

Article

A Comparative Study of E-Waste Management Practices of Regional Councils in Victoria and Queensland, Australia

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Abstract

Globally, Australia is ranked the fourth-top producer of e-waste. While Australian states and territories are increasingly recognising the e-waste problem and developing policies and regulations that deal with e-waste, huge amounts of e-waste still go undocumented. Currently, regional councils are concerned with the existing recycling practices owing to the escalating quantities of e-waste generated yearly. This paper examines the e-waste management practices of Victorian and Queensland regional councils, compares the current practices in managing e-waste, identifies the problems and challenges, and recommends innovative approaches to address e-waste collection and recycling practices in Australia. This study was conducted in regional Victoria and Queensland councils. A qualitative research method employing semi-structured interviews is adopted in this study. The study interviewed 49 employees of Victorian and Queensland regional councils. The findings of the study identified a number of areas that needs improvement in the management of e-waste such as: (a) lack of education and awareness about e-waste for the residents in the communities, (b) absence of knowledge about e-waste recycling (c) poor attitude towards e-waste recycling, (d) lack of sufficient funding; (e) limited number of e-waste recyclers to engage, (f) lack of specific policies and legislation on e-waste management (g) inability of the current National Television Computer Recycling Scheme (NTCRS) and mobile muster national product stewardship initiatives and schemes to cover all categories of e-waste. These results suggest that e-waste management practices in Victorian and Queensland Regional Councils need improvement. The findings of this study show that there are more similarities and fewer differences in how the Victorian and Queensland regional councils manage their e-waste. This study provides numerous practical and workable suggestions for addressing the e-waste management practices of regional councils in Australia. From a real-world scenario, this study will be useful to regional councils, environmentalists, and policymakers in identifying areas of improvement in e-waste management practices and developing impactful solutions.



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1. Introduction

Worldwide, discarded electrical and electronic equipment (EEE) broadly branded as “e-waste” is recognised as a waste stream with the fastest growth rate, amassing rapidly at a speed of around 3–5% annually. When compared to other solid waste streams, e-waste is growing three times faster than other solid waste streams globally [1]. The

Global E-Waste Monitor 2024 indicates that e-waste generation is now rising five times faster than documented e-waste recycling [2]. The reason for the rapid growth is due to: (a) growing population, (b) rapid urbanisation, (c) endless availability of newer designs, (d) innovative technologies, and (e) speedy obsolescence of EEE [1,3,4]. Prompted by the high rate of consumption, shortened lifecycles, and limited options for repair, e-waste is largely inappropriately managed, as the majority of e-waste generated is informally recycled [3]. According to Islam et al. [5] and Yang et al. [6], the way e-waste is defined and categorised varies considerably among countries globally. Forti et al. [1] defined e-waste as “a broad and growing number of electronic devices ranging from large household devices and consumer electronics to computers and accessories which have been discarded by their users”. According to a global study conducted by United Nations Environmental Program (UNEP) on e-waste in 2023, e-waste is described as “any discarded product that has a battery or plugs and contains toxic and hazardous substances that can pose severe risk to human health and the environment” [7]. While there are various ways to describe e-waste, the global definition of e-waste by the UNEP has been adopted in this study. The authors adopted this definition because it clearly represents the meaning of e-waste and emphasises toxic and hazardous substances contained in e-waste as well as its impact on human health and the environment. To clarify, the authors note that the scope of e-waste analysed in this study includes all categories of e-waste and not just the narrower categories currently covered by Australian collection and recycling initiatives and schemes to align with the definition/meaning of e-waste adopted in this study.

E-waste can significantly impact the health of humans and their environment if it is not appropriately treated, disposed of, and recycled [7]. These effects are strongly connected to the e-waste quantities generated and the existence of harmful metals and toxic chemicals contained in most e-waste [8]. The issues emanating from the management of e-waste also bring about remarkable prospects and opportunities to advance and take full advantage of the outcomes from the circular economy across the supply chain and product life cycle. From a circular economy perspective, e-waste can be transformed from a harmful environmental pollutant into a valuable resource while drifting away from a “take-make-waste model” to a “3R model” of re-use, repair and recycle. The 3R model of the circular economy aims to continually reuse discarded EEE through recovering rare metals and reducing the need for raw materials while decreasing the volume of toxic waste generated [1]. Globally, around 53.6 million tonnes of e-waste were produced in 2019 and are on track to reach 82 million tonnes by 2030. Out of these quantities generated in 2019, only 17% were collected and formally recycled, and the remaining were incinerated or dumped in landfills [7]. This exemplifies considerable magnitudes of valuable metals, including aluminium, gold, silver, platinum, copper, steel and other valuable materials that can be recycled, which were not recovered for treatment, processing and reuse for the production of new products [7].

Australia significantly contributes to the rising quantities of e-waste generated worldwide [4]. Presently, fewer than 40% of e-waste produced in Australia is recovered and recycled, and the rest ends up in landfills [9]. At the moment, local governments in Australia (particularly those in regional Australia) are struggling to deal with the current approaches adopted in recycling owing to the vast quantities of e-waste that are generated annually [10]. This creates a need to come up with new guidelines, strategies, policies and procedures to address the prevailing and current e-waste collection and recycling practices. This study focuses on regional councils in two Australian states (Victoria and Queensland) and adopts the broad definition of “regional councils” in Australia. In Australia, “regional councils” are a tier of local governments responsible for governing specific geographic areas outside of major capital cities. These regional councils are established by state and

territory laws. They manage essential community services (including the management and disposal of general waste as well as e-waste), local infrastructure, town planning, and represent the interests of rural and regional populations in their communities [11].

Consequently, by this broad definition, “regional councils” in Australia are comparable. The aim of this study is to examine the e-waste management practices of Victorian and Queensland regional councils, compare the practices implemented to manage e-waste, identify the problems and challenges, and develop innovative approaches to address the collection and recycling practices in Australia. The authors have selected these two Australian states because they have divergent positions regarding the respective state government outlook on e-waste management and legislation. For example, Victoria has a strict e-waste landfill ban, which means discarded electronic devices are not allowed in the general waste. In contrast, Queensland relies heavily on general waste levies/fines rather than a direct statewide e-waste ban. Thus, it will be interesting to explore and compare the e-waste management practices of these two states. In addition, the two states have different population metrics, which are a strong driver of e-waste generation, management and recycling.

Thus, this study attempts to provide answers to the following research questions:

- What are the problems and challenges faced by Victorian and Queensland regional councils in managing e-waste?
- What policies are implemented in managing e-waste in Victorian and Queensland regional councils?
- What are the practices implemented in the management of e-waste?
- How can regional councils in Victoria and Queensland better manage e-waste?

A review of the literature resulted in the adoption of Valence Theory and Norm Activation Theory as the theoretical foundation for understanding e-waste management practices of regional councils in Victoria and Queensland. Understanding consumer recycling intentions is crucial to council employees in designing efficient and workable e-waste policies and interventions, reduce/eliminate e-waste in landfills, preventing contamination during e-waste recycling, enhancing local e-waste management infrastructure, aligning policy with consumer behaviour, and meeting environmental requirements [4]. In the context of e-waste recycling, Valence Theory is a behavioural economics and psychology framework used to understand consumer recycling intentions. It proposes that consumers decide whether to recycle their used and discarded electronic devices by weighing the perceived benefits, such as convenience, monetary reward and environmental benefits, against perceived risks such as data theft from a discarded electronic device, effort required in finding a drop-off location and inconvenience [12,13]. On the other hand, Norm Activation Theory explains why individuals engage in pro-environmental and altruistic actions, such as e-waste recycling. The theory proposes that individuals are driven by personal moral norms or obligations. These norms are activated when an individual understands the detrimental consequences of their actions and feels responsible for them. Norm activation theory is based on three central ideas: (a) personal norms, (b) acknowledgement of responsibility and (c) awareness of consequences [12,14]. These theories have been applied by researchers [12–16] in understanding e-waste management practices and recycling benefits to consumers and the environment. Details of these theories and how they are applied in this study are discussed in Section 3.

Although there are prior studies on e-waste management and recycling practices in Australia [4,5,10,17–20], to the best of the authors’ knowledge, this is the first study to examine the e-waste management and recycling practices of regional councils in Victoria and Queensland. The novelty/originality of this paper lies in the premise that it is the first comparative research to examine the e-waste management and recycling practices of

Victorian and Queensland regional councils, identify the problems and challenges, and develop innovative approaches to address e-waste collection and recycling to help resolve the e-waste problem in Australia.

This paper consists of five sections. The introduction, significance of the research, statement of the problem, and the research questions are presented in Section 1. A critical review of the literature on e-waste management and recycling practices in Victoria and Queensland is presented in Section 2. The theoretical foundation for studying the e-waste management practices of regional councils in Victoria and Queensland is discussed in Section 3. The research methodology adopted for this study is provided in Section 4. The results and discussions are presented in Section 5. The conclusion of the paper, along with the recommendations and future research opportunities is provided in Section 6.

2. Literature Review

In conducting this research, earlier studies on e-waste are reviewed to: (a) identify key issues associated with e-waste management and (b) evaluate e-waste management practices in the Victorian and Queensland regional councils. This new knowledge and these insights are expected to assist these regional councils in addressing their difficulties and challenges, as well as come up with suitable strategies and approaches for recycling and disposal of e-waste. In this section, Australia's e-waste generation, management practices adopted, as well as the environmental and health impacts of e-waste disposal in landfills are reviewed and discussed. Furthermore, this section presents a synopsis of the scope of e-waste management in the State of Victoria and Queensland.

2.1. E-Waste Management in Various Countries

Worldwide, the management and recycling of e-waste is fragmented, inconsistent and patchy, with just 22.3% documented and appropriately recycled out of the 62 million tonnes generated in 2022, driven by technological progress, increased consumption, limited repair options, shorter lifecycles and inadequate e-waste management infrastructure [2]. Presently, Europe is leading the world in highly regulated recycling rates for domestically generated waste, with around 366 million tonnes (56%) in 2022 supported by strict and workable extended producer responsibility (EPR) policies and legislation [21]. Most Asian and African countries have very low recycling rates and currently rely worryingly on informal, harmful recycling methods with human and environmental consequences. Although the global e-waste report 2024 indicates some modest improvements, the global e-waste recycling rate has remained extremely low at around 21%, which indicates that approximately 80% of e-waste generated globally is still unaccounted for, with the majority ending up in landfills and informal recycling sectors predominantly in regions with low income [2].

Prior studies in Australia [3,5,17–19,22] and other countries such as China, India, Indonesia, Malaysia, Ghana, Nigeria and Kenya [23–30] offer valuable insights into the management of e-waste and why it is necessary to develop comprehensive and all-inclusive strategies for managing e-waste. For example, Andeobu et al. [3] examined AI technologies and their application in several areas of waste management, including e-waste, to boost sustainable waste management practices in Australia. Islam and Iyer-Raniga [5] utilised a combined Delphi-analytic hierarchy approach to ascertain possible and prospective e-waste products that should be included in Australia's "National Television and Computer Recycling Scheme (NTCRS)". Herat and Pinikkar [18] examined how Australia deals with and manages the evolving problems of e-waste due to its distinct topography and layout, and the information technology market sector, and then likened it to other nations across the world. Islam and Huda [10] presented an estimation of EEE products put on the market (PoM), e-waste generation and the stock of EEE products in Australia

from the year 2000 to 2047 using Holt's double-exponential smoothing and the Weibull distribution function to calculate past and future PoM and the generation of e-waste in Australia, respectively. Dias et al. [19] investigated the arrangements, organisation, methods of collection and processes of recycling of Australia's NTCRS scheme, taking into consideration the perspectives and views of the various parties involved in the scheme. Morris and Metternicht [17] assessed the efficiency of the legislation, policies and associated policy instruments on waste management in Australia, focusing on the national and sub-national level of implementation.

