.4 Suggestion for Further Research

This thesis has provided first valuable insights into consumers' awareness regarding e-waste for the countries of Italy and Switzerland. However, there are several areas that require further research.

Future studies could build upon the provided insights to further analyze consumers' knowledge in more detail and to bridge the existing gaps.

The association between demographic characteristics and awareness level could be researched. As claimed by Sivathanu (2016), significant correlations between education and income levels with awareness were found in previous studies.

Moreover, as this study did not make any difference between the different WEEE categories, it would be important to replicate the study differentiating between the various EEE to analyze whether the small EEE household devices display a different pattern of awareness compared to larger EEE appliances.

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# 8. Appendix

## 8.1 Questionnaire for the Quantitative Data Collection

What is your age range?

- ○ Under 20 years old (1)
- ○ 20-30 (2)
- ○ 31-40 (3)
- ○ 41-55 (4)
- ○ Older than 55 (5)

What is the highest degree of school level you have completed?

- ○ No schooling completed (1)
- ○ High school diploma (2)
- ○ Bachelor degree (3)
- ○ Graudate degree (4)
- ○ Other degrees (trade/technical/vocational training) (5)

What is your yearly income?

- ○ Less than 25'000 (1)
- ○ 25'000 to 49'999 (2)
- ○ 50'000 to 99'999 (3)
- ○ more than 100'000 (4)

In which country do you live?

- ○ Italy (1)
- ○ Switzerland (2)

In which city do you live?

_____

Q1 How would you rate your general awareness on the e-waste recycling topic?

| | Low | | | | | | | | High | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Please rate on a scale 1-10. () | | | | | |  | | | | |

Q2 Which of the following electric and electronical devices are considered e-waste? Please select the correct answer(s).

- ☐ Not working and broken devices. (1)
- ☐ Not working devices but in good condition. (2)
- ☐ Working but unused devices. (3)

Q3 Rate your level of awareness regarding **e-waste recycling regulations** in your own region/country.

| | Low | | | | | | | | High | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Please rate on a scale 1-10. () | | | | | |  | | | | |

Q4 How well are you informed about how to properly dispose of e-waste devices (bring them back to a retail center, bring them to designed collection points)?

| | Very little | | | | | | | | Very much | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Please rate on a scale 1-10. () | | | | | |  | | | | |

Q5 Do you know where the next collection points close to you for e-waste devices/appliances are?

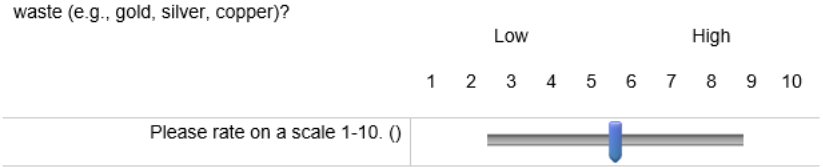
- ○ Yes (1)
- ○ No (2)

Q6 To what extent would you rate your awareness about the impact that disposed e-waste material has on the **environment**?


Q7 To what extent would you rate your awareness about the impact that disposed e-waste material has on **human health**?


Q8 To what extent are you aware of the **harmful** components that can be found in electronic waste?


Q9 To what extent are you aware of the **precious** components that can be found in electronic waste (e.g., gold, silver, copper)?




Q10 How aware are you about your responsibility as a citizen towards e-waste recycling?

Q11 A better awareness of the **impact e-waste has on the environment**, will probably affect my recycling behavior.

| | Strongly disagree 1 2 3 4 5 6 7 8 9 10 Strongly agree |
|---|---|
| Please rate on a scale 1-10. () |  |

Q12 A better awareness of **e-waste rules and regulations** will probably affect my recycling behavior.

| | Strongly disagree 1 2 3 4 5 6 7 8 9 10 Strongly agree |
|---|---|
| Please rate on a scale 1-10. () |  |

Q13 A better awareness of **consequences caused by my behavior as a citizen**, will probably affect my recycling behavior.

| | Strongly disagree 1 2 3 4 5 6 7 8 9 10 Strongly agree |
|---|---|
| Please rate on a scale 1-10. () |  |

Q14 What do you think would help to raise awareness of citizens?
Please select one most important answer for you.

- ○ Training for schools (Introduce topic e-waste recycling and its impact in schools). (1)
- ○ Training for companies (Introduce topic e-waste recycling and its impact in working environments). (2)
- ○ Direct and clear communication in retails centers. (3)
- ○ Targeted information campaign/ Media and social networks. (4)