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Circular Economy Management of Waste Electrical and Electronic Equipment (WEEE) in Italian Urban Systems: Comparison and Perspectives

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Abstract: This study evaluates the current collection and recycling of Waste Electrical and Electronic Equipment (WEEE) in Italy by means of the analysis of national and regional data from EUROSTAT and the Italian WEEE Coordination Centre database, as well as through qualitative interviews with key stakeholders of the WEEE management system of the Campania region (Southern Italy). Urban systems, among which the metropolitan city of Naples in the Campania region, are the main users of Electrical and Electronic Equipment (EEE) and, as a consequence, the main generators of WEEE, which must be managed and recovered properly in order to prevent the loss of valuable resources and the associated environmental impacts. In addition to analysing the current state of WEEE collection and recycling in Italy and its regions and urban systems, the study aims to improve our understanding of the WEEE reverse supply chain and the main barriers and drivers to collection and recycling. The results reveal that the main barriers to the collection/delivery/recycling of WEEE resulted in the low awareness of the citizens about the importance of WEEE recovery, the lack of trust towards administrators, the lack of certified first treatment plants, the aversion of the citizens to the opening of new plants due to past inefficient solutions in solid waste management, the exploitation of high value materials only (so-called "cannibalization", the illegal trade of WEEE, the influence of the market on the valorization of secondary materials), and, finally, the dominance of economic efficiency over the proximity advantage for the disposal of solid waste. On the other hand, the main drivers for collection emerged to be the adoption of education programmes in schools and constant communication campaigns directed to citizens in order to improve WEEE collection and recycling behaviour; the adoption of economic and non-economic incentives; the availability of municipal collection points (ecological islands) and other collection centres characterised by easy access by citizens for the delivery of their WEEE.

Keywords: waste electrical and electronic equipment (WEEE); circular economy; WEEE recovery; collection; recycling; reuse; product design; stakeholders' awareness; EU WEEE directives; Italian WEEE treatment; Campania region

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1. Introduction

Waste Electrical and Electronic Equipment (WEEE) management is one of the key waste value chains in the EU Circular Action Plan [1]. As a waste flow, it is growing rapidly, by about 2 Mt annually worldwide [2,3]. This is due to the continuous and fast development of new technologies, decreasing prices, and reduction of the lifetime of EEE—Electrical and Electronic Equipment [4], as well as their limited repair by users [5]. Consumers also appear even more interested in purchasing hi-tech, last generation products [6]. WEEE recovery is

a complex series of processes due to their different natures: refrigerators, air conditioners, car batteries, smartphones, computers, electric engines and turbines, photovoltaic modules, and more [7]. Valuable materials are extracted from recovered WEEE, thereby generating circular economy opportunities [1,8]. Yet, the continuous growth of the amount of WEEE is raising relevant environmental and social concerns [3–5]. In fact, they should be managed by means of adequate processes and technologies, since the treatment and recovery process in all the needed steps may release toxic substances, such as polybrominated dibenzo-p-dioxins (PBDD), polychlorinated dibenzodioxins (PCDD), dibenzo-p-furans (PCDF), halogen-containing flame retardants, heavy metals, and PM10, among others, that could be sources of potential risks for humans and other species, if improperly managed [7,9]. Plants performing the recovery of metals (e.g., copper and precious metals) from WEEE by means of hydrometallurgical/pyrometallurgical processes are located in Germany, Belgium, Switzerland, Canada, Korea, and Japan [5].

Electrical and electronic devices are mainly used within urban systems as a consequence of increasing purchasing power, quality of life, and access to grid electricity. The consequent generation of WEEE requires appropriate management, based on urban collection centres and collection and recovery networks, an increase in awareness of the recoverable valuable materials, the need to prevent environmental impacts, and the potential for new jobs in the urban mining sector. In fact, WEEE contain important resources such as iron, steel, aluminium, rare earths (e.g., lithium, cobalt), and precious metals (gold, silver, palladium, and platinum) [10,11], whose valorization would provide relevant benefits for the environment and global society [12,13] in terms of avoided extraction of natural resources and related environmental and social impacts [14–17]. For example, more than half (60%) of the world supply of cobalt (used in lithium batteries in mobile phones as well as electric car batteries) comes from the Democratic Republic of the Congo, where in many unregulated mines children are employed as miners, being exposed to huge health risks [17–20].

1.1. The EU WEEE Directives

The perception that WEEE recovery may become a valuable economic business is very recent, dating from 2002, with the adoption of the first WEEE Directive 2002/96/EC, when the EU started to promote formal WEEE collection schemes [21] and the circular economy model in WEEE management [22], with the goal of stimulating appropriate collection, reuse, and recycling. The second WEEE directive became effective on 14 February 2014 with the aim of overcoming some limitations of the previous 2002 Directive, such as the low achievements of WEEE treated in compliance with the Directive, the high amount of WEEE discharged in landfills, illegal WEEE trade to non-EU countries, the presence of a high amount of electric and electronic products manufactured not in compliance with the EU substance restrictions, and finally the very large differences in the collection rates among the EU countries [23]. The second WEEE Directive defined new and more ambitious targets in terms of minimum collection rates to be achieved and improved over time [13]. It is therefore after the second WEEE Directive that most EU countries started thinking in terms of "urban mining" and "sea mining" [24], identifying WEEEs as a major source of valuable materials and metals and promoting circular patterns to support other industrial processes.

The WEEE Directives are applied in many different ways across the EU member states [25], with rather heterogeneous performances in terms of collection and recycling rates [26,27]. Despite the fact that collection rates have grown over time, less than 40% of WEEE is recycled [28]. In order to improve the current state, the Circular Economy Action Plan pointed out the need for consolidating the existing measures and the adoption of new ones on both demand and supply sides by means of specific circular electronic initiatives [29]. These measures are aimed to strengthen the adoption of the circular economy model and its principles in WEEE management and with regard to the promotion of longer product lifetimes, the implementation of eco-design criteria and the right to repair, the durability of chargers, the improvement of collection, and recycling by means of

the evaluation of an EU-wide take-back scheme for the return or sell-back of old mobile phones [1].

The Circular Economy Action Plan stresses the relevance for society and the environment to perceive solutions over the whole reverse supply chain and be more ambitious for WEEE management beyond the achievement of minimum collection targets and recycling rates to scale up the other circular practises/principles of the waste hierarchy beyond recycling, such as reuse and repair [24]. Moreover, another important issue is the mapping of the end-of-life flows of WEEE in the EU countries and the availability of information and data on these stages. A recent analysis underlined that more than half (54%) of the WEEE generated in the EU in 2018 was not reported in the WEEE collection system [26]. Concerning the Italian situation, a number of studies have analysed the current performances of WEEE management systems by focusing on the generation and collection rates per capita and the factors affecting the collection in the whole country and across its regions [22,30,31] and provinces [7].

1.2. Campania Region and Southern Italy Case Studies

The present study aims to evaluate WEEE collection and recovery systems in Italy at the regional scale by means of qualitative face-to-face interviews with the most relevant stakeholders of the regional WEEE management system of the Campania region, the leading Italian southern region in terms of population [32] and gross domestic product [33].

This study specifically focuses on the Campania region for three main reasons: (i) its high population density (411 inhabitants per km^2); (ii) its high consumption of EEE; and (iii) its very low performance in terms of WEEE collected per capita, being the worst performing region in Italy, with around 3.62 kg/per capita in spite of its total number of collection centres being one of the highest in Italy [22,34]. The results of this case study could help identify new and unexpected barriers to WEEE collection and recycling and further confirm the barriers already discussed in the literature. Results could also suggest solutions or best practises to improve the performance of the formal WEEE management system in Campania and, hopefully, of the whole Italian and EU WEEE management systems. The latter is probably the most advanced and a benchmark case for other countries, but it is still unable to map and treat all the generated WEEE in the EU [26].

The structure of this study includes the analysis of the available literature in Section 2, while Section 3 (Materials and Methods) describes the main sources of data collection and the methods of analysis used in this study. Section 4 presents the results, providing first an overview of the collection and recycling performances of the EU, Italy, and the Italian regions. Then, the main results from face-to-face interviews with stakeholders are analysed. Section 5 discusses the main results, comparing them with those of the existing literature. Section 6 summarises the conclusions, limitations, and recommendations.

2. A Review of WEEE Management Systems in Italy and Selected European Countries

The first international studies provide evidence that the formal WEEE management system of Italy has much improved the annual collection rates per capita since the year 2008 [8,30,31] thanks to communication campaigns (and also initiatives in schools) aimed at informing students and citizens about the importance of collecting WEEE and how it should be managed and conferred. Further positive factors have been the integration of municipal WEEE collection points (ecological islands) in all the areas for urban waste collection (such as eco-points or eco-stops), the improvements of the national laws transposing the WEEE Directives, as well as the availability of more funds to improve the separated collection [31]. These latter authors compared the performance of the Italian WEEE collection system with the Romanian one from 2008 to 2013. Such a comparison allows us to identify the common factors affecting WEEE collection rates. Among these, communication has been found to be a significant factor, positively affecting WEEE collection by citizens in both countries [31].