Earlier studies on the various aspects of e-waste management carried out in Australia and other countries are presented in Table 1. An evaluation of these studies indicates that the bulk of the articles in these countries were on e-waste management, e-waste generation, e-waste recycling, e-waste legislation and e-waste disposal behaviour. Only a few articles covered e-waste research areas such as environmental management, health impacts, problems and challenges. This outcome indicates that more research is required in these areas, particularly in the countries reviewed. Furthermore, Table 1 provides the scope, location and context of earlier studies on e-waste management. It can be seen that these studies are conducted in several locations, including Australia [3–5,20,31,32]; China [6,24,33–40]; India [25,41–53]; Indonesia [26,54–58]; Kenya [30]; Malaysia [27,59–65]; Nigeria [66–68] and the United States [69,70]. These studies provide valuable insights into e-waste management and recycling in these countries. The authors also highlight the challenges associated with managing and recycling e-waste, the significance of managing e-waste responsibly, as well as developing appropriate e-waste management interventions, programs and schemes.

Table 1. Previous studies on e-waste conducted in Australia and other countries.

Main Area	E-Waste Categories Analysed	Study Location	References
Environmental management	General	China	[71]
E-waste Recycling	Computers, televisions, refrigerators, air conditioners, personal computers, mobile telephones, washing machines, home appliances and computers, printed circuit boards (PCBs), Cathode ray tubes, TVs and monitors, general	Australia, India, China, Indonesia, Ghana, Nigeria, Switzerland, Japan, Germany, South Korea, United Kingdom, France, USA, Netherlands	[3,5,19,25,28,29,33,34,37,58,72–86]
E-waste disposal and behavior	Mobile phone, general	Australia, India, Nigeria, China, Malaysia, South Korea, Germany	[4,5,38,43,59,68,87–89]
E-waste problems and challenges	General	Australia, Malaysia, Kenya, India	[4,20,30,49,60]
Environmental and health impacts of e-waste	General	Australia, India, China	[20,24,47–49,72]
E-waste legislation	Household hazardous waste, general, ICT equipment, home appliances	Australia, India, China, Malaysia, Nigeria	[17,51,62,65–67,69,70,90–95]
E-waste management	Printed circuit boards (PCBs), televisions, computers, printers, IT peripherals, television and computer waste, photovoltaic panels and battery energy storage systems, general	Australia, India, China, Malaysia, Indonesia; Switzerland, Japan, Germany, South Korea, France, Netherlands	[5,20,23–27,32,33,35,36,40–42,44–46,50,53,55,56,58,60,61,63,64,78–82,84,86,96–100]

Table 1. *Cont.*

Main Area	E-Waste Categories Analysed	Study Location	References
E-waste generation	TV sets, refrigerators, washing machines, air conditioners, personal computers, general, mobile phones	Australia, India, China, Indonesia, South Korea, France, Netherlands	[5,6,20,26,31,39,45,52,54,57,82,84,86,99,101–103]

A comprehensive review of the literature identified two research gaps. Firstly, while there is previous research on e-waste management in Australia, no study has examined and compared the e-waste management practices of regional councils in Australia to identify key obstacles and areas where improvement is needed. Secondly, there is a lack of knowledge about the harmful and perilous nature of e-waste and the adverse ecological and health risks connected with inappropriate disposal [8,10]. Earlier studies [3,10,18] reported that e-waste quantities currently being generated in Australia greatly surpass the methods approved in the legislation to deal with and manage the e-waste problems, particularly in regional and remote areas. Owing to the increasing volume of e-waste generated in Australia every year, an understanding of how best to manage e-waste to enhance environmental sustainability and reduce health issues emanating from inappropriate disposal practices in the communities has become necessary.

2.2. Australia's E-Waste Generation

E-waste generation rate in Australia has significantly increased, with the majority originating from businesses and households. In 2023, Australians generated around 22 kg/person of e-waste per capita, which is more than double the global average of 7 kg. This means that an average Australian produced 22 kg of e-waste when compared to the global average of 7 kg. As one of the world's top producers of e-waste per capita, it is projected that Australia's total e-waste generation is expected to rise by 30% and could reach 657,000 tonnes by 2030 [104]. Currently, Australia recovers less than a third of the total value of the precious materials in the e-waste it generates. In 2019 alone, Australians disposed of around \$430 million worth of valuable materials in landfills along with their e-waste. According to DCCEEW [85] e-waste is responsible for more than 70% of toxic chemicals such as "lead (Pb), cadmium (Cd), mercury (Hg), barium (Ba), lithium (Li), polychlorinated biphenyls (PCBs), Polybrominated biphenyls (PBBs), brominated flame retardants (BFRs) as well as persistent organic pollutants (POPs)" among others found in landfills. The presence of these chemicals provides evidence to conclude that e-waste contains substantial amounts of toxic metals and contaminants, and informal recycling and inappropriate disposal of e-waste lead to environmental pollution and a negative impact on human health [86]. E-waste dumping and associated items (such as batteries) in landfills also create significant burdens on the environment and long-term threats to human health [8].

Although large organisations and industries that depend on the refrigeration of products, batteries and computers contribute greatly to this volume of e-waste, small and medium enterprises (SMEs) and households, as previously noted, are also responsible for Australia's high level of electronic equipment consumption and associated e-waste generated [104]. While the volume of e-waste generated year after year is certainly a huge challenge and has created Australia's e-waste problem, it also presents a circular economy opportunity for large-scale impact for e-waste recycling. Leveraging this opportunity, Australia can become a leader in creating a circular economy that mitigates environmental harm and generates economic opportunities in the growing sustainability sector. The "National Waste Report 2022" reveals that, of the 500,000 tonnes of e-waste generated in Australia in 2020–21, less than 50% was sent to formal recyclers [105], and the rest ended up

in landfills. Fixing/repairing, refurbishing, and recycling electronic products in Australia can create local jobs and tap into the value inherent in the materials used in electronic products. Currently, Australia recovers only 20% of the total value of the materials in e-waste it generates [106].

2.3. E-Waste Management in Australia

E-waste is a key environmental challenge owing to the cumulative quantities of e-waste that are generated as well as the content of both perilous and treasured substances found in them [1,8]. The value of precious metals present in e-waste is understood to be worth around \$14 bn worldwide. However, over 50% of these precious metals are often not recovered [1]. Australia is a significant importer of e-products [10]. The major problems with the management of e-waste in Australia and other countries are: “(a) high obsolescence rate of electronic products, (b) lack of effective collection and recycling systems, and (c) producers of electrical and electronic equipment (EEE) are not held responsible for the end-of-life disposal” [8]. As the quantities of e-waste produced in Australia are rising every year, the amount of e-waste recycled does not match the speed of e-waste generation.

Currently, Australia has two collection and recycling schemes. The first scheme is the “National Television and Computer Recycling Scheme (NTCRS)” which deals with the handling of discarded television sets, computers and other IT peripherals. The second scheme is the “Mobile Muster- a voluntary mobile telecommunications industry product stewardship program, managed by the Australian Mobile Telecommunications Association (AMTA) on behalf of its members and accredited by the Commonwealth Government in 2018. These two schemes recycle EEE, which makes up fewer than 10% of the total e-waste generation in Australia [107]. The remaining EEE are not within the scope of Australia’s current e-waste management schemes and programs.

2.4. Background of the State of Victoria and Scope of E-Waste Management

The State of Victoria is situated in the southeastern part of Australia. It is the smallest state by landmass after Tasmania, the second most inhabited state after New South Wales and covers a land area of 227,444 km² [88]. The population of Victoria is about 6.8 million as of June 2023 and is on track to reach 7.0 million by the end of 2024, which makes the state the most populous state in Australia. To the north, Victoria shares borders with New South Wales and to the west with South Australia. Approximately half of the population in Victoria is concentrated in the central-south area of the state, more specifically within the Metropolitan areas of Greater Melbourne, which is the capital of the State of Victoria [88]. With the growing population of Victoria, the quantities of e-waste produced yearly are substantial. In 2021, approximately 170,000 tonnes of e-waste were produced in Victoria, and this is projected to surge to around 279,000 by 2035 [89]. In particular, solar PV systems and battery storage e-waste generation are predicted to increase the most with a 15% annual growth rate [89]. Recognising the issues and challenges as well as the opportunities linked with e-waste, in July 2019, the Victorian government banned e-waste from Victoria’s landfills. Presently, new policies, which take the form of waste-management strategies and guidelines, are now established, which stipulate how waste (including e-waste) should be managed [9]. Figure 1 shows the map of Victoria indicating its location in Australia.

In addition to Victoria being recognised as the second most inhabited state, the state is the second largest in Australia, and its growing population is driving an e-waste crisis, with e-waste increasing three times faster than general municipal waste. Victorians produce an estimated 130,000–170,000 tonnes of e-waste annually [89]. This increase in population is having a significant impact and creating more e-waste management and recycling challenges. As the population of Victoria expands, shorter electronic products’ lifespans,

rapid technological upgrades and digitisation mean more electronics are purchased, used, and discarded. Figure 2 shows Victoria's population by age and gender (male and female) during the financial year 2023–2024.



Figure 1. Map of Victoria and its location in Australia. Source: Google Maps 2026. Note: The red portion of the map represents the state of Victoria.

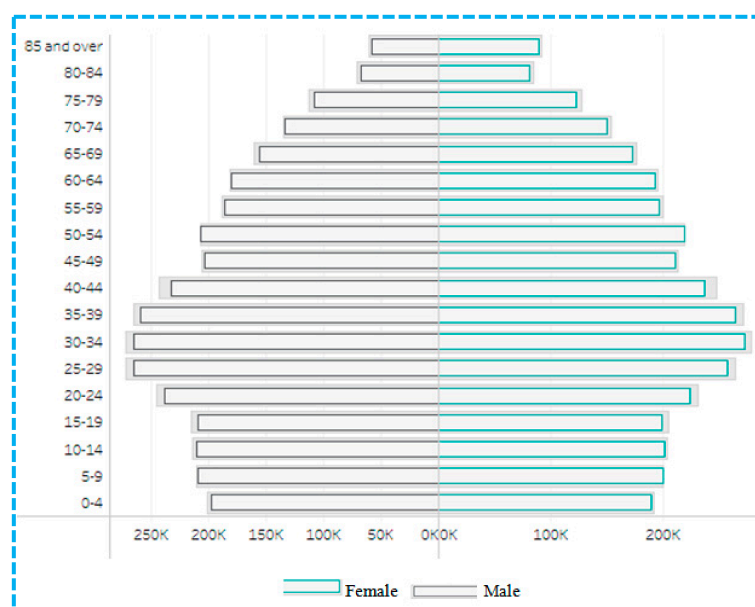


Figure 2. Victoria population by age and gender 2023–2024. Data Source: Australian Bureau of Statistics (ABS) [90].

2.5. Background of the State of Queensland and Scope of E-Waste Management

The State of Queensland is positioned in the northeastern part of Australia. The state is the second largest in terms of landmass and the third most populous Australian state and shares a border with the Northern Territory, South Australia and New South Wales. Queensland is popularly called the Sunshine State and has a large landmass covering an area of 1,723,030 square kilometres. Owing to the size of Queensland, its topographical landscapes and weather are varied and include humid rainforests, rivers, coral reefs, mountains, sandy beaches and deserts along its coastal regions [91]. As of December 2023, the population of Queensland is around 5.5 million, with the majority of the inhabitants

concentrated on the east coast, mostly in South East Queensland. The capital of the State of Queensland is Brisbane, and it is the third largest city in Australia. Apart from the capital city, Brisbane, 10 of Australia's 30 major cities are situated in Queensland. In terms of economy, Queensland has the third-largest economy, with its main strengths in natural resources such as coal, liquefied natural gas (LNG), and mining, as well as in other sectors including banking, insurance, tourism, agriculture, transportation and international education. For example, the Great Barrier Reef and other various beaches and sites for tourism contribute significantly to the economy of the state [91].