Favot and Grassetti [30] showed that the number of collection points, the percentage of females in the population, and the percentage of household waste separately collected

positively affect the rate of WEEE collection per capita. In their analysis, these authors estimated that a change of 1% in the presence of collection points determines a change of 0.25% in the collection results. The policy implications derived from the study considered the widening of the collection infrastructure in agreement with the local municipalities. The impact of the collection infrastructure on collection rates has been further explored and expanded with data at province level by several researchers [8,22], who also found that the Italian WEEE management system, although improving the collection performances over time, still shows a territorial divide between the Northern and Southern Italian Provinces as far as collection rates and collection centre infrastructures are concerned. Most of the provinces that perform better are in Northern Italy (Aosta, Bologna, Como, Gorizia, Isernia, and Nuoro), while those performing worst are in Southern Italy (provinces of Agrigento, Barletta-Andria-Trani, Caltanissetta, etc.) [8].

Ibanescu et al. [27] analysed and compared the WEEE management systems of selected European countries (including Germany, Sweden, Romania, Bulgaria, and Italy) in the years between 2007 and 2013 and found that Italy was the country with the highest amount of WEEE transported towards extra-EU countries. The results provide evidence that Germany performed well in all years from 2007 to 2014 in both reuse and WEEE recycling, highlighting that the recycling performances of Romania, Bulgaria, and Italy have substantially improved over the analysed period, increasing the amount of recycled WEEE [27]. Finally, the study also underlines the lack of data in some countries (including Italy) about the reuse of WEEE.

Berežni et al. [35] compared the WEEE management systems of Italy and Serbia, providing a thorough analysis of the weaknesses (institutional framework, organisation of the collection systems, collection, and treatment activities) of both management systems. Both Italy and Serbia share the possibility of WEEE collection in permanent facilities and at retailer centres. In Serbia, "the old for new" scheme proved to be an efficient instrument to collect unused electrical and electronic equipment from households. The amount collected of WEEE in Italy was higher than that of Serbia (5.14 kg per capita versus 2.78 kg per capita) at the time of the study (year 2018), but still below the European target.

The authors also evaluated and compared the treatment capacities of Italy and Serbia at the single plant level. Two case studies of the recycling plants of Verona (Northern Italy) and Niš (Serbia) were compared by applying the Material Flow Analysis approach. The method provided interesting results for each category of WEEE, improving the understanding and traceability of the treatment stage by showing the original output from the dismantling of the WEEE and their weight compared to the total amount of each WEEE category. The authors conclude by highlighting four main points: (a) the need for reliable data on WEEE management systems, as they are essential for the design of e-waste management strategies; (b) the lack of infrastructure for WEEE treatment and international standards; (c) the adoption of best available technologies to increase the recovery of materials; and finally (d) the need for cooperation between developed and developing countries for improving the wellbeing of producers, recyclers, and users. Table 1 summarises the existing literature discussed in this section, pointing out the main aspects investigated in each study, some results, and the adopted indicators.

Table 1. Literature dealing with Italian WEEE management systems or comparing them with other European WEEE management systems.

Authors	Subject	Main Results	Adopted Indicators
Berežni et al. [35]	Evaluation and comparison of WEEE collection systems in Italy and Serbia, their treatment performances, mass balance, and technological capacity.	The weaknesses and strengths of both management systems are presented. Lack of data in both countries at some stages of the end-of-life cycle of WEEE. In Italy, e.g., gaps are evidenced in the reporting system and evaluation method of the WEEE put on the market and the WEEE collected. There is no data on the quantity of WEEE delivered in other countries for reuse. Some EEE producers act as free riders, as they are not registered but benefit from the legal collection and treatment system.	• WEEE generated (kg per capita per year); • Number of collection points; • Total WEEE collected (t); • WEEE collection rate (kg per capita per year); • WEEE treated annually (t) at national and plant levels; • % of WEEE treated categories; • No. of employees in plants; • WEEE treated (t per employee per year); • Total no. of pre-treatment facilities.
Bruno et al. [22]	Analysis of the spatial accessibility of citizens to the collection network of WEEE by means of the identification of quantitative indicators that measure the the availability of collection centres and the accessibility of the citizens to these centres in Italy across regions and provinces.	Refers to the availability of indicators of PPR change across regions. It ranges between 2.90 collection centres per 100,000 inhabitants in Southern Italy (Sicily region) and 20.88 in North East Italy (Trentino Alto Adige), with an average national value of 6.81; Relates to accessibility indicators: in the northern regions, 80% of the population is covered between 2.3 (Trentino Alto Adige), and 3.7 km (Piemonte). In the central regions, the distance ranges between 4.4 (Lazio) and 4.9 km (Tuscany); in the southern regions, the distance is between 4.8 (Puglia) and 9.0 km (Calabria).	Availability indicators: • Percentage of served population; • Provider to Population Ratio (PPR) is defined as the total number of collection centres per unit of population. In the study, they are considered a unit of population of 100,000 inhabitants. Accessibility indicators: • Percentage of covered population within 1 to 5 km, 10 km, and 20 km; • Average Accessibility Distance (km) and Maximum Accessibility Distance (km).
Isernia et al. [8]	WEEE collection performances in Italy across Italian provinces and geographical areas. The focus is on the amount of WEEE collected and the distribution of the collection centres in the 110 Italian provinces.	Territorial divide across Italian provinces and areas in WEEE collection performances (WEEE collection rate and number of WEEE collection centres). WEEE collection performances are positively correlated with the number of collection centres. A wider diffusion of collection centres and the organisation of events for disseminating the importance of virtuous behaviours by the citizens are key factors for improving WEEE collection performances.	• WEEE collection rate (kg per capita per year); • No. of collection centres; • Distribution of WEEE collection centres by performing state (high, medium, and low) and geographical area.

Table 1. *Cont.*

Authors	Subject	Main Results	Adopted Indicators
Ibanescu et al. [27]	Assessment of WEEE management systems profile and sustainability in Germany, Sweden, Italy, Romania, and Bulgaria.	Germany and Sweden were the best-performing countries in collection and recycling in the investigated period. Italy is the great exporter of WEEE outside the EU and still shows inefficiencies in collection. Romania and Bulgaria showed progress by the end of 2014. Developed countries focus more on waste prevention than developing ones.	• WEEE collection rate (kg per capita per year); • % of WEEE collected from EEE put on the market; • Transport of WEEE, inside the country, in other MS or other countries (kg/capita and % of transported waste from collected waste); • Quantity of reused WEEE (t/year); • Quantity of recycled WEEE (t/year); • (%) waste recycled/waste collected; • Carbon footprint of recycled WEEE (t CO_2 eq./year); • GHGs efficiency indicator (total carbon footprint/treated waste).
Favot and Grassetti [30]	Performance of the WEEE collection system in Italy	The presence of collection points, the percentage of household waste collected separately, and the percentage of females in the population are positively correlated with the collection rate per capita per year. Population density is negatively correlated with the collection rate per capita per year.	• Presence of collection points (number of WEEE collection points per 100,000 inhabitants); • % of households where waste is collected separately; • % of females in the population; • Population density; • WEEE collection rate (kg/per capita per year).
Torretta et al. [31]	WEEE management in Italy and Romania	The involvement of citizens with communication campaigns, the improvement of legislative tools, and more funds have been found to be significant factors in increasing collection rates in both countries since the initial stages of the implementation of the first WEEE Directive.	• WEEE generated (kg per inhabitant per year); • WEEE collection rate (kg per capita per year); • % of WEEE collected during an event (an annual event) across regions; • Amount of WEEE collected (kg) in an event (an annual event) in a city; • % and amount (t) of materials recovered in WEEE collected in a year; • Share (%) of collected WEEE in a region compared to the total national amount collected; • Annual amount of WEEE collected (t).

3. Material and Methods

3.1. Source of Data

The data for this study came from primary and secondary sources. In particular, two types of primary sources were analysed, namely the European statistical database EUROSTAT and the Italian WEEE Coordination Centre (IWCC), as well as a number of interviews with the representatives of the most relevant stakeholders of the formal WEEE management system of the Campania region. With regards to the secondary sources, we

also consider specialised journals, newspapers, grey literature, online blogs, company reports, conference papers, etc. Primary and secondary data were used to provide:

(a) Clear information about European and Italian levels of WEEE collection and recycling, in order to provide a basis for a better understanding of where and why WEEE are better managed;
(b) A deep discussion about the existing barriers to be removed and drivers to be implemented. This type of information is half-a-way between qualitative and quantitative, but it is the only tool that may connect stakeholders and policymakers for an effective step ahead towards awareness and the achievement of higher rates of WEEE recovery.

This study initially evaluates and compares the collection and recycling performances of the WEEE management systems of the European Union and Italy using Eurostat data. Then we assessed the performance of the Italian WEEE management system at regional and provincial scales by using data from the IWCC. These data were finally integrated, for a better understanding of the technological, social, economic, and environmental aspects, by face-to-face interviews with the main WEEE system stakeholders. It should not be disregarded that the experts interviewed represent hundreds of members of their organisations and may operate effectively for improved WEEE management. Interview results should also be considered primary data in that they provide first-hand information directly extracted from the activities of each organisation. On the other hand, organisations may positively affect each other by providing reliable information and appropriate interaction.

Selection of the Literature Sources

The manuscript aims at assessing the awareness and perception of policymakers, businesses, stakeholders, and researchers in the Campania region concerning the need and advantages of appropriate WEEE collection and recycling, to be compared with the state of the art in Europe and Italy. Therefore, a literature search was performed starting in 2002, when the first WEEE EU Directive was issued. The keywords used have been: waste electrical and electronic equipment (WEEE); Campania region; circular economy; collection; recycling; reuse; awareness; and perception. The keywords were always used in pairs, always keeping the first one (waste electrical and electronic equipment, WEEE) and adding a second one, e.g., waste electrical and electronic equipment, WEEE, and circular economy; waste electrical and electronic equipment WEEE, and the Campania region; and so on. EU and Italian directives have also been included among the results of the search, when available. In so doing and only selecting published papers and official EU and Italian government documents, 45 papers were chosen and referred to, out of which only six match the specific goals of the present research, reviewed in Section 2 and listed in Table 1. Since some of them are review papers, the overall picture is sufficiently large to provide an overview of the situation in Italy and worldwide.

3.2. Stakeholder Interview: Main Stages

In the following subsections, the stages of the whole interview process are summarised. The latter can be broken down into four stages: interview design, interview preparation, conduct of the interviews, and assessment of the data after the interviews [36].

3.2.1. Interview Design

The present study aims to deeply understand the features and functioning of the formal WEEE management system in the Campania region. The research and then the protocol for the interviews have been designed to collect data related to the following topics:

- Activities of the organisations involved in the collection and recycling of WEEE in the Campania region;
- Drivers and barriers to the collection, reuse, recycling, and adoption of further circular economy strategies aimed at extending the service life of WEEE-related products, materials, and components;

- The adoption by organisations in the WEEE system of methodologies and tools for the evaluation of their environmental and social performances;
- Their awareness about the social issues associated with WEEE management;
- The traceability of the whole life cycle of the WEEE from collection to treatment is mainly performed outside Campania (in other Italian regions and abroad).

To reach this aim, the present study takes into account both the specificities of defined territorial areas (on a local/regional scale as part of a larger geo-economic and regulatory context) and the point of view of the different actors of the reverse supply chain [8,37] and of the societal system as well, based on a multistakeholder approach [38–41].

3.2.2. Panel Selection

The panel of experts was composed of the main representative stakeholders of the formal WEEE management system of the Campania region, as part of the Italian and European Union WEEE systems. Moreover, stakeholders who are not part of the formal system but who are strongly involved in WEEE management issues were interviewed. It is clear that each of these stakeholders represents hundreds of researchers, workers, and activists in the field. The panel has been composed of the following respondents, listed in Table 2:

- Three stakeholders from national organisations:
  - The director of the ECOEM consortium, which is the National Collective System for the collection, treatment, and recycling of WEEE, including batteries and accumulators, domestic, and professional photovoltaic modules [42];
  - The director of the Laboratory Technologies for the Reuse, Recycling, Recovery, and Valorization of Waste and Materials of the ENEA (Italian National Agency for New Technologies, Energy, and Sustainable Economic Development) located in Naples [43];
  - The project manager of the communication campaign (RAEE@scuola; RAEE is the equivalent of WEEE in Italian) of ANCI (National Association of Italian Municipalities) aiming to support awareness of the importance of proper WEEE collection and treatment in primary, secondary, and high schools [44].
- Three stakeholders from regional institutions and organisations:
  - The director of the Department of the Regional Government in charge of elaborating the regional plan for special waste (which also includes WEEE) and authorising the opening of new treatment plants [45];
  - A representative of the ARPAC (agency for the protection of the environment of the Campania region), monitoring WEEE activities and collecting data about the collection and recycling rates as well as WEEE movements inside and outside the Campania region [46];
  - A regional representative of the non-profit environmental association Legambiente [47].
- Three stakeholders from private treatment companies and associations:
  - The chief operating officer of a consolidated recycling company with plants in the Basilicata and Lazio regions and treating more than half of the WEEE collected in Campania [48];
  - The founder of a small local collecting/treatment company located in the metropolitan city of Naples, whose activity consists of first dismantling WEEE generated in Campania and then transporting it outside of the Campania region towards other plants for a first treatment;
  - An association of citizens that recycles some WEEE components and materials (motherboards and copper cables) and plastic bottles for the production of new products realised by means of a 3D printer and sold to support social initiatives [49].

Table 2. List of performed interviews, classified based on stakeholder category.

Stakeholders' Categories	Interviewees	Number of Interviewees for Each Stakeholder Category
Citizens/consumers	**Founder** of an association of citizens.	1
Civil society organisations	**Communication project manager** of the ANCI (National Association of Italian Municipalities).	2
	Representative of the Environmental Association, Legambiente.	
Private companies	**Director** of the ECOEM consortium for the collection, treatment, and recycling of WEEE, including batteries and accumulators, domestic, and professional photovoltaic modules.	3
	Founder of a small local collecting/treatment company.	
	Chief Operating Officer (COO) of a large and consolidated treatment company.	
Public authorities	**General director** of the Integrated Water and Waste Cycle, Environmental Assessments, and Authorisations Department (Campania regional government).	2
	Representative of ARPAC (agency for the protection of the environment in the Campania region).	
Research community	**Laboratory director** of ENEA research centre, Portici.	1

3.2.3. Interview Protocol

A valid interview protocol is crucial to collecting good qualitative and quantitative data. The latter helps the researchers gain a better understanding of the respondents' experiences and identify crucial elements relevant to the research. Previous studies on interview protocol development have emphasised some crucial elements such as interview ethics, interviewing skills and experiences, question construction, understanding of the subject matter, and interview settings [41]. The adoption of an interview protocol improves the effectiveness of the interview process by guaranteeing that complete information is obtained within the allotted time.

Based on the framework by Yeong et al. [50], we followed a four-step interview protocol. In particular, these steps are:

- Ensuring alignment between interview questions and research questions: The questions are listed in an interview protocol. The researchers examine the constructed questions and identify any gaps that may be present. Moreover, they are allowed to fill the gap by adding relevant questions to the protocol based on their research objectives [51];
- Constructing an inquiry-based conversation: This phase is devoted to the refinement of the proposed questions from formal academic language to daily conversation discourse. Moreover, different follow-up questions are defined for different conversation styles [51]. The interview starts with casual and friendly introductory questions that every respondent can answer. This facilitates rapport-building and reduces anxiety. At this stage, the interviewer aimed to gauge the respondent's conversation style and literacy level and to build rapport. It is worth underlining that the interviewer should adjust the language level and review it if the interview style is not culturally appropriate and respectful to the respondent [52];
- Receiving feedback on interview protocols from a panel of experts (e.g., lectures, scholars, and practitioners): This stage is addressed to receive input on the feasibility of the interview protocol from a panel of experts with high-level skills in qualitative research. The panel of experts has examined our protocol structure, length, writing style, and ease of understanding. Special attention was paid to the ethical and cultural

sensitivities of the interview questions. The informed consent sheet was also included in the review process;

- Pilot testing of the interview questions: The researcher must ensure that the instrument can perform the desired job as required by the research objectives [53]. Pilot testing the instrument ensured that the questionnaire would work well as intended in real practise. The proper testing should closely simulate the actual interview process in the real world [54]. The pilot testing was conducted with two practitioners, and it was very productive as numerous useful suggestions were provided. This feedback helped us further refine the questionnaires for their clarity, user friendliness, and smoother flow of conversation.

A fundamental step of this interview stage is the receipt of ethical approval from the future participants. The research team always sent the information sheet about the interview and the consent form by email to the selected participants. The information sheet and the form contain information about the research project, why participants have been selected, their rights as interviewees, and the handling of the information collected after the interview and after the closure of the research.

All the selected participants agreed to participate in the interviews and allow the use of the data resulting from them for research purposes. Moreover, before the interviews, the research team carefully analysed the activities of the organisations/stakeholders interviewed by visiting their websites or other secondary sources of useful information to assure a rich discussion during the interviews.

3.2.4. Conduction of the Interviews

Due to the emergence of the pandemic, the selected stakeholders have all been interviewed by means of online meetings on the most common platforms that they prefer. This has been performed with the purpose of avoiding any type of technical impediment and creating a climate that is as friendly as possible. The interviews were handled with a conversational approach supported by a data collection guide [55] and took place from November 2021 to June 2022. The final group of interviews consisted of nine stakeholders in the WEEE reverse supply chain (Table 2).

Each interview lasted about 1 h and a half. All interviews were recorded after receiving the consent of the interviewee. At least two researchers participated, taking separate notes. Finally, the interviewees were informed that an interview report would subsequently be sent by email for final control and that the content could be used and/or published for the research project's aims.