Queensland's waste management and resource recovery strategy reported that the new EEE flowing into Queensland was about 239,000 tonnes as of 2019 and is anticipated to surge to 204,000 tonnes by 2030. There was a substantial annual increase in e-waste generation in Queensland from around 100,000 tonnes in 2018 to 138,000 tonnes per annum in 2023. E-waste per capita grew to 19.5 kg in 2019 and is predicted to increase to 23.7 kg per capita by 2030 [92]. Queensland's waste management and resource recovery strategy, also known as the "Waste Strategy", sets the basis for dealing with various streams of waste, including e-waste. In 2023, the Queensland government replaced the "Waste Reduction and Recycling Regulation 2011 with the Waste Reduction and Recycling Regulation 2023 (WRR Regulation)". The main aim of the WRR Regulation is to continually provide a regulatory mechanism for implementing the "Waste Reduction and Recycling Act 2011 (the Waste Act)". The WRR Regulation provides support for the management of waste through encouraging waste avoidance, reuse, recycling and appropriate disposal, through the establishment of regulatory requirements and providing enabling heads of power for waste reduction and recycling activities [93]. Figure 3 shows the map of Queensland indicating its location in Australia.



Figure 3. Map of Queensland and its location in Australia. Source: Google Maps 2026. Note: The red portion of the map represents the state of Queensland.

Likewise, the state of Queensland's population is booming, with waste generation, particularly e-waste, growing even faster. With less than 40% of e-waste currently being recycled in Australia, the upsurge in consumer technology and household appliances puts enormous pressure on local councils [4]. Most of this e-waste has historically ended up in landfills, leaching toxic chemicals and wasting precious raw materials and valuable metals. In addition, Queensland has a substantial uptake of rooftop solar. Waste from solar panels and battery storage is estimated to be the fastest-growing category of e-waste in Queensland when compared to other states and territories in Australia [92]. Figure 4

shows Victoria’s population by age and gender (male and female) during the 2023–2024 financial year.

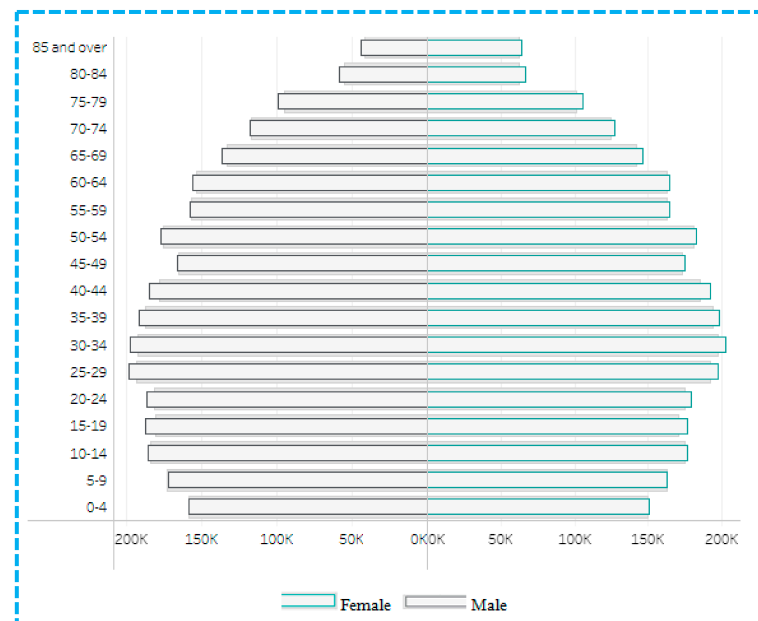


Figure 4. Queensland population by age and gender 2023–2024. Data Source: Australian Bureau of Statistics (ABS) [90].

2.6. Key Australian Legislation

Australia has a number of Commonwealth Government legislations enacted in relation to hazardous waste, including the “Hazardous Waste (Regulation of Exports and Imports) Act 1989”. This Act deals with regulations relating to imports and exports as well as transit of hazardous waste to ensure that hazardous waste is properly managed so that human beings and the environment are well protected from the detrimental effects of the waste both within and outside Australia. The Act basically covers and controls the movements and activities of wastes that do not have any financial value and are often prearranged/organised for onward disposal through incineration or landfill disposal operations. The Act helps to satisfy Australia’s commitments under the Basel Convention and relates only to non-functional wastes being dispatched to non-OECD countries [84]. Other legislation includes the “Product Stewardship (Televisions and Computers) Regulations Act of 2011”, which aims to provide a framework for effectively managing the environment, human health and other safety impacts of products through the promotion of recycled products. The Act was amended to make importers of large volumes of computers, computer accessories and televisions responsible for funding the recycling of e-waste from computer and computer accessories and television products [84].

The Regulations also specify the scheme’s annual recycling targets. These targets denote a percentage of waste arising from television and computer waste for that year and aim to increase the recycling rate to 80% as of 2022. A share of annual Scheme recycling targets is allocated to approved industry organisations operating under the Scheme based on the import and manufacture share of their members. In 2020, the Commonwealth introduced the “Recycling and Waste Reduction Act 2020”, which regulates the export of various categories of waste, including waste from plastic, tyres, glass and paper. In 2023, there was a commitment from the Australian government to develop a “mandatory product stewardship scheme” to support the reduction of waste from EEE as well as solar photovoltaic systems, which is currently at the early developmental stages [85]. Currently, no precise legislation on e-waste exists in Australia, and any approach by the state and

territory governments is voluntary and specific to each state and territory. As a result, there is little motivation and incentive for producers and dealers of EEE to adopt workable recycling programs and take-back schemes that support a green-design principle that is expected to enhance environmental sustainability and promote good health [84].

2.7. Environmental and Human Health Impacts of E-Waste Disposal to Landfills in Australia

According to Forti et al. [1] and Robinson [93], the amounts of environmental contaminants and pollutants found in e-waste are determined by the category of EEE that is discarded and the period the device was manufactured. Nearly all categories of e-waste contain precious metals, especially aluminium, gold, steel, and copper. These metals are valuable and significant because they provide the basis for and a motivation and incentive to formally recycle e-waste [42]. E-waste can contaminate soil, groundwater sources and food supply chains, and this is particularly common with EEE that is older, which makes up the majority of today's e-waste [108].

In recent times, owing to the surging demand for EEE and technological advancement, huge quantities of e-waste have been produced in Australia. If recycled correctly, valuable metals can be extracted and recovered efficiently and reused [109]. Environmental contamination and pollution due to inappropriate disposal of e-waste to landfills lead to direct and indirect exposures through air, dust, soil and water around e-waste landfill sites [24,42]. These harmful contaminants and pollutants can be dispersed into the atmosphere, groundwater, and soil around and close to the landfill sites and neighbouring regions. In some instances, e-waste is discarded straight into the soil or river, where the resulting draining and leaching of toxins pollutes the soil and impacts natural aquatic life and ecosystems [24,110]. For example, plants' roots can absorb toxic substances (particularly heavy metals) from the soil while growing and then transfer them to the stem and leaf; as a result, the soil is viewed as a significant source of contaminants in crops and vegetables [111]. In addition, lithium batteries embedded in e-waste cause fires in e-waste trucks and recycling facilities, which pose considerable safety issues for e-waste staff and properties.

Previous studies [112–119] on the adverse health consequences arising from e-waste disposal to landfills have constantly highlighted the threats to human health from exposure to harmful metals and toxins. Recent studies have found that unregulated e-waste recycling is connected with growing numbers of adverse health effects in humans. Examples include: adverse respiratory effects [120], hearing loss [116,121], adverse learning outcomes [122], skin diseases [123,124], adverse effects on the immune system [125], cancer [126], altered neurodevelopment [127], adverse birth outcomes [128], adverse cardiovascular effects [129] and DNA damage [130]. Thus, e-waste disposal to landfills in Australia has far-reaching consequences on human health and the environment. E-waste decomposing in landfills releases toxic gases and other greenhouse gases into the atmosphere, which contribute significantly to global warming and the climate change crisis. Alarmingly, Australia moves additional tonnes of e-waste to landfills every year, which is a serious issue that requires urgent attention. Transitioning from a linear economy to a circular economy can help minimise e-waste generation and reduce the environmental and health impact of e-waste disposal to landfill. Extending the lifecycle of EEE manufacturing materials and emphasising recycling can move Australia towards a cleaner, greener future [8].

2.8. E-Waste Recycling Companies and Material Recovery Facilities in Australia

Section 2.7 discussed the environmental and human health impacts of e-waste disposal to landfills in Australia. This section presents some of the major e-waste recycling companies and material recovery facilities (MRFs) in Australia. Recycling e-waste and averting

disposal to landfills prevents hazardous substances such as lead, mercury, barium and dioxins, among others, inherent in discarded electronic devices from contaminating soil and water systems. It safeguards human health, mitigates climate change, conserves valuable resources, and prevents the carbon-intensive process of mining for new raw materials. Inappropriate disposal of e-waste poses severe risks to entire ecosystems and communities, particularly regional and remote communities [8,24]. Table 2 lists some of the recycling companies and material recovery facilities in Australia, with the majority concentrated in the capital cities, predominantly in Melbourne and Sydney.

Table 2. List of Some of the Major E-waste Recycling and Material Recovery Facilities in Australia.

	Name	Description	Location
1	E-waste Recycling Cairns	E-waste recycling Cairns specialises in the recycling of electronic waste. Established in Portsmith, Australia, the company focuses on the responsible disposal and recycling of e-waste to extract valuable materials	Portsmith
2	1800 e-waste	1800 e-waste offers professional and reliable e-waste recycling services. Recycling e-waste not only prevents e-waste from ending up in landfills but also prevents hazardous materials from entering our waterways and food chains, highlighting the significance of appropriate e-waste recycling for a sustainable future	Sydney
3	IT E-waste	The company focuses on environmentally friendly IT disposal solutions and offers services such as computer recycling, data destruction, and equipment refurbishing and marketing. The company offers services that make it easy for clients to dispose of or refurbish their old electronic devices while supporting a healthy environment	Sydney
4	Electronic Recycling Australia	Electronic Recycling Australia specialises in recycling various discarded electronic devices. The company offers free collection services of home appliances while addressing and supporting the need for appropriate disposal and recycling, to mitigate the environmental impact of hazardous materials from e-waste	Adelaide
5	Secure Computer Recycling and Disposal	Secure Computer Recycling and Disposal is dedicated to providing environmentally sustainable e-waste recycling solutions. The company specialises in safe and secure e-waste management to ensure that harmful toxins inherent in e-waste are properly handled to reduce their environmental impacts	Perth
6	SPC eCycle	SPC eCycle is a dedicated e-waste recycling company that offers solutions to recycling discarded electronic devices of all categories, including IT equipment. The company also provides drop-off points and pickup services in Sydney and Melbourne, making it easy for residents to responsibly dispose of their e-waste.	Sydney & Melbourne
7	ReSource Pty Ltd.	ReSource is a major e-waste recycler in Australia and operates the first large-scale e-waste recycling facility. The company's innovative approach incorporates AI-driven sorting and advanced recycling techniques that ensure efficient and sustainable e-waste disposal.	Melbourne
8	ERS Queensland	The company specialises in e-waste recycling and data destruction and provides environmentally compliant recycling and sustainable e-waste management services	Brisbane