3.2.5. Assessment of the Interviews

The information collected in the interviews has been transcribed in the form of reports and analysed by the research team members. Moreover, this information has been further elaborated to be useful for the goals of the research project by extracting qualitative and quantitative data from it. In some cases, the interviewees have been contacted to check the correctness of the information they provided during the interviews as well as for a deeper understanding of some specific questions and topics [41,56].

4. Results

This section presents the results of the study, starting with an overview of the evolution of the collection and recycling rates of European Union countries, including Italy [57]. The collection and recycling performances have also been investigated for Italy and its regions. Next, the results of the case studies of the WEEE management system of the Campania region, the foci of the present research, are presented. The Campania system is analysed by integrating quantitative data from databases with qualitative data from stakeholders' interviews, with the main focus on drivers and barriers to the collection and recycling of WEEE in the Campania region (the third-highest-populated region of Italy). The whole procedure is summarised in Figure 1:

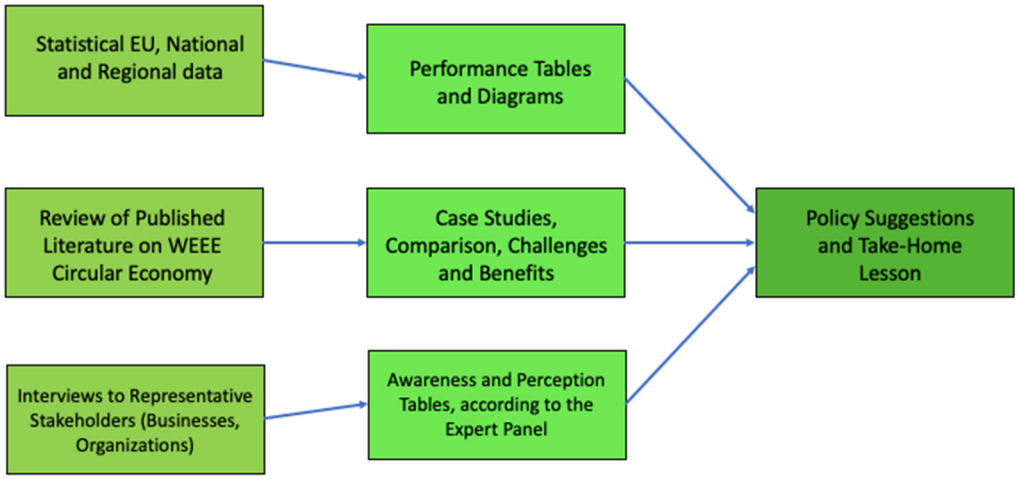

Figure 1. Schematic overview of the WEEE management assessment and evaluation.

4.1. Collection and Recycling Rate Indicators of WEEE in the European Union

Figure 2 shows the amount of WEEE collected per inhabitant in the EU member states (27 countries) in the year 2020. More than half of the member states, including Italy (8.0 kg per inhabitant), have collected an amount per inhabitant that is lower than the EU average (10.5 kg per inhabitant), while only ten countries have collected more than the EU average. The most effective countries in terms of collected WEEE are Austria and Finland (15.7 kg/per capita and 15.7 kg/per capita, respectively). Furthermore, it is worth noting that most of the countries performing above the European average are in Western Europe, while those performing below are in Eastern Europe. These results show the presence of a WEEE territorial divide between EU member states, with northern-western countries performing better in terms of collection rates, as already highlighted by other authors [8,25,58,59].

Figure 3 shows the collection rates in the EU in the year 2020 as a percentage of the average weight of EEE put on the market in the three preceding years from 2017 to 2019.

This indicator represents the collection target that the EU has fixed at 45% for the reference year 2016 and increased to 65% from the reference year 2019 onwards. The collection rate of the EU is equal to 45.9% of the average weight of EEE put on the market, while for Italy it is a low 36.5% of EEE put on the market. In the year 2020, three countries (Bulgaria, Croatia, and Poland) surpassed the 65% collection target [60].

A further indicator worth careful consideration from the Eurostat database is the recycling rate [61]. The European average recycling rate (27 countries) was 38.4% in the year 2018, while for Italy, the indicator was available until the year 2015, when the recycling rate was equal to 32.1%. Figures 2 and 3 confirm that in Italy, the WEEE collection rate per capita and total collection rate are lower than the EU average, indicating the need for improving collection performances [62,63].

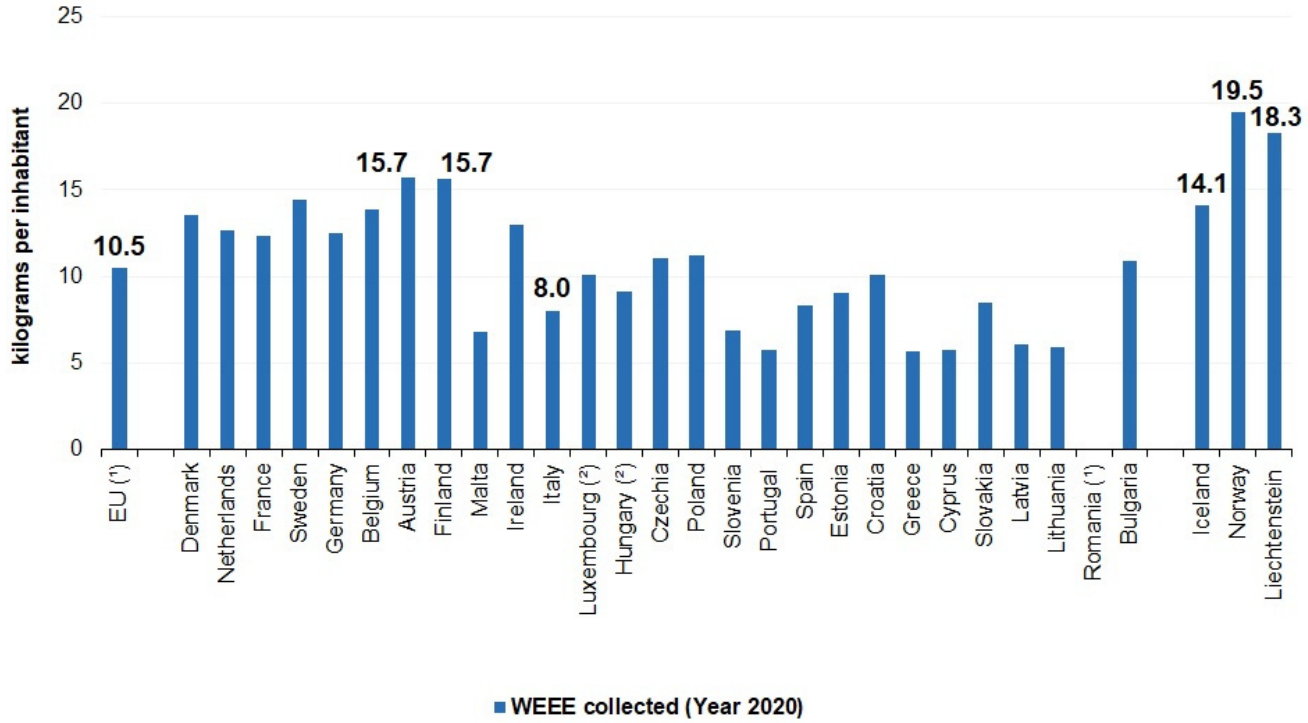

Figure 2. WEEE collected in the EU in 2020 (kilogrammes per inhabitant). Source: own elaboration from Eurostat data [60]. Numerical values have only been placed for the EU as an average, for the two best-performing countries in the EU, for Italy as a reference for this study, and finally for three non-EU countries. The latter and the EU are separated from the EU countries for clarity. ([1]) Eurostat estimate. ([1]) Romania: data not available. ([2]) Luxembourg, ([2]) Hungary: collection rate calculation methodology based on share of WEEE generated.

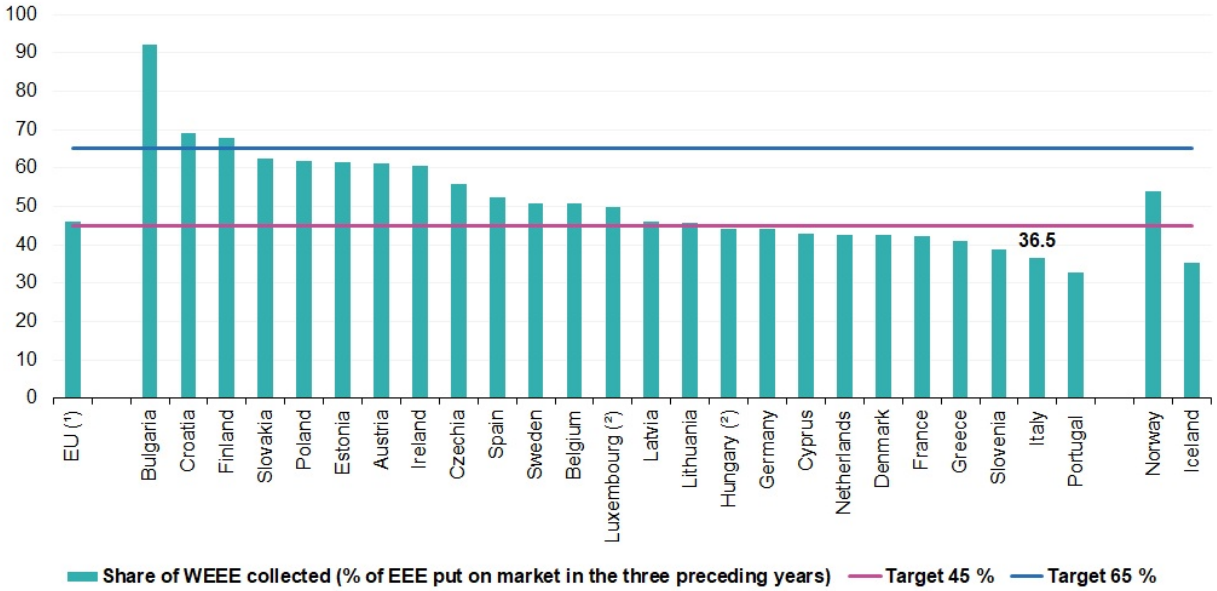

Figure 3. Total collection rate for WEEE in 2020 (% of the average weight of EEE put on the market in the three preceding years (2017–2019). Source: own elaboration from Eurostat data [60]. A percentage value has only been placed for the EU as an average. Norway, Iceland, and the EU are separated from the EU countries for clarity. Note: Romania: data not available. ([1]) Eurostat estimate. ([2]) The 65% target is not applicable, as Luxembourg and Hungary have chosen the calculation methodology based on the share of WEEE generated.

4.2. Collection of WEEE at National and Regional Scales

The IWCC for collective systems of producers is one of the reference organisations in the WEEE Italian collection system introduced by Ministerial Decree 185/2007. Collective systems of producers are voluntary consortia or non-profit organisations funded and financed by the EEE producers, whose role is to fulfil the obligations of the producers and handle the transport, treatment, and recovery of the WEEE in compliance with the rules established by the IWCC [64].

The IWCC publishes annual reports about the collected amount of WEEE for each category in the whole of Italy, its regions, provinces, and municipalities.

According to the last report of the IWCC for the year 2021, the total amount collected has been 385,258 tonnes, recording an increase of 5.3% from the previous year. The amount collected per capita was 6.4 kg, increasing by 5.5% relative to the year 2020. The total amount of WEEE collected in each region of Italy is shown in Figure 4. The Lombardy region collected the highest amount (70,784 tonnes), followed by Emilia Romagna (35,657 tonnes) and Veneto (35,625 tonnes). The lowest quantities are collected in the smallest regions of Italy: Molise (1679 tonnes) and Valle d'Aosta (1387 tonnes).

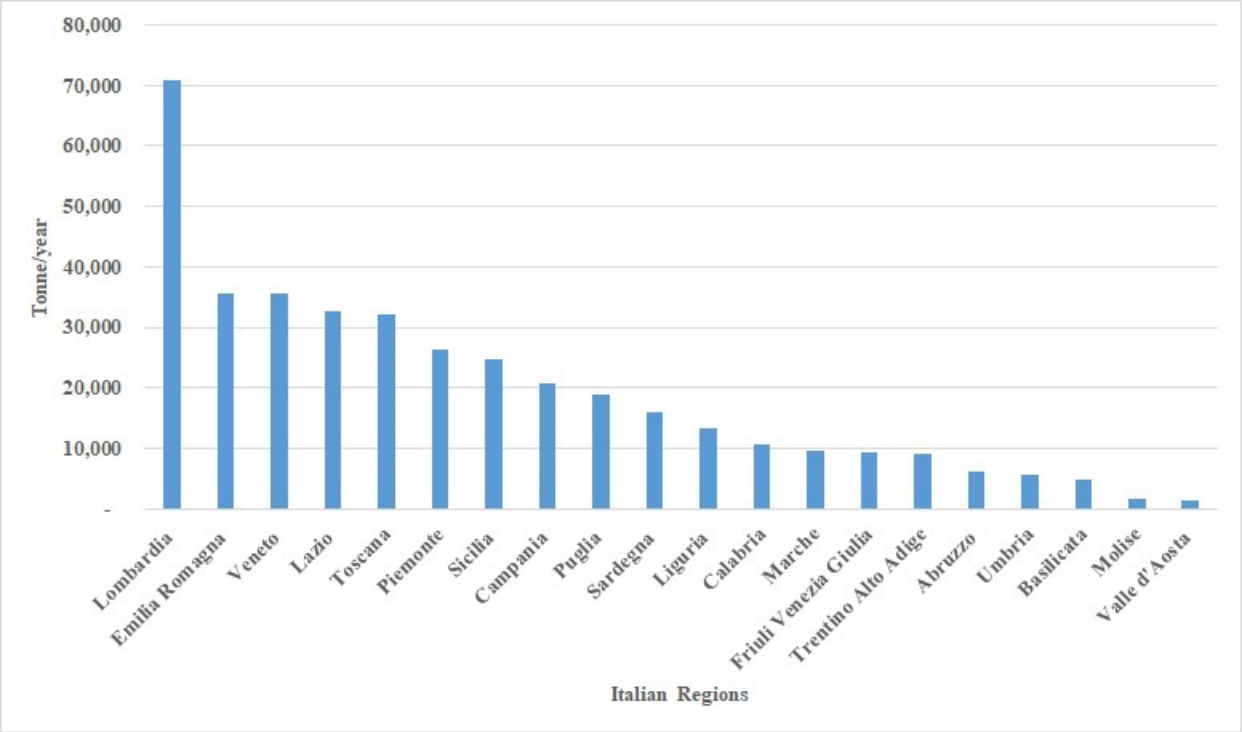

Figure 4. Total amount of WEEE collected in the Italian regions in 2021. Elaboration from the data of the Italian WEEE Coordination Centre [64].

When it comes to the amount of WEEE collected per capita (Figure 5), it is interesting to note that Valle d'Aosta (the smallest Italian region in terms of surface) [65] is the region with the highest value for this indicator (11.09 kg per capita), followed by Sardinia (9.93 kg per capita), Liguria (8.71 kg per capita), and Tuscany (8.71 kg per capita). The lowest amounts of WEEE collected have been observed in the southern Italian regions: Apulia (4.78 kg per capita), Abruzzo (4.68 kg per capita), and Campania (3.62 kg per capita), showing a territorial divide in terms of WEEE collected between the north and south of Italy.

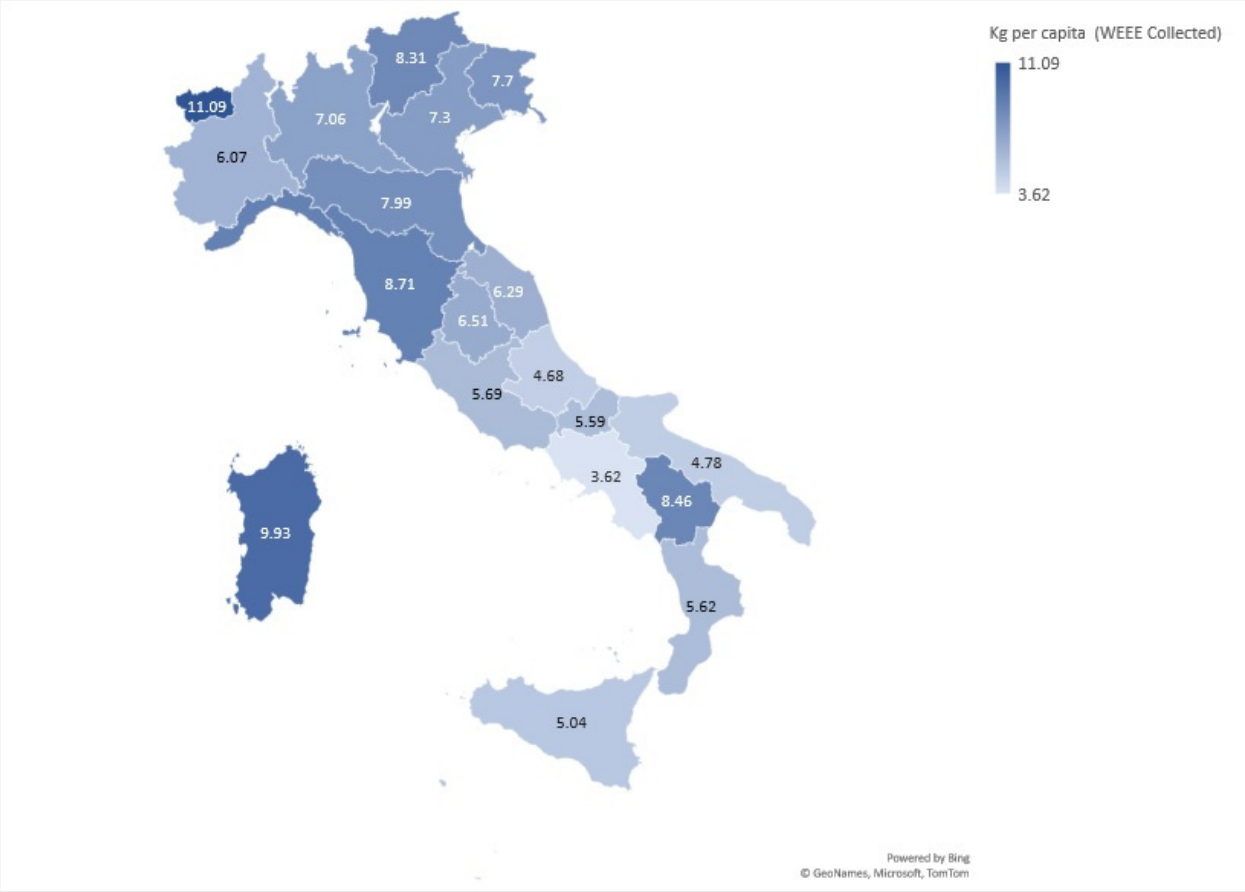

Figure 5. WEEE collected (kg per capita) in the Italian regions in 2021. Elaboration from the data of the IWCC [64].