Table 2. *Cont.*

	Name	Description	Location
9	Victorian Environmental Waste Services	Victorian Environmental Waste Services offers a tailored solution to the environmentally responsible disposal of e-waste. The company prioritises recycling methods that reduce the impact on the environment and handles all categories of e-waste.	Melbourne
10	Sims Pty Ltd.	Sims is a major e-waste recycler in Australia. The company processes end-of-life electronics and contributes to a sustainable circular economy through repurposing, refurbishing and recycling e-waste to reduce environmental impact	Sydney
11	United Resource Management (URM)	United Resource Management (URM) offers reliable and convenient e-waste recycling services, enabling residents in the community to responsibly dispose of their e-waste. The company focuses on recycling and re-purposing of discarded electronics to prevent the impact of inappropriate disposal in landfills	Sydney
12	Zolo Australia	Zolo Australia offers collection services and secure data destruction of discarded electronic devices. The company promotes circular economy practices through encouraging re-using, refurbishing, and recycling while supporting climate action initiatives	Sydney
13	Cleanaway Waste Management Ltd.	Cleanaway Waste Management Ltd. offers e-waste recycling solutions. The company is committed to sustainable e-waste management practices through efficient handling of various categories of e-waste as well as other hazardous and organic waste.	Melbourne
14	Green Collect Pty Ltd.	Green Collect specialises in e-waste collection and recycling services to support responsible disposal and resource recovery. The company encourages circular economy practices and also creates employment opportunities for communities	Melbourne
15	Ecoactiv Pty Ltd.	Ecoactiv specialises in e-waste recycling and offers collection services for discarded electronic devices in Australia. The company handles e-waste from both residential and commercial clients and encourages circular economy practices.	Melbourne
16	Ecocycle Pty Ltd.	Ecocycle is a major recycling company that offers tailored e-waste recycling solutions. The company specialises in safe recovery of hazardous substances from various categories of e-waste, including monitors, laptops and fluorescent tubes	Melbourne
17	Shred-X Destruction Pty Ltd.	Shred-X Destruction specialises in e-waste recycling and secure destruction services and offers solutions for the responsible disposal of e-waste. The company is committed to sustainably recycling e-waste and ensures that data and sensitive materials are securely destroyed, thereby contributing to environmental preservation	Gold Coast
18	KTS Recycling Pty Ltd.	KTS Recycling specialises in e-waste recycling. The company encourages circular economy practices and supports the Victorian Government ban on e-waste to landfills. KTS Recycling freely collects and recycles e-waste, thereby helping to reduce the environmental harm posed by inappropriate disposal of e-waste.	Melbourne

Table 2. *Cont.*

	Name	Description	Location
19	Green Tech Recycling Pty Ltd.	Green Tech Recycling (GTR) specialises in e-waste recycling solutions and offers collection services, processing and data destruction according to industry standards. The company supports households and businesses in responsible and sustainable e-waste disposal.	Sydney
20	EraseIT Pty Ltd.	EraseIT specialises in ICT asset disposal and e-waste recycling. The company offers recycling solutions that ensure safe and compliant disposal of computer assets and other electronic devices. Services offered include secure data erasure and e-waste recycling while complying with environmental legislation and best practices	Melbourne
21	Envirostream Australia Pty Ltd.	Envirostream Australia specialises in e-waste recycling, including batteries. Services provided include collection and establishment of drop-off locations. The company supports circular economy practices through efficiently recycling e-waste and addressing the growing challenge of battery waste in Australia	Melbourne
22	Pure Environmental Pty Ltd.	Pure Environmental specialises in e-waste recycling as part of its commitment to waste management and resource recovery services. The company prioritises innovative solutions that promote environmental sustainability and circular economy practices through appropriate recycling of hazardous and toxic materials	Brisbane
23	Waste Choice Pty Ltd.	Waste Choice Pty Ltd. specialises in the safe and efficient recycling of e-waste and lithium batteries. The company is committed to environmental sustainability and ensures compliance with regulatory guidelines, disposal and recycling practices	Melbourne
24	Reuse-RecycleIT Pty Ltd.	Reuse-RecycleIT is dedicated to e-waste recycling, repurposing, and refurbishing. The company focuses on end-of-life IT, printers, copiers and other office equipment and ensures responsible recycling practices and data destruction while complying with environmental management standards.	Canberra

Developed for this study.

Regional and remote parts of Australia often lack recycling companies, creating a challenge for regional councils in terms of high transportation costs, issues with contamination, as well as fires on e-waste trucks during transportation due to lithium batteries embedded in discarded electronic devices. In addition, geographic isolation and small population size in the regional and remote areas often inhibit investment in recycling and recovery facilities. These challenges are often unique to regional communities in Australia and need to be addressed through national policymaking. Generally, distances to these recycling and resource recovery facilities make e-waste recycling for regional councils too costly to run and manage. Even some e-waste recycling services close to some regional councils are not able to process certain categories of e-waste, creating additional challenges. Thus, investing in e-waste recycling and resource recovery facilities in regional areas would: (a) prevent long trips for e-waste trucks, (b) safeguard landfill space, (c) create new job opportunities in the communities, and (d) make regional communities self-reliant [11].

3. Theoretical Foundations

This study adopts the Valence Theory and Norm Activation Theory as the theoretical foundation for studying the e-waste management practices of regional councils in Victoria and Queensland. Previous studies [12,13,15,16] have applied these theories to determine strategies that can be employed in recycling e-waste to design interventions that will bring affirmative outcomes to consumers through understanding their intention to recycle.

In recent years, Valence Theory and Norm Activation Theory have been applied to this topic because motivating and engaging consumers to recycle e-waste necessitates an in-depth understanding of the various dimensions and preferences that underlie and trigger behavioural intentions [13,14]. Consequently, this study applied these two theories to explore how consumers evaluate and weigh their choices to participate in e-waste recycling based on their rational and moral considerations in determining recycling intentions. Table 3 presents a summary of previous studies and findings on consumer intentions to recycle e-waste.

Table 3. Summary of research results on consumer intentions to recycle e-waste.

Framework Used	Research Method	Sample	Outcomes/Findings	Reference
Valence Theory	Quantitative	A survey questionnaire was administered to 774 Japanese consumers	Intentions and choice to participate in e-waste recycling are influenced and determined by factors such as environmental concerns and the perceived benefits of engaging in the behaviour	[13]
Valence Theory & Norm Activation Theory	Quantitative	A survey of 398 questionnaires was conducted in Vietnam	Social support value, monetary risk, awareness of consequences, educational background and acknowledgment of responsibility influence intention to recycle e-waste	[12]
Valence Theory	Quantitative	A questionnaire survey was administered to 346 Ugandan residents	Perceived risks, the role and contribution of governments and awareness of e-waste recycling significantly affect e-waste recycling intentions	[111]
Norm Activation Theory	Quantitative	A survey questionnaire was administered to 544 respondents residing in Ho Chi Minh City	Social norms, personal norms, inconvenience of recycling, awareness of e-waste pollution, age, and income considerably impact the readiness to pay a fee for e-waste recycling	[112]
Valence Theory	Quantitative	A self-administered online questionnaire on 412 restaurant customers	Privacy concerns, useful value, convenience, compatibility, technology acceptance and smartphone affinity significantly affected an individual's intention to recycle	[16]
Norm Activation Theory	Quantitative	The study analysed a total 500 responses from residents in the mainland and Jeju Island to determine their ' e-waste recycling intentions, choice and behaviours using structural equation modelling via the WarpPLS approach	Publicly available information does not directly encourage and influence residents' intentions to recycle e-waste, instead, it indirectly affects them through two mediating variables such as recycling attitudes and moral norms	[14]

3.1. Valence Theory

Valence Theory was first conceptualised by Peter and Tarpey in 1975. The theory is largely founded on the notion of cognitive-rational decision-making and has proven to be an efficient framework to understand how organisations make decisions through evaluating both optimistic and adverse valences. The theory originated from the field of economics and psychology literature and incorporates the two major critical aspects of organisations' decision-making process, which are perceived benefits and perceived risks [116]. Perceived benefit relates to the consumers' view of the overall benefit and value arising from products and services, while perceived risk is the subjective probability of loss. Valence Theory is acknowledged as a rational and balanced model and works on the premise that consumers tend to "maximise benefits and minimise the risks, based on the optimal net valence resulting from negative and positive effects" [116,117]. Consequently, Valence Theory has been adopted as a more integrated approach that is used to evaluate the influence of positive and negative perceptions, respectively. The theory has also been embraced in many research studies as a theoretical foundation that involves the engagement of individuals, organisations and communities [117]. For example, Xiao et al. [117] used Valence Theory to examine the organisations' negative valences of social, physical and privacy risks as well as positive valences of financial value and convenience value on consumers' intention towards online health services. Heinonen [118] adopted Valence Theory in investigating organisations' interest in engaging in online activities with their customers. Previous studies by Nguyen [12] and Dhir et al. [13] adopted the Valence Theory in investigating e-waste management and consumers' outlook towards recycling of e-waste. According to Nguyen [12] and Dhir et al. [13], the Valence Theory is appropriate for e-waste management and recycling owing to the fact that it supports both perceived benefit and perceived risk, which better assesses the intention of consumers to be involved in e-waste recycling behaviour. Moreover, Han et al. [119] and He [120] reported that consumers' values and behaviours are key predictors of their readiness to partake in the recycling of e-waste.

3.2. Norm Activation Theory

Norm Activation Theory was initially proposed in 1970 by Schwartz and was originally used to explain the concept of helping behaviours such as "bone marrow donation" [121]. Later, the theory was expanded and adopted to forecast a variety of altruistic pro-social intentions and behaviours [122]. In recent years, Norm Activation Theory has been broadly implemented in explaining organisations' engagement in moral and ethical scenarios, including waste recycling, energy conservation and protection of the environment [123,124]. Norm Activation Theory suggests that behaviour is activated when individuals and organisations become aware and mindful of the consequences and implications of their actions and feel a personal responsibility to act. The theory recognises the association between personal norms and behaviour, which is the central idea that emphasises the individual's moral norms impacting pro-social behaviour [125,126]. Precisely, an individual's pro-environmental behaviour is the extent of his/her personal responsibility relating to such behaviour, which is replicated in the personal norms. Personal norms are often seen as "feelings of moral obligation or duty to act" in a socially responsible manner and have an association with behaviour [126]. Thus, the initiation of an individual's personal norms is inadequate for socially acceptable behaviour owing to the effect of other factors such as refusal of responsibility. Consequently, the Norm activation process is identified by being aware of the consequences and acknowledging responsibility. In the context of e-waste recycling, Norm Activation Theory suggests that recycling behavior starts with an individual's awareness of the consequences and implications of inappropriate disposal

and then develops that sense of responsibility in relation to the adverse consequences and implications of that behavior, which eventually increases the individual's intentions to take action in a socially responsible manner to participate and contribute to the recycling of e-waste [12].

3.3. Research Framework

On the basis of the discussion on Valence Theory and Norm Activation Theory in Sections 3.1 and 3.2, this research study proposes an integrated framework with the aim of exploring the determinants of consumers' intention to recycle e-waste. Consumers' intention to recycle e-waste is described as the likelihood that a consumer will participate in e-waste recycling and willingness to do so [13]. Figure 5 below illustrates the research framework for this study. The framework represents a pictorial overview of this research and outlines the concepts, ideas and approaches developed in this study. The study combines insights from Valence Theory and Norm Activation Theory to study how influencing factors such as: "(a) perceived benefits, (b) perceived risks, (c) openness to change and environmental concerns, (d) perceived behavioral control; (e) awareness of consequences and (f) acknowledgement of responsibility" influence consumers' willingness and intentions to take part in formal collection of e-waste and recycling schemes in Victorian and Queensland regional councils. In addition to this, the study explores the influence of the demographic characteristics of consumers such as: "(a) gender, (b) age, (c) educational background and (d) personal income" on the intention of consumers to participate in e-waste recycling.