In general, it is also important to underline that collection performance patterns vary within regions depending on contextual, cultural, and socioeconomic factors, among others [30]. For instance, there is a large variability in Campania, with provinces where the quantities of collected WEEE are higher than the regional average (3.62 kg per capita) or almost equal to the Italian regional average (Table 3). This could be due to the wider diffusion of municipal WEEE collection centres, which are more distributed in some provinces of Campania than in others [8,22]. Moreover, Favot and Grassetti [30] also show that the population density is negatively correlated with the collection rates per capita per year. Naples has the highest population density (2519 inhabitants per km^2) compared to the other provinces of the Campania region, such as Avellino (142 inhabitants per km^2), Benevento (126 inhabitants per km^2), Caserta (341 inhabitants per km^2), and Salerno (214 inhabitants per km^2) [66].

Table 3. WEEE Collection performance of Campania provinces in 2021.

Campania Region	WEEE Collected (kg per Capita)
Avellino	4.18
Benevento	2.94
Caserta	6.44
Napoli	2.66
Salerno	3.89
Regional average	3.62
National average	6.45

4.3. Barriers to WEEE Collection and Recycling in the Campania Region

Based on the stakeholders' interviews, we identified positive and negative factors influencing the performance of the WEEE management system in the Campania region (Table 4). Specifically, the interviews with the stakeholders from the regional WEEE management system allowed us to identify not only a list of drivers and barriers but also to thoroughly analyse them in order to gain an overview of the WEEE management system in a regional context.

Table 4. Barriers to the collection and recycling of WEEE.

End-of-Life-Stage	Categories	Identified Barriers	Frequency of Barrier Identification
Collection	Behavioural	• The low WEEE collection rates of the Campania region (and in general of the southern regions) compared to Italy are due to a low awareness of the citizens about the importance of WEEE collection and recycling;	3
	Social	• A lack of trust by citizens towards the local institutions and administrations, caused by their inefficient waste management;	1
Recycling	Infrastructural	• The small number of certified WEEE first treatment plants in a regional context;	3
	Cultural	• A negative perception of the citizens towards the opening of new WEEE treatment plants;	2
	Operational	• The issue of cannibalization of WEEE materials and components of high value by the informal sector;	4
	Ethical	• A lack of information about the illegal trade of WEEE;	2
	Market	• Market prices affect the valorization of the secondary raw materials;	1
		• The treatment of WEEE is based on the principle of economic efficiency instead of geographical proximity, as in the case of the disposal of solid waste;	1
	Administrative/ regulatory	• Limits posed by the authorities to the amount and type of materials to be treated.	1

As shown in Table 4, it is interesting to note that the identified barriers to the collection process are mainly behavioural, while to the recycling of WEEE they are infrastructural, cultural, operational, social, market, and administrative/regulatory.

Some stakeholders (3 out of 9, hereafter only indicated with the name of his/her institution) commented on the low average collection rates of the Campania region compared to the national average of Italy and declared poor knowledge and awareness as final consumers about the importance of proper WEEE collection. In line with this, e.g., the ENEA stakeholder also stated that:

> *"People keep WEEE at home or dispose of it in the unsorted collection. In particular, the way in which the collection is carried out influences all subsequent stages of the life cycle. Therefore, policymakers should pay great attention in the addressing this issue as, even*

if the infrastructural criticality is resolved, the treatment plants must be powered, and effective collection is therefore necessary".

The Legambiente Association stakeholder also pointed out that a non-negligible social barrier to the collection is the lack of trust of citizens towards the management of WEEE conducted by the local public administrations, which is believed to be ineffective. This is the case, particularly in small municipalities.

When dealing with the barriers to WEEE recycling, the infrastructural barriers were cited and discussed as relevant criticalities of the WEEE system by several stakeholders (3 out of 9). The interviews tried to understand the reason for the small number of certified treatment plants in the Campania region, which only treat a small fraction of the WEEE collected and are in particular devoted to the first stage of dismantling WEEE. The largest fraction of the WEEE collected in the region is treated outside of it, in other nearby regions. This prevents the society of the Campania region from fully retaining the socioeconomic benefits (in terms of labour opportunities and the further economic development of the region) of WEEE valorization.

The interviews summarised in Table 4 also highlight another relevant aspect that can be considered a barrier to the local recycling of WEEE in the Campania region. Specifically, the general director of the Department of Regional Government stated that:

"Contrary to solid waste which disposal in landfills is regulated by the principle of geographical proximity, the recycling for solid waste (Including WEEE) is mainly guided by the economic efficiency, neglecting the social and environmental aspects related to such activity". In line with this, the ARPAC stakeholder highlighted the current trend in Italy towards opening large recycling plants to treat waste from more than one Italian region.

In further commenting on the barriers to recycling at the local level, it is important to mention the existence of cultural barriers. Some of the interviewed stakeholders argued that there is a negative perception among the citizens of the opening of new plants due to the past solid waste management problems experienced in the Campania region [67]. In line with this, the general director of the Department of the Campania Regional Government stated that "*there is a very low acceptability level to the opening of new plants especially from the communities of the suburbs*".

With regard to the operational barriers, four stakeholders claimed that another criticality is represented by the so-called "cannibalization" of WEEE by the informal sector, i.e., extracting the WEEE materials and components characterised by higher economic value while landfilling the less valuable ones, thus creating potential risks for people and the environment. In particular, the director of ECOEM stated that:

"The presence of informal activities are potential sources of numerous adverse external impacts for the environment, society, and the economy. The WEEE stream comprises a wide variety of products and some of them are made of a complex mixture of toxic materials and metals, that if treated not adequately could be source of negative impacts for human health and the environment."

Additionally, the small local association stakeholder claimed that:

"the presence of an informal sector that retains the parts of a WEEE product of higher value and abandon those of lower value represents a criticality for the whole WEEE system".

Finally, it is worth considering the limits imposed by the local public authorities regarding the WEEE treatment in the first treatment plants. Specifically, as stated by the large treatment company stakeholder that treats about 70% of the WEEE generated in the Campania region: "*there are administrative limits with reference to maximum amount and type of WEEE that could be treated in each plant; this contributes to affect negatively the activity of the treatment companies causing also the transfer of WEEE in other plants of the country (e.g., in Northern Italy). Moreover, the excess of prudence of the public authorities in the valorisation of WEEE or its parts leads to the disposal in landfills of materials that could be otherwise valorised*". He also underlined that WEEE recycling is a purely economic activity and is influenced by market prices.

4.4. Drivers for WEEE Collection and Recycling in the Campania Region

Table 5 summarises the different types of drivers for the improvement of WEEE collection resulting from the interviews with the stakeholders of the WEEE management system in the Campania region. The majority of stakeholders underlined the critical role played by communication campaigns (a socio-cultural driver) in improving the awareness of consumers/citizens about WEEE collection. Accordingly, the Legambiente stakeholder indicated that: "*campaigns should be continuous and massive in order to be effective in improving the WEEE collection behaviour*".

Table 5. Driving factors for the improvement of WEEE prevention, collection, and recycling.