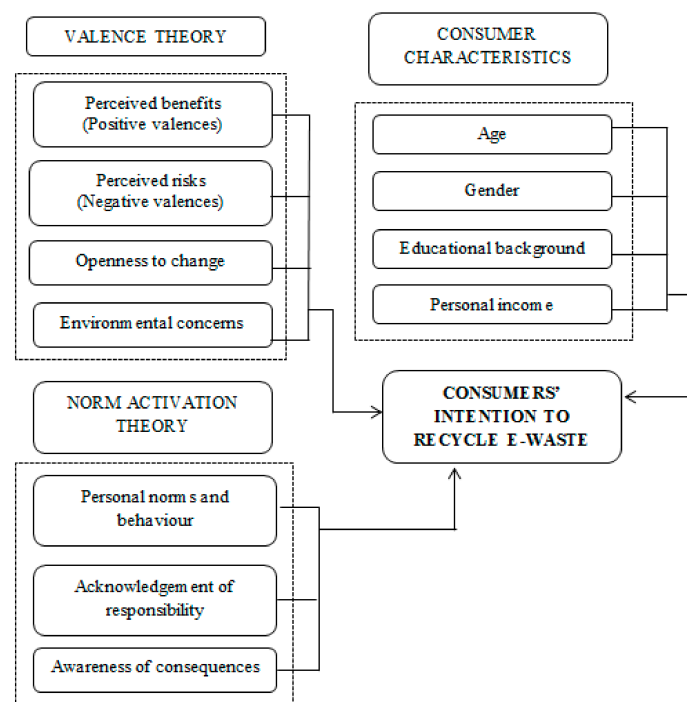


Figure 5. Research Framework.

Perceived benefit is a fundamental aspect of an individual's decision-making process as established and demonstrated in Valence Theory and acts as an enabler that drives individuals to engage in a specific behaviour. Perceived risk, on the other hand, is the opposite of perceived benefit and has a negative impact on consumers' decision-making. In the context of recycling of e-waste, consumers' perception of risks involves loss of money, effort, and time, which could hinder consumers from participating in e-waste recycling [13,127]. Awareness of consequences considers adverse and detrimental consequences on others, the

natural environment and the entire ecosystems due to individuals' attitudes and behaviours towards e-waste recycling. Previous studies [128,129] reported that awareness of environmental consequences is considered a determinant of consumers' intention to recycle e-waste. Acknowledgement of responsibility is the feeling of responsibility for the negative consequences of not acting pro-socially. Prior studies on pro-environmental behaviours [128–130] emphasised the relevance of the responsibility of consumers in lessening environmental problems associated with e-waste recycling. Therefore, it is recognised that acknowledgement of responsibility for recycling e-waste can be a driver of consumers' intentions.

4. Methodology

This study is purely a qualitative study. The primary aim of adopting a qualitative methodology is to provide a comprehensive, straightforward analysis of the participants' experience in the management and recycling of e-waste in the respective regional councils. According to Chu [131], qualitative research is highly descriptive because its primary goal is to capture the depth, complexity, and meaning of human experiences. Unlike quantitative research, which focuses on numerical data and statistical relationships, qualitative research seeks to answer the "why" and "how" behind the "experiences" and "behaviours," which is a goal of this study. The researchers used these detailed descriptions to extract core themes, identify underlying participants' experiences and build a conceptual understanding of the e-waste problem.

Further, adopting a qualitative research methodology is deemed to be appropriate in this study for the following reasons. Firstly, qualitative research is employed in order to gain a deeper understanding of the integral issues arising from the management and disposal of e-waste using analytical and investigative procedures. Secondly, this study adopts a qualitative research methodology to enable the authors to appropriately address the research questions and to gain an in-depth knowledge of the various perspectives of e-waste management, the experiences of the research participants, as well as the context. Thirdly, a qualitative research methodology enables the researchers to seek answers to questions that would otherwise be difficult to put into numbers to better understand human experience and knowledge [132,133]. Understanding the daily realities of a social phenomenon such as the management and recycling of e-waste and answering the research questions on how they are practised would help to extend new knowledge and understanding of the management of e-waste of regional councils in Victoria and Queensland.

4.1. Research Design

The qualitative research for this study involved conducting individual semi-structured face-to-face interviews with a total of forty-nine (49) Victorian and Queensland regional councils' employees with roles and responsibilities linked to e-waste management and working and interacting with consumers of electrical and electronic products in the communities. Semi-structured interviews are used when researchers intend to explore respondents' thoughts, feelings, and experiences about a social problem. Semi-structured interviews provide a mix of a list of planned questions with the opportunity to ask follow-up questions [134]. Previous studies by Thukral and Singh [135] used semi-structured interviews to interview six experts from producer organisations about their perspectives towards e-waste management. Nisha et al. [136] also used semi-structured interviews to explore the perspectives of eight selected consumers about their awareness and perceptions of e-waste management. A total of 32 regional councils from Victoria and Queensland participated in this study. Thirty-one (31) employees from Victorian regional councils were interviewed, while eighteen (18) employees from Queensland regional councils were interviewed for this study. The study will enable the regional councils to ascertain the obstacles to e-

waste collection and recycling, contemporary industry best practices, and establish the regional councils' perspectives for future regulatory support for funding. A qualitative research design allowed respondents to share their detailed views and perspectives about the present-day practices implemented in the management of e-waste, as well as issues and challenges encountered. The interview questions focused on e-waste management practices of regional councils and current practices adopted to identify areas for improvement. Face-to-face interviews rather than telephone interviews were preferred in order to build and establish connection/rapport and to discern non-verbal cues in what has been established as both a global and a local problem [132,137]. The research design also reinforced and supported a fact-finding approach to collecting data using an interview guide and making sure that respondents can freely discuss their viewpoints and include extra information they consider pertinent.

4.2. Research Setting

This study was carried out in regional Victoria and Queensland and engaged regional council employees with roles and responsibilities related to e-waste management in the communities. The regional councils that participated in this study have a strong self-motivated workforce with highly experienced employees. Ethics approval was provided by the University Human Ethics Review Board, and written informed consent was acquired from each respondent before proceeding to collect data.

4.3. Recruitment of Participants

In conducting this study, a purposive sampling method was adopted [138]. Purposive sampling is adopted "with a purpose in mind and enables a sample to be selected to include the issues of interest and eliminate those that do not meet the requirements of the study" [138]. All participants were from Victorian and Queensland regional councils. An email with an invitation to participate in a research study was sent to a mailing list of council employees with roles relating to the management and recycling of e-waste. The email was supported with an information sheet specifying the aim and purpose of the research, the rationale and significance of the study, the interview process, matters relating to anonymity and confidentiality, data security and dissemination of research outcomes. In addition, a consent form was also provided to the participants prior to the individual interviews. If required, respondents were requested to get in touch with the researchers using their university email address provided if they would like further information about the research. Reminder/follow-up emails were distributed prior to each interview. In addition, meetings were attended by the researcher within the regional councils to introduce the study. Victorian and Queensland regional councils' employees with roles and responsibilities linked to e-waste management and working and interacting with consumers of electrical and electronic products in the communities were invited to participate in the interview. Initially, fifty-four (54) council employees responded to the invitation to participate. The respondents were then contacted again to organise interviews with dates, times and locations of their choice. Forty-nine (49) interviews were completed; five employees could not take part due to unexpected work commitments.

4.4. Data Collection Procedure

This study targeted e-waste management and recycling employees of Victorian and Queensland regional councils. The investigator carried out semi-structured interviews with individual council employees. Participants' ages range from 28 to 54 years. The length of time employed in the respective councils ranges between 1 year and -25 years. The individual interviews were conducted at the respective councils' offices located across the various parts of Victoria and Queensland. A total of 49 interviews, ranging from

30–60 min in length, were audio-recorded after obtaining consent and transcribed for this study. As the interview questions were open-ended, participants responded to these questions within varying time frames. However, the majority of the participants provided a response to the interview question within 45 min to 60 min. The average time of the interview was 45 min. The longest interview was 60 min, while the shortest interview was 30 min. Audio recordings were anonymised for confidentiality by the researcher, and all respondents were allocated a distinct identification number. At the commencement of each of the interviews, the investigator explained the information sheet and provided the interview questions, prior to working through the consent form, which was then completed and signed. Participants were asked open-ended questions. There were 25 open-ended interview questions (not including demographic information) organised into three sections. Section 1 asked questions relating to what constitutes e-waste in the respective participating regional councils and matters relating to e-waste management. Section 2 focused on the problems and challenges emanating from the management of e-waste, and Section 3 focused on practices adopted to manage e-waste.

4.5. Data Analysis

In order to examine the e-waste management and disposal practices of the contributing regional councils, a qualitative data analysis was conducted. Semi-structured and individual in-depth interviews were carried out, and data collected through the interviews were analysed by means of qualitative content analysis.

4.5.1. Qualitative Content Analysis

Qualitative Content Analysis (QCA) is referred to as a systematic research methodology that is used for the interpretation of textual, visual, or audio data by means of coding data into categories and themes. In educational and social research, QCA is very useful in addressing the “how” and “why” research questions while providing an in-depth understanding of the experiences of research participants, phenomena and context. Qualitative content analysis is also useful in transforming huge, unstructured data such as interviews and large texts into prearranged, structured and concise summaries in order to analyse a social phenomenon, including human and organisational behaviour [20]. The qualitative content analysis process involves condensing the raw data into categories and themes as noted above and is based on valid inferences and interpretation. The process makes use of an inductive reasoning process, which allows the emergence of themes and categories from the raw data after a careful and constant examination and comparison by the investigators [20]. The authors followed the qualitative content analysis procedure and coding process outlined in the manuscript below. Credibility and reliability in qualitative content analysis ensure qualitative data, such as interview transcriptions/interpretations, accurately reflect participants’ lived experiences and the raw data collected. The authors view this process as the qualitative equivalent of internal validity. To establish credibility and reliability, the researchers used strategies like triangulation, checking and rechecking, and peer-debriefing to validate the findings and to enhance the credibility and reliability of the qualitative content analysis.

Most QCA in previous studies are largely inductive, focusing on the examination of topics and themes as well as inferences drawn from them in the data collected. According to Patton [138] there are three main methods of conducting QCA and this depends on the degree and extent of inductive reasoning involved, and these are: “(a) conventional qualitative content analysis (b) directed qualitative content analysis and (c) summative qualitative content analysis”. This study adopts conventional qualitative content analysis, which requires coding categories to be derived directly and inductively from the transcribed

interview data. The purpose of QCA in this study is to: “(a) organise and draw meaning from the interview data collected and to obtain realistic inferences from it; (b) determine and identify the keywords and themes in the interviews and (c) develop a qualitative classification and categorisation of the transcribed data” [20,131].

In addition, QCA is used in this study because it facilitates and supports the analysis of extensive data, whether it is textual, visual, or audio data [131]. Specifically, the data used in this study are textual data or written text (transcribed data), and this forms the data source for the QCA adopted in this study. Generally, when carrying out a QCA, the researcher needs to ascertain whether the analysis should be of a broad surface structure (which is a manifest analysis that focuses on what has been said) or of a deep structure (which is a latent analysis and is based on what is intended to be said) [131]. For this study, a broad surface structure (manifest analysis) has been selected, which is consistent with the nature and structure of this research while taking into consideration the inevitable subjective interpretation of the authors of this research [139,140].

4.5.2. The Procedure for Qualitative Content Analysis

The process of the qualitative content analysis proceeded by first generating a descriptive coding structure that organised and made sense of council employees' views and experiences, and then using qualitative content analysis that sought meaning and themes in those views and experiences [138]. According to Saunders et al. [134], the procedure of coding or categorising in qualitative data plays a significant role in analysing the collected data. It entails subdividing and segmenting the data as well as assigning codes or categories. Codes or categories are referred to as tags or labels that are used for apportioning units of meaning to the textual data that has been gathered and compiled during a study. In most cases, in QCA, codes are usually attached to chunks or pieces of various-sized words, phrases, sentences or whole paragraphs in the qualitative data [138]. Seidel and Kelle [141] reported that the primary role of coding in QCA is in the: “(a) identification of relevant and appropriate phenomena; (b) gathering examples of those phenomena; and (c) evaluating those phenomena in order to find commonalities, variances, differences, patterns and structures”.

An explanation of the steps used in the qualitative content analysis is described below. Based on a three-step approach adopted by Srivastava and Thomson [142], and Ritchie and Lewis [143], the transcribed data were carefully analysed for trends and inconsistencies and emergent categories across the data were then identified. Firstly, transcripts were scrutinised and analysed using an approach to qualitative content analysis [142]. Thereafter, based on the interview questions and the themes that emerged from the preliminary evaluation of the data, a coding frame was created. These codes were complemented by the emergent codes identified through closer and careful reading and re-reading of the transcripts [138]. Secondly, the transcripts were coded in Microsoft Word following an iterative process of initial coding, refining of the coding and subsequent re-coding to ensure the robustness of the coding while checking for potential researcher bias and a degree of congruence and similarity between the coding. Thirdly, coded data were then summarised with respondents' IDs in rows and themes and sub-themes in columns. Summaries of coded transcripts were compared with demographic information to identify emerging themes and patterns. The following initial themes emerged from the qualitative content analysis of the data: (a) meaning and classification of e-waste, (b) e-waste management strategies, (c) policies to manage e-waste, and (d) e-waste problems and challenges. Figure 6 represents a thematic map indicating e-waste management themes and sub-themes from the analysis. The dotted lines demonstrate the relationship between the themes and sub-themes.

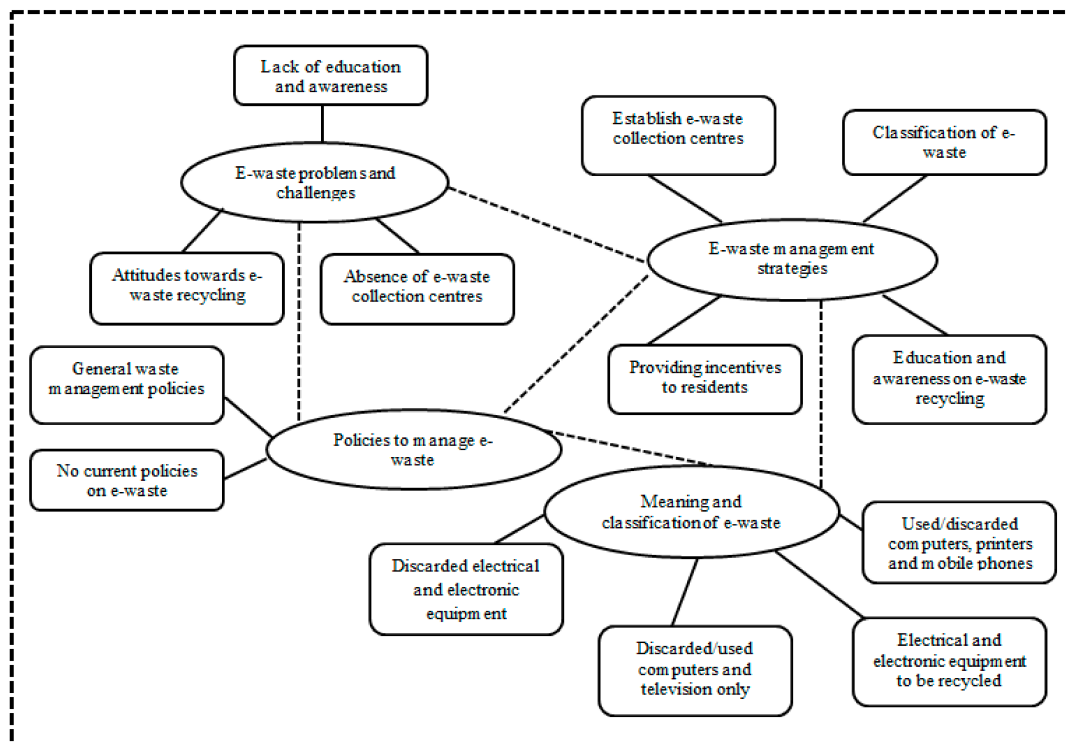


Figure 6. Thematic map indicating e-waste management themes and sub-themes.

5. Findings and Discussion

5.1. Findings

This section presents the results/findings of this study. It provides the outcomes of the responses to the research questions. Detailed responses to each of the questions in Section 1 are provided below.

5.1.1. What Are the Problems and Challenges Faced by Victorian and Queensland Regional Councils in Managing E-Waste?

The interview participants were requested to comment on the specific problems and challenges facing their respective councils on e-waste management and disposal practices. All of the 49 participants (100%) agreed that a major difficulty and challenge in managing e-waste is the lack of education and awareness creation for the residents in their communities. This lack of knowledge and awareness reduces the amount of e-waste that would have been collected and leads to a poor e-waste recycling attitude. Another specific challenge noted by all 49 participants (100%) is the absence of e-waste collection centres at strategic locations within their communities.

Specifically, according to participant 29 from the Victorian regional council:

“Presently, we have a limited number of drop-off collection services for e-waste collection as they are only located in our office, transfer stations or community centre sites only. We need to create more collection centres at strategic locations throughout the community to facilitate more e-waste collection from our residents” (Participant 29).

A significant challenge stated by all 49 participants (100%) is the possibility of fires on trucks during the transportation of e-waste with lithium batteries in them that consumers dump along with other rubbish. According to a participant from the Queensland regional Council:

“A few years ago, fires from lithium batteries were not common, but now lithium batteries have caused a lot of fires in our council. We have had several incidents of fires during e-waste transportation, which have created enormous challenges for our council” (Participant 11).

Further, 39 of the 49 participants (80%) agreed that their councils are under-resourced and not adequately funded, and this makes it hard to get things done quickly when there are many processes and procedures to go through. Another significant challenge arises in situations where the councils do not have a choice but to dispose of some of the e-waste that they cannot recycle in landfills due to limited recyclers available to recycle. Of the 49 participants, 28 participants (57%) stated that their councils dispose of e-waste that cannot be recycled in landfills due to a lack of capable recyclers. According to all 28 participants, this situation is particularly obvious in some of the e-waste collected from EEE made from non-recyclable materials, and this is disposed of in landfills.

Participant 12 from the Queensland regional council and participant 21 from the Victorian regional council shared a common view, stating:

The current National Television Computer Recycling Scheme (NTCRS) adopted is limited in scope, and only TVs and computers can be recycled under this scheme. The situation is made more difficult because there are limited e-waste recycling companies to engage. The few available recyclers are not able to recycle all the e-waste categories collected by the council. Those not collected by the recycler are moved to landfills (Participant 12 and Participant 21).

5.1.2. E-Waste Management Policies Are Implemented to Manage and Dispose of E-Waste

All participants were asked to explain what policies are used in the management of e-waste in their respective councils. All of the 49 participants (100%) from the Victorian and Queensland regional councils reported that their councils do not have any specific policies in place for e-waste. According to one participant from the Queensland regional council.

“At the moment, we do not have any policies on e-waste management. General waste management policies are used for e-waste management. The current general waste management policies do not sufficiently address the management of e-waste as well as the problems and challenges associated with e-waste recycling and recovery” (Participant 7).

All of the 49 participants (100%) recognised the issues inherent in the management of e-waste and the protection of human health and the environment as complex, leading them to describe the concept of e-waste management as both a local problem and a global problem.

“The reality is that e-waste management is a complex issue globally, and many countries, including Australia, are still struggling with how they can effectively manage their e-waste and more still needs to be done. There is a need to develop appropriate policies that deal with e-waste management in Australia” (Participant 49).

5.1.3. Practices Adopted by Regional Councils to Manage E-Waste

Participants were asked to explain the practices implemented in managing e-waste in their respective councils. In general, there was a focus and strong emphasis on the lack of state and national legislation in the management of e-waste, as well as a broader concept of approaches implemented by each council in managing e-waste. All 49 participants (100%) identified the lack of appropriate specific legislation on e-waste, citing “National Television Computer Recycling Scheme (NTCRS) and the Mobile Muster- a voluntary mobile telecommunications industry’s product stewardship program”, as the only schemes

which solely consider computers, television and mobile phones as e-waste, respectively. The majority of the participants stated that the management of e-waste is based on the council's general waste management regulations.

Participant 15 from the Queensland regional council described what happens when consumers bring their e-waste to the waste facilities.

"When the residents bring their e-waste to the facilities, they are directed to the designated areas where they can drop the various categories of e-waste. The e-waste is then transported to the recyclers for recycling and recovery. Some categories of e-waste are not collected and recycled. For example, our council does not collect solar panels from its residents" (Participant 15).

Meanwhile, Participant 31 from the Victorian regional council adds that:

"Currently, residents drop off their e-waste at any of our council's waste management facilities. We need to set up specific e-waste collection centres closer to the residents to facilitate more e-waste collection. At the moment, e-waste collection from our residents is free. Our council can start introducing fees and fines to deter people from just throwing e-waste into their bins" (Participant 31).

Most of the participants agreed that many of the general waste (including e-waste) policies, laws and regulations are not made known to the consumers. Most residents in the communities are not aware of current waste policies and regulations.

According to participant 10 from the Queensland regional council:

"Generally, residents will want to recycle, but the problem is that they just do not know the best practices" (Participant 10).

Further, in relation to e-waste ending up in landfills, 46 of the 49 participants (94%) stated that their councils do not have an illegal dumping team that can monitor what people are doing and fine offenders. For example, Participant 4 from the Queensland regional council stated that:

"There is concern about the future outlook of e-waste management in our council and other councils in Queensland. This is because we do not have specific policies on e-waste, and most of the state and federal policies and regulations are not sufficiently addressing the management and disposal of e-waste of our council" (Participant 4).

Furthermore, 36 of the 49 participants (73%) agreed that their councils need to outline the numerous environmental and health risks associated with the e-waste streams they currently have and engage capable recyclers that can come up with the best way to recover the valuable resources in e-waste, while 13 of the 49 participants (26%) stated that the responsibility of engaging capable recyclers to recycle e-waste lies with the state and federal government.

According to participant 1 from the Queensland regional council:

"Outlining and categorising these risks will facilitate more e-waste collection and the likelihood of recycling them with recycling companies. Also, policies and regulations on product design and product specification are not being enacted to facilitate recycling. Presently, most e-waste is composed of non-recyclable materials, especially plastics, which end up in landfills".

5.1.4. How Can Regional Councils in Victoria and Queensland Better Manage and Dispose of E-Waste?

With regard to how e-waste can be better managed, the participants from the Victorian and Queensland regional councils had varying opinions and perspectives. However, 30

of the 49 participants (61%) agreed that to better manage e-waste, there is a need for a common definition and classification of e-waste by all councils in Australia and not just what each council can recycle.