Categories	Identified Drivers	Frequency of Driver Identification
Products related	• Circular EEE products designed for a longer life and for product-life extension;	2
Infrastructural	• Municipal ecological islands as primary relevant elements of the WEEE collection systems;	3
	• Mobile ecological islands as drivers for higher collection rates;	1
	• Creation of a more widespread and proximity-based collection network;	1
Sociocultural	• Educational programmes within schools to increase the awareness of students and their families about WEEE prevention, collection, and recycling;	8
	• Constant and massive communication campaigns addressed to citizens to raise their awareness about the importance of WEEE collection and recycling are more effective than targeted communication campaigns;	2
Operational	• Involvement of new professionals who manage particular categories of equipment in an effective and transparent collaboration in order to prevent cannibalization;	1
Legislative	• The specific measures in Legislative Decree no. 49/2014 are an incentive for the management of photovoltaic (PV) panels that have achieved the end-of-life covered by the Conto Energia measures;	1
	• Italian legislative "Ecodesign" decree (no. 140/2016) aimed to promote product design to perform according to environmentally sustainable criteria;	2
	• Higher and proper controls in WEEE collection centres to reduce e-waste diversion from the official collection system;	2
	• Avoidance of the legislative status of waste for still functional EEE or with minor failures to promote their reuse;	1
Administrative/ contextual	• Good skills of municipalities and administrators and the presence of other favourable conditions (active participation of the citizens and the presence of schools and research centres);	2
	• The commitment of regional governments to decreasing the amount of waste in general and the adoption of economic incentives for the realisation of new treatment plants;	1
Economic	• Economic incentives for citizens to dispose of their WEEE at the collection centres or other points such as smart bins. Awarding system (economic and non-economic) to enhance the conferment of WEEE by citizens, students, and their families.	3

In line with this, the ANCI stakeholder stressed that campaigns should deliver key messages to consumers and make them aware of "being active participants to the issue of WEEE collection as well as that are part of a larger community where the actions of each individual matter and each one share the responsibility with the others in contributing to WEEE prevention and collection". The ECOEM stakeholder claimed that "More communication to citizens and more controls on collection centres are key actions to improve WEEE collection and at the same time reduce the e-waste stream that is diverted from the official collection system". In line with this, the Legambiente stakeholder, on the basis of their participation in previous local projects in the area of Naples, also pointed out the effectiveness of education initiatives within schools in improving the amount of WEEE collected and the awareness of students and their families about the value of WEEE collection behaviour.

Furthermore, the ANCI stakeholder extensively talked about a previous national project namely "WEEE school" that she coordinated, starting in 2013. "WEEE school" was a national environmental education and awareness project that was aimed at improving the knowledge of students and their families about the category of small WEEE and how it should be managed correctly. She underlined that "*by means of the project, students became promoters of good practices towards their families including parents and grandparents*". Table 6 shows some relevant information about such a project involving 1356 primary and secondary schools. Four editions of the project have been organised from September 2013 to March 2016. Overall, the project involved 138 municipalities throughout Italy, more than 128,000 students, and was carried out in urban contexts inhabited by over 10 million people.

Table 6. Summary of relevant information and data about the project WEEE school.

Number of Municipalities	Period of the Project	Type of Schools	Number of Schools	Number of Students	Number of Inhabitants	Collected kg of WEEE	Period for the Collection
30	September 2013–March 2014	Primary school	292	23,669	2,805,415.00	45,767.15	Two weeks
60	October 2014–May 2015	Primary school	586	55,916	4,845,632.00	38,712.70	Three weeks
48	October 2015–May 2016	Primary school and secondary school	478	48,848	(not available)	37,150.20	Three weeks

The ANCI stakeholder also pointed out that "the project was characterized by a close collaboration between the municipalities, the schools and the relative managers of the urban management services". We therefore distributed an information kit to the schools and invited students, with the support of a web competition, to bring their unused electronic devices from home and place them in special containers located inside the schools.

Finally, the project was also associated with the slogan *"Take a WEEE photo and win a super rucksack".* In order to favour the involvement of the students, it was required that students take photos with their electronic equipment, and the most original, funny, creative, scary, and greenest photo would win a prize (there were six rucksacks to be won). There was also a EUR 2000 voucher for the most virtuous school that had distinguished itself in raising the students' awareness. Families have also been involved with the web contest "Get a photo WEEE FAMILY and win". Additionally, in this case, there were prizes for children and schools. Finally, in the last part of the project, the awarding system involved all the students, and the web content was: "Take a class photo and win".

Implementing an awarding system for citizens who dispose of WEEE properly (an economic driver) is a further driver to increase the WEEE collection rate. In this view, the Director of the Laboratory of the ENEA Research Centre stated that "*Awarding systems and economic incentives can represent valid instruments to enhance the conferment of WEEE at the collection centres*". The laboratory has promoted the European project INNO-WEEE (Innovative WEEE traceability and collection system and geo-interoperability of WEEE data), which involved the implementation of dedicated smart bins where the citizens could introduce small WEEE and receive feedback on the amount of CO_2 emissions avoided, as well as receiving an economic award to be used in the local shops (e.g., bakeries, libraries)

of the cities adhering to the project (pilot cities of the Campania region, provinces of the city of Turin, and Bath in England). The project INNO-WEEE was accompanied by further actions (educational courses to promote the regeneration and reuse of EEE that can still be used; the proper recycling and evaluation of valuable materials to be recovered into new production cycles; communication campaigns on social networks for students and citizens; and promotional actions to encourage primary school children to participate in WEEE collection) [68]. To support this educational approach to the problem and encourage best practises, the Laboratory Head of ENEA also said that "*our group is working to improve the traceability of the supply chain, promote a real cultural change through a system of rewards for the most virtuous behaviours and provide technical-scientific support to local authorities also through the transfer of innovative methodologies and tools for the adoption by citizens of the best practices available*".

Other critical drivers to improve the WEEE management system regard infrastructure and operational aspects. Specifically, the Campania regional government stakeholder stated that "*Public authorities are committed in decreasing the overall amount of e-waste and the adoption of economic incentives for the realization of regional infrastructures as the creation of a more widespread and proximity collection network could improve the WEEE collection rate*". In conjunction with this, Legambiente stakeholder highlighted that "*Municipal ecological islands are of course primary relevant collection points for WEEE, but adopting different approaches, such as mobile ecological islands, could lead higher collection rates*".

Results from interviews also showed that a critical role in improving WEEE collection and recycling processes is played by the governments and the laws they enact, as well as by the Campania regional government regions, which also have responsibilities and duties for WEEE management. Both the founder of a local collection/treatment company stakeholder and the ANCI stakeholder highlighted the importance of the so-called legislative decree "Ecodesign decree" (10 June 2016) to promote product design according to environmentally sustainable criteria and the production of EEE, which is easy to reuse and recover at its end-of-life [69]. The regulation assigns EEE producers the task of implementing ecodesign strategies that take into account the use of recyclable and biodegradable materials; the reduction of the quantity and diversity of materials; the increase in the recyclability of the product and its components; limiting the use of dangerous substances; and the optimisation of the disassembly of the products. To encourage "green" production, the regulation provides producers who can prove reducing the end-of-life management cost with the possibility of requesting a reduction in the eco-contribution. The decree addresses the issue of waste prevention by requiring that EEE producers increase the reliability of the product, facilitate its maintenance and repair, and promote training courses and information campaigns. The introduction of the "refurbished product" label is also envisaged, with a minimum guarantee of 12 months for a refurbished product placed on the market 90 days after the regulation comes into force. (Communication Manager of ANCI). In this perspective, the experience of the founder of an association of urban stakeholders that recovers some WEEE components, materials, and plastic bottles for the production of new products by means of a 3D printer remarked on the crucial role of EEE producers and designers *who "have to try to produce longer lasting products and design for maintenance and repair, design for upgradability and adaptability, design for dis- and reassembly".*

Further, the ECOEM stakeholder underlined the effectiveness of legislative decree no. 49/2014 that defines specific economic incentives for the management of photovoltaic (PV) panels that have achieved the end-of-life covered by energy accounting measures. Additionally, this measure aims to improve the PV at the end-of-life collection rate as well as the adequacy of the management processes for this kind of e-waste. In his opinion, another very important initiative was the introduction of the eco-contribution, which is an amount added to the sale price of any new electrical and electronic product purchased by the consumer. ECOEM stakeholder points out that "*The eco-contribution paid by the consumers is entirely used by the EEE producers to fund the whole system of management of WEEE involving first their collection in the different centres available on the national territory, and then their*

transport to treatment plants where they are recycled. This measure was introduced on 12 November 2007, in application of the principle of "extended producer responsibility" envisaged by Legislative Decree 151/2005 and currently it represents an important driver for the collection and recycling of WEEE". Moreover, contextual factors, such as the presence of several universities and research centres, as well as the good skills of municipalities and administrators, represent further critical drivers underlined by the interviewees as being able to positively influence WEEE management (administrative/contextual driver). In particular, the Legambiente stakeholder evidenced that "*larger municipalities perform better than smaller ones and are able to assure a more transparent end-of-life cycle of WEEE delivering directly the WEEE from the ecological island to the certified first treatment plants*".

5. Discussion: Clarifying Research Significance

This study mainly aims to evaluate the current performances of WEEE collection and recovery systems in one of the leading southern regions of Italy (namely the Campania region), compare them with EU and national Italian performances, and contribute to identifying solutions to improve the performances of its formal WEEE management system that could also be useful for other regions, including the Italian and EU WEEE management systems. Of course, it should not be disregarded that WEEE collection and recovery mainly occur in urban systems and that the largest urban system in the region is the Metropolitan City of Naples, gathering 92 municipalities with a total population slightly higher than 3.1 million people, compared with the 5.8 million inhabitants of the whole of the Campania region. The results achieved from databases, interviews, and questionnaires provide a deep and reliable understanding of the current regional and urban systems performance as a basis for WEEE circular policy adjustment and improvement.