According to Participant 2 from the Queensland regional council,

“There is no real education of the communities on what e-waste is and its classification. We need to provide adequate and ongoing education on e-waste and create awareness of e-waste recycling and recovery in the communities. For example, we can provide residents with various options on what to do with their e-waste through various media, including social media. Residents should be adequately informed about the environmental and health implications of disposing of their e-waste in landfills” (Participant 2).

Another participant from the Victorian regional council stated that:

“We need to make e-waste collection easier for the residents and encourage them to bring their used electrical and electronic equipment for recycling. Encouraging residents to bring their e-waste for recycling through providing incentives can significantly improve e-waste collection and prevent e-waste in landfills” (Participant 25).

Participant 12 from the Queensland regional council disagrees with the provision of incentives to residents and believes that:

“Residents should be made to take responsibility for the waste they generate, including e-waste. This will help to make a difference in people’s attitudes towards waste management in general. Charging/requesting residents to pay for their e-waste will make them start thinking about what they throw into the bin” (Participant 12).

All of the 49 participants (100%) agreed that establishing e-waste collection centres at strategic points for residents in the communities to drop off their e-waste will significantly improve the management of e-waste and recycling. Of the 49 participants, 41 (84%) stated that there are only a few collection points currently available. Specifically, Participant 37 from the Victorian regional council stated that:

“Currently, only a limited number of regional councils offer a drop-off collection service for e-waste with collection points located at community centre sites only. Smaller e-waste items are typically disposed of in wheeled bins, and larger e-waste items through the council’s quarterly clean-up days and ‘very large items’ during kerbside collection events, where householders are allowed to leave acceptable larger household items at kerbside for separate collection. These events typically take place quarterly, and the majority of the items collected during these events are disposed of in the landfill, and a small quantity is recycled as there are limited recycling companies in the state”

Further, the majority (47 of 49) of the participants (96%) agreed that regional councils’ collaboration through the state governments and the Commonwealth government, as well as the respective state regulatory agencies, manufacturers, retailers and consumers, can introduce “user pays” or “take-back programs” so that residents can take responsibility for the waste they generate. This strategy will help consumers find a reuse, donate, or sell it to charity. In addition, regional councils can collaborate with their Victorian and Queensland state governments to introduce e-waste management schemes and programs such as “extended producer responsibility (EPR)”. Currently, most regional councils manage e-waste under the “National Television Computer Recycling Scheme (NTCRS)”. This scheme merely considers computers and televisions as e-waste.

5.2. Discussion

Based on the analysis of the qualitative data collected, the findings arising from this study highlight a number of problems and challenges shared by the Victorian and Queensland regional councils in managing e-waste and identify areas where improvements could be made. Some of these challenges and areas that need improvement include: (a) the lack of education and awareness creation about e-waste for the residents in the communities, (b) the absence of knowledge about e-waste recycling and poor attitude towards e-waste recycling, (c) illegal dumping of e-waste, (d) lack of sufficient funding and high cost of recycling, (e) limited number of e-waste recyclers to engage, (f) lack of specific e-waste policies and legislation to implement in the management of e-waste and (g) inability of the current NTCRS and mobile muster collection and recycling schemes to cover all categories of e-waste. The inability of these current e-waste collection and recycling initiatives and schemes to cover all categories of e-waste in Australia has created additional challenges faced by the regional council interviewed in this study. While this study covers all categories of e-waste and adopts the definition by UNEP [7], the council employees stated that there is a need for a common definition and classification of e-waste by all councils in Australia, not just what each council can recycle, indicating that the definition of e-waste also varies across regional councils in Australia, which is a major challenge in managing e-waste. Prior to conducting the interviews, the regional council's employees were aware that this study covers all categories of e-waste and offered responses based on their respective councils' scenarios, which provides a basis for comparisons.

While the participants in the Victorian and Queensland regional councils have similar challenges, there are differences in some of the practices adopted to manage e-waste. A notable difference in the practices implemented to manage e-waste is in the provision of incentives to residents to encourage e-waste collection. Each council has a different view on these issues. Some Victorian regional councils believe that there is a need to make e-waste collection easier for the residents and encourage them to bring their used EEE for recycling by providing incentives to residents to enhance e-waste collection and reduce the quantities going to landfills. By comparison, the majority of the Queensland regional council disagreed with the provision of incentives to residents and believes that residents should be made to take responsibility and pay for the waste they generate, including e-waste, as this will help to make a difference in people's attitude towards waste management in general and make them start thinking about what they throw into the bin. Table 4 below provides an in-depth comparison between the two states.

The results of this study have emphasised a number of important knowledge gaps across both Victorian and Queensland regional councils in Australia. For instance, there is no data in relation to the e-waste disposed of in landfills and little data on that collected. Hence, it is problematic to plan and forecast for future infrastructure and e-waste facilities for treatment, where most of the e-waste dumped in landfills goes unaccounted for. The findings of this study resonate and are consistent with the studies of Islam and Huda [10] and Morris and Metternicht [17], which found that Australia is yet to adequately address how to dispose of its e-waste in an environmentally sound and safe manner. There are also very few recycling facilities with the capabilities to deal with the processing and recycling of e-waste. This situation further compounds the inability of e-waste collected by both Victorian and Queensland regional councils to recycle the collected e-waste.

Table 4. Comparison between Queensland and Victorian regional councils.

		Queensland Regional Councils	Victorian Regional Councils
Problems and challenges	Similarities	■ Limited number of drop-off collection services for e-waste collection ■ Lack of sufficient funding to deal with e-waste ■ High cost of recycling ■ Limited number of e-waste recyclers to engage ■ Lack of education and awareness creation about e-waste for the residents	
	Differences	■ Increasing quantities of e-waste are generated each year ■ Nonexistence of specific e-waste policies and legislation to implement in the management of e-waste. Currently, the Waste Reduction and Recycling Regulation 2023 (WRR Regulation) is used in the management of e-waste ■ Most of the councils are compelled to dispose of some of the e-waste that they cannot recycle in landfills due to limited recyclers available to recycle, particularly those from non-recyclable materials ■ There were varying views on the meaning and classification of e-waste, which forms the basis for how e-waste is to be managed. For example, most councils refer to e-waste as computers and TVs only	■ Absence of specific e-waste policies and legislation to implement in the management of e-waste. The new waste duties in the Environment Protection Act 2017 (the Act) are used to manage waste, including e-waste ■ Some of the councils are compelled to dispose of some of the e-waste that they cannot recycle in landfills due to limited recyclers available to recycle, particularly those from non-recyclable materials ■ There were similar views on the meaning and classification of e-waste, which forms the basis for how e-waste is to be managed. For example, most councils refer to e-waste as EEE, including household electronic devices
	Similarities	■ There are no specific policies to manage e-waste	
	Differences	■ Queensland’s waste management and resource recovery strategy, also known as the Waste Strategy, sets the basis for dealing with waste streams, including e-waste	■ The new waste duties in the Environment Protection Act 2017 (the Act) and the Waste Reduction and Recycling Act 2021 are used to manage various waste categories, including e-waste ■ Waste duties apply to those who generate, collect, transport or receive waste
Practices adopted to manage e-waste	Similarities	■ All participating councils have implemented the National Television and Computer Recycling Scheme (NTCRS) and Mobile Muster ■ Some of the councils do not have specific e-waste collection centres closer to the residents ■ Councils have varying views on the introduction of the weight billing system (pay as you throw) to help reduce e-waste ending up in landfills and encourage re-use and recycling	
	Differences	■ Few councils have introduced fees and fines to deter people from just throwing e-waste into their bins ■ Most councils do not have an illegal dumping team that can monitor what people are doing and fine offenders ■ The majority of the councils did not favour the provision of incentives to residents to encourage e-waste collection. Each council has a different view on these issues	■ The majority of the councils have introduced fees and fines to deter people from just throwing e-waste into their bins ■ Some councils do not have an illegal dumping team that can monitor what people are doing and fine offenders ■ The Victorian government banned e-waste to landfills in 2019

There is a need for all e-waste stakeholders, such as governments, regional councils, retailers, wholesalers, manufacturers, regulators, e-waste importers and consumers, to collaborate and ensure the dissemination/distribution of relevant information and to cooperate to develop a workable funding and legislative system, which can sustainably manage the present and future streams of e-waste in Australia. At the moment, recycling of e-waste in Victoria and Queensland, as well as other states and territories, is centred

on televisions and computers. The participants of the regional councils in Victoria and Queensland in this study perceived and believed that a wider and stronger awareness of e-waste should be accomplished through adequately educating consumers of e-waste in the communities and the collaboration of all stakeholders of e-waste to come up with better ways of managing and recycling e-waste to protect the health of humans, the environment and the entire ecosystem. This outcome is in line with the recommendations of numerous prior studies such as [10,17–19] that “Australia’s approach to e-waste management requires improvement and the development of appropriate legislation to manage e-waste”.

In terms of how Australia’s e-waste management compares to other developed countries, based on the review of the literature and outcomes of this study, Australia’s e-waste management system focuses heavily on TVs and computers through the National Television and Computer Recycling Scheme (NTCRS) and lacks strong national waste regulations specific to e-waste. In addition, compliance enforcement varies greatly between Australian states and territories when compared with top e-waste recyclers such as Germany, Switzerland, Japan, and South Korea, among others, which mandate recycling of all categories of e-waste. While e-waste volume and generation in Australia is similar to other advanced countries, there is disparity in terms of recycling rates, e-product scope, adoption of extended producer responsibility (EPR), e-waste laws and enforcement and in terms of re-use and repair. For example, Switzerland successfully recycles around 75% of its e-waste and Japan 79%; this is in contrast to Australia, which recycles less than 40% of its e-waste generated [85]. Further, in Switzerland and Japan, independent organisations are used to ensure that recycling companies are complying with e-waste regulations. In Australia, state and territory laws on waste, including e-waste, differ, with some states like Victoria banning e-waste disposal to landfills. In Germany, South Korea and Japan, EPR is used to make manufacturers of electronic products responsible for their products at the end of their useful life; in Australia, the burden often falls on local councils or voluntary programs such as Mobile Muster. Also, in Germany, the USA, South Korea, Japan, and Switzerland, among others, e-waste refers to anything that has plugs or uses a battery. These nations have adopted a comprehensive system that targets all categories of electronics. In contrast, Australia’s primary national e-waste scheme, NTCRS, mainly targets large household TV screens and computers, and this leaves other household appliances essentially unprotected.

There are limitations in this study that suggest future research. Firstly, this study only collected data from Queensland and Victorian regional councils. It is necessary to collect data from regional councils in the other states to ascertain how different states manage their e-waste in Australia. Secondly, the study focused mainly on the qualitative methodology. Therefore, the study can be extended with quantitative data analysis for a better understanding of the influence of consumers’ demographic characteristics such as gender, age, educational background and personal income on the intention of consumers to participate in e-waste recycling. This will provide additional knowledge on how e-waste can be better managed in Australia. Thirdly, further research in this area needs to be undertaken to enable regional councils to establish the tools needed to make sound decisions on e-waste recycling and treatment options for their particular region, based on individual councils’ current situation and e-waste management strategies.

Figure 7 provides a matrix of the summary of the similarities and differences in the e-waste management practices of Victorian and Queensland regional councils.