5.1. Understanding Stakeholders: Barriers to Be Removed

The results from interviews show that the main barriers to collection in the Campania region (which explain the low collection rates compared to the average of Italy and the EU) are the low awareness of the citizens about the importance of collecting WEEE. This barrier is mirrored by the fact that one of the most important drivers of WEEE collection has been educational programmes in schools for students and their families, as well as constant communication campaigns with citizens to raise their awareness. In this regard, the interviews provided the opportunity to highlight that both educational programmes in schools and communication campaigns to citizens should also be associated with further tools such as web contents and school material awards (WEEE school project) or economic incentives and the nearness of WEEE collection centres (INNO-WEEE project). The results are also confirmed by other research and projects [22,69] conducted across the EU. Key findings from the co-funded Interreg European Union project "Race against waste" revealed the critical role of WEEE education in schools and of students in influencing the decisions about WEEE and sustainability of their parents.

The claimed low awareness of the citizens means that consumers are still mainly guided by individual economic interests [70] and give low or no value to WEEE and, in general, to environmental integrity and sustainability. The recent literature underlines that pro-environmental awareness is the basis of green consumption [71], which is considered a pro-environmental behaviour. In the latter, the attention of the consumer is at the stages of "purchase, use, and disposal of goods" as well as in reducing as much as possible "the individual impact to the environment" [71].

5.2. Policy Implications: Drivers to Be Implemented

Regional public authorities and policymakers play a critical role in supporting and improving WEEE awareness, as it is a crucial factor towards behavioural change—and more successful WEEE management [28]. In particular, they should pay greater attention to the organisation of communication and educational campaigns to sensitise citizens and make them more aware of the risks associated with the incorrect disposal of WEEEs, given

that the success of collection and recycling programmes strongly depends on the active and sustained involvement of citizens [31]. Behaviours are, in fact, influenced by awareness of an issue, understanding of the consequences of a given behaviour, and acceptance of those consequences [72]. As a consequence, knowledge of environmental impacts associated with WEEEs can be considered a predictor of accurate recycling and disposal behaviours [73–75]. In other words, increasing consumer knowledge about e-waste products and hazards may be important in boosting recycling behaviours. If people are not informed about these issues, then it is difficult to stimulate their willingness to properly dispose of e-waste. Moreover, improving knowledge on WEEE recycling represents a relatively easy way to take action through the involvement of the education system [76]. This highlights that actors in the formal system (and institutions) dedicated little attention to informing and involving citizens, even though they were following a top-down approach.

Another important driver for WEEE collection, which emerged from the interviews, is the availability of municipal WEEE collection points (e.g., ecological islands) as well as other collection points (e.g., mobile ecological islands). This is in line with the previous literature that stressed the role of infrastructure (e.g., creation of a proximity collection network) and operational aspects (e.g., hiring of experts and professionals) as essential factors in increasing WEEE collection rates [22,30,31]. More specifically, the interviews highlighted that WEEE collection systems should be characterised by high convenience [77]; in other words, such systems should be easily accessible, with centrally located multiple collection points and a reduced distance to travel to reach them [78]. It is worth underlining that appropriate recycling behaviours can also be motivated through the provision of different recycling opportunities (e.g., mobile ecological islands and the organisation of specific initiatives and events) [31,74]. Hence, local administrations should work in this direction to create policies and infrastructure that allow for convenient and low-cost recycling of e-waste [79]. In fact, the commitment of local administrations is another important driver towards higher collection rates, as confirmed in the interviews as well as by the official data.

5.3. Enhancing the Circular Economy

Legislative drivers aimed at enhancing collection and recycling have also been pointed out by the interviewed stakeholders. Several previous studies have shown that the improvement of existing legislative tools and the enactment of new regulations useful to support proper collection and recycling behaviours are very important [7,31]. On the other hand, the current Italian Legislative Decree "Ecodesign" (no. 140/2016) [80], which aims to favour a circular product design, seems very promising for the development of new EEEs that are more in line with the principles of the circular economy.

Finally, but not least, crucial drivers to improving WEEE recycling in the regional context will be the adoption of dedicated policies and economic incentives for the realisation of new treatment plants. In this view, the role of the regional government in shortening the authorisation procedures and the role of the institutional actors in promoting and supporting a more conducive environment for investments in new plants can play a key role. These measures would provide positive benefits to the socio-economic development of the Campania region and accelerate the transition from the recycling economy to a circular economy, which is very much based on the principles of social and environmental justice rather than economic efficiency and the cheapest labour [81]. In this regard, the study by Ibanescu et al. [27] is particularly meaningful since it shows that in the investigated EU member states, the transport of WEEE varies substantially, with Italy being the country with the highest transport distances due to the WEEE exported in other EU countries and outside the EU, while Germany and Sweden are able to fully treat their WEEE internally. The indicators of transportation of WEEE within other member states and countries outside the EU (kg/capita and percentage of transported waste from collected waste), summarised in Table 1, are very important and should be added to the EU framework along with the most commonly used collection method and recycling rate per capita.

6. Conclusions

The present study was aimed at evaluating the current performances of WEEE collection and recovery systems in Italy, with a special focus on the Campania region (the third highest populated region in Italy) taken as a case study, by means of the analysis of data from official European and national statistics and the results of qualitative face-to-face interviews with all the relevant stakeholders of the regional formal WEEE management system of Campania. According to the last available Eurostat data, the collection rate in Italy was 7.7 kg per inhabitant in 2019, while the EU average collection rate was 10 kg per inhabitant. The analysis of national Italian performances across all regions showed that in 2021, about half of the Italian regions performed better in collection rates per capita than the Italian average, while the other half performed worse. The Campania region is included among the less-performing regions.

6.1. Barriers and Drivers: A Take Home Lesson

The interviews with stakeholders in the WEEE supply chain in the Campania region identified as a relevant barrier to the collection phase the low awareness of citizens about the importance of collecting and recycling WEEE. This barrier can also be found for other types of waste and novel green products [82]. In the recycling stage, one of the most frequent barriers emerged as the lack of certified first treatment plants in the regional territory, which forces WEEE transfer to plants in neighbouring regions. The lack of plants seems due to the lack of a favourable/conducive environment for entrepreneurial initiatives and the attractiveness of the needed investments. It should not be disregarded that the Campania region is sadly known for the presence of criminal organisations [83] making their own business in the waste sector. Moreover, bureaucracy continues to play a negative role in that the time and administrative burden required to obtain permits for new plants are still discouraging factors. Furthermore, there is a parallel feeling of aversion among the local populations to the opening of new waste treatment plants in general, as a consequence of past problems in solid waste management in particular in areas such as the Campania region. Finally, cannibalization creates a sort of secondary market parallel to the official one, although there is not yet sufficient data about the amount of WEEE that is extracted and traded in this secondary market.

A number of potential drivers also emerged from this study, among which the role of policymakers efforts to raise citizens/consumers awareness about WEEE collection and recycling by means of educational programmes in schools involving students and their families and communication campaigns for citizens. Educational programmes in schools are particularly meaningful as they can also stimulate the collective actions of students towards the understanding of WEEE recycling value and their collection, generating virtuous patterns at the local level by involving schools, students and their families, local municipalities, research centres, and other actors. Several scholars [8,22,31] also suggest the addiction of further cultural events to all citizens to stimulate their WEEE collection behaviour, thus improving the collection rates.

6.2. Limits and Recommendations

This study has some limitations due to the low number of reviewed papers matching the awareness and perception topics of interest for this study as well as the number of stakeholders interviewed (even if key actors of the WEEE supply chain were interviewed) and the lack of direct results related to the involvement of consumers as participants in the interviews. This last aspect can only be addressed by involving a very large number of consumers and is currently under evaluation by our research group to become a topic of future research. In order to limit these shortcomings, this study cross-validated its results with selected literature outcomes.

Last but not least, considering the large amounts of WEEE generated within urban systems, this study pointed out the importance of the presence or the need for urban collection networks, collection points, and an awareness of increasing activities (among

which are educational programmes in urban schools, communication campaigns, urban mobile collection points, repair points, and recycling companies, among others) to facilitate reuse and repair as well as collection and recovery of WEEE in Italy and worldwide.

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Abbreviations

Acronyms	Full Term
EEE	Electrical and Electronic Equipment
WEEE	Waste Electrical and Electronic Equipment
EU	European Union
IWCC	Italian WEEE Coordination Centre
ENEA	Italian National Agency for New Technologies, Energy, and Sustainable Economic Development
ANCI	National Association of Italian Municipalities
ARPAC	Agency for the Protection of the Environment of Campania
INNO-WEEE	Innovation-Waste Electrical and Electronic Equipment
RAEE	RAEE is the equivalent of WEEE in the Italian
ECOEM	National Collective System for the collection, treatment, and recycling of WEEE, including batteries and accumulators, domestic, and professional photovoltaic modules

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