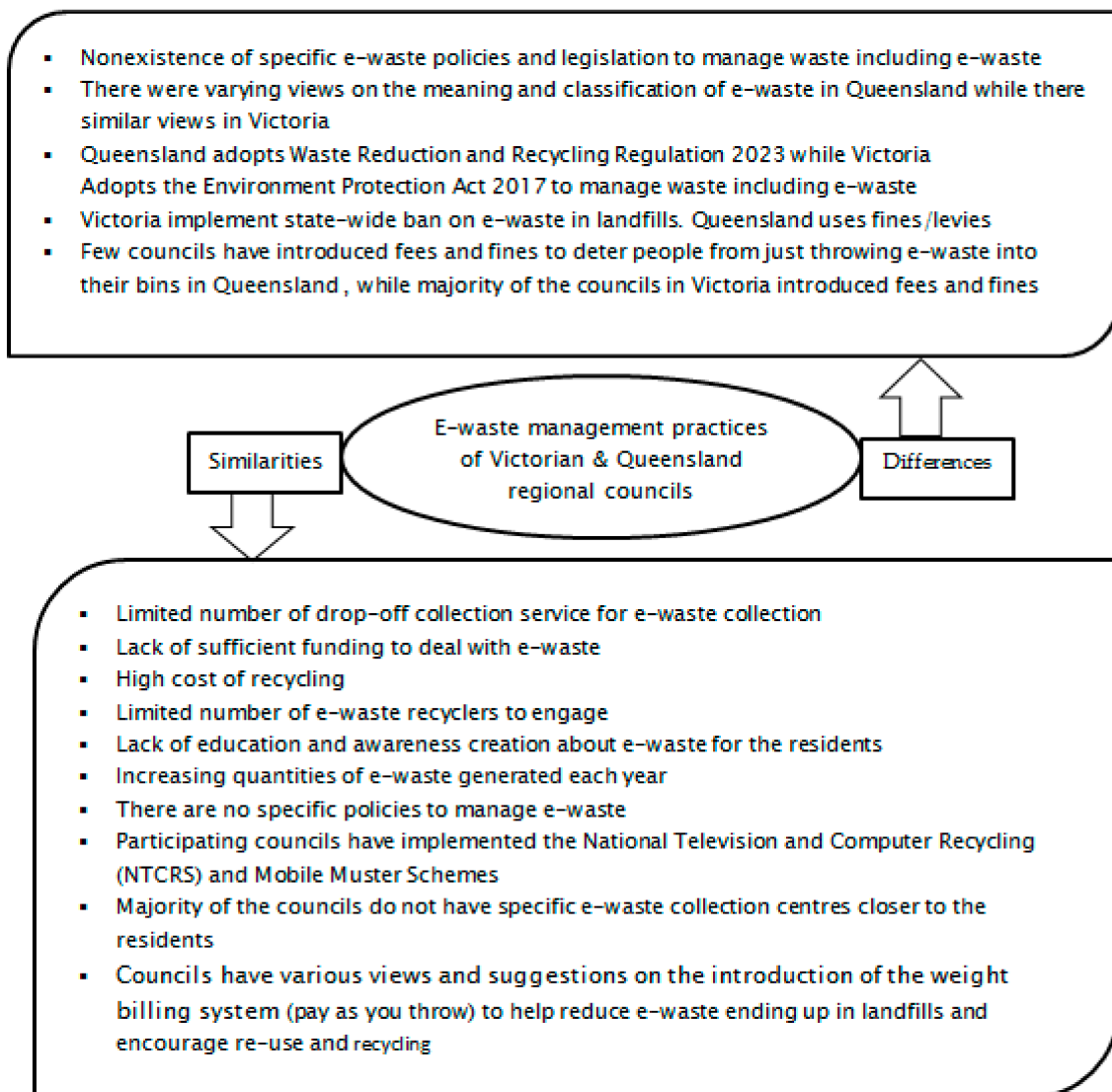


Figure 7. Matrix of the summary of the similarities and differences in the e-waste management practices of Victorian and Queensland regional councils. Developed for this study.

6. Conclusions and Recommendations

6.1. Conclusions

This paper examines the e-waste management practices of Victorian and Queensland regional councils, compares the practices implemented to manage e-waste, identifies the problems and challenges and develops/recommends innovative approaches to address e-waste collection and recycling practices in Australia. The findings of this study show that there are more similarities and fewer differences in how the Victorian and Queensland regional councils manage their e-waste, as shown in Figure 7.

Qualitative interviews with forty-nine participants from Victorian and Queensland regional councils identified a number of areas that needs improvement in the management of e-waste such as: (a) the lack of education and awareness creation regarding e-waste for the residents in the communities, (b) the absence of knowledge about the recycling of e-waste and poor attitude towards the recycling of e-waste, (c) the lack of sufficient funding; (d) limited number of e-waste recyclers to engage, and (e) the lack of specific policies and legislation on e-waste to adopt in the management of e-waste. The findings suggest that e-waste management in Victorian and Queensland regional councils, as well as other councils in other states and territories, needs improvement, and greater focus by state

and federal government is required for a more transformative approach and best practices in the management and recycling of e-waste.

The outcomes of the analysis of the interviews highlighted a high degree of support for (a) the introduction of transformative legislative measures that can manage and recycle e-waste, with particular support for a funding mechanism, consumer education and awareness programs, (b) take-back schemes where customers return their electronic products to the brand at the end of their useful life for that customer. The brands then determine if these electronic products can be resold, repaired, donated or recycled, and (c) the introduction of “Extended producer responsibility” (EPR)—another policy approach that is designed and intended to move the responsibility for collecting and managing e-waste from municipalities and consumers to manufacturers. Participants tended to consider that the introduction of these policy approaches would encourage and support manufacturers to create better and improved designs of electronic products and use recyclable materials to manufacture their EEE for durability and reusability in order to comply, which could lead to improvements in designs for the EEE that are imported into Australia.

Further, based on the findings/outcomes of the qualitative data analysis, the idea of providing incentives to consumers had differing and opposing responses. Of the 49 participants, only 26 agreed with the idea of providing incentives for consumers to encourage them to partake in the management and recycling of e-waste. The participants agreed that incentives in the form of rebates, discounts on new products when e-waste is collected, cash rewards, or even charitable donations should be applied to improve e-waste collection and to avoid e-waste ending up in landfills. Of the 49 participants, 23 disagreed with this idea. The participants who disagreed stressed that households and businesses should be made to take responsibility for the e-waste they generate through implementing weight-based billing (pay as you throw) for the collection of e-waste.

We consider that by offering rewards, state and federal governments can motivate individuals to take action and contribute to the sustainable management of e-waste. Alternatively, by introducing the weight billing system (pay as you throw) and economically penalising the generation of e-waste, consumers are obliged to reduce their e-waste generation and adopt more environmentally responsible habits. Previous studies by Dahlen and Lagerkvist [144] conducted in Sweden investigated 290 householders’ responses to weight-based billing for the collection of household waste with the primary aim of providing support for decisions relating to waste management policies. The study found that the impacts of weight-based billing in collecting household waste are inconsistent and unpredictable, but showed a clear drop and reduction in waste in some municipalities.

While Pay-As-You-Throw (PAYT) systems charge households and businesses for waste based on the quantities they dispose of, rather than a flat rate, different countries use diverse methods to calculate the cost of disposal. The aim is to prioritise waste prevention, reduce/eliminate inappropriate waste disposal in landfills and encourage recycling. For example, South Korea adopts a volume-based waste fee (VBWF) which mandates households and businesses to buy and use government-issued plastic bags for disposal of all general and non-recyclable waste, while waste that is recyclable and for composting is collected for free. According to UNEP [137], the adoption of VBWF reduced daily waste by 24% and increased food waste recycling to around 90% in South Korea. Taiwan adopted the per-bag trash collection fee, which mandates residents to place their unsorted household trash into specially designated, official blue bags, while using regular, non-compliant bags results in heavy fines. This system successfully reduced the overall municipal solid waste volume by one-third and increased recycling rates [145]. Italy and the European Union adopted the weight and frequency-based systems, where waste trucks weigh and charge the bins upon lifting them and link the amount payable directly to the

weight of the trash. This weight-based PAYT method helped reduce waste generation from 15% to 90% and supports circular economy goals [146].

We propose that the introduction of weight-based billing (pay-as-you-throw) in Australia will significantly reduce the volume of e-waste generated in the communities by encouraging responsible production/consumption and re-use of EEE. The “pay as you throw scheme” has been successful in some advanced nations such as Germany, Austria, the Netherlands, Japan, Switzerland, South Korea, Taiwan, Italy and the European Union [147]. Some of the strengths of implementing a weight-based billing (pay as you throw) scheme in e-waste management include (a) fair allocation of recycling costs to the consumers, (b) reduction in e-waste generation, (c) ensuring transparency of e-waste management and recycling costs, and (d) increase in sorting of e-waste recyclables. The weaknesses include (a) increased costs to consumers, (b) encouraging illegal e-waste dumping, and (c) increased amounts of contaminants in e-waste recyclables. Finally, based on the outcomes of this study, Australia needs to implement unified and workable policies and strategies for the management and recycling of e-waste. This study will benefit regional councils by reducing/eliminating e-waste in landfills, creating localised job opportunities, preventing environmental risks associated with illegal dumping, recovering precious metals present in e-waste, and fostering circular economy practices in regional areas. The study identified areas where improvements are needed, which would assist regional councils in designing appropriate intervention strategies to better manage e-waste in regional areas. The future of e-waste recycling in Australia is optimistic. However, to fully realise the potential of the enormous quantities of e-waste continuously generated, the government and other stakeholders must embrace innovation and invest in sustainable e-waste management practices.

6.2. Recommendations

Based on the findings of this study, the recommendations below are proposed at the local, state and federal levels.

At the local government level:

- (1) Regional councils should establish comprehensive e-waste collection programs and permanent collection centres and ensure that these centres are accessible to residents. These collection centres can be located in schools, churches, supermarkets, major electronic retail outlets, town halls, and cinemas. There should be clear communication with residents about the location of collection centres, e-waste items accepted and proper disposal procedures.
- (2) Regional councils should collaborate with major retailers to offer e-waste collection as part of their services, making it convenient for residents in the communities. They should also explore the possibilities of providing home collection services for large e-waste items, such as televisions, computers, refrigerators, dryers, and washing machines. For example, major retailers can offer services for collecting large electronics from home when a customer buys a new one.
- (3) Create awareness in the communities through launching campaigns/events to educate residents about the benefits of reusing and repairing their electronic devices, with more emphasis on the environmental and economic advantages. For example, regional councils can consider the possibilities of setting up community repair cafes where residents can learn basic repair skills and fix their own devices. They can also develop and implement public awareness campaigns to educate residents about the relevance of e-waste recycling and the potential risks to human health, the environment, and the entire ecosystem due to inappropriate disposal in landfills.

- (4) Regional councils should ensure that all e-waste management activities comply with the state and federal governments' e-waste regulations; implement robust monitoring and enforcement mechanisms to prevent illegal dumping and ensure that e-waste is properly managed and not diverted to landfills.
- (5) Regional councils can help improve consumers' e-waste collections and recycling attitudes through (a) advocating for e-waste management in school curricula to raise awareness among young people and (b) organising community events and workshops to promote and encourage e-waste recycling and reuse.
- (6) Consider the 3R's—(a) Reduce e-waste generation through encouraging residents to limit their consumption of electronic devices and choose products with longer lifespans, (b) Reuse through promoting the reuse of electronic devices, donation or resale, and (c) Recycle to ensure that e-waste is appropriately recycled and valuable materials are recovered.

At the federal and state levels,

- (1) At the national level, the Australian government can introduce extended producer responsibility (EPR) schemes or take-back schemes. This policy approach will make manufacturers/producers responsible for their products throughout the entire life-cycle, including the post-consumer stage. By doing so, Australia's environmental/conservational goals and recycling targets can be achieved.
- (2) There needs to be an incentive for both regional and metropolitan councils to promote e-waste recycling and facilitate e-waste collection. All the stakeholders, including e-waste recyclers, need to collaborate and get involved in the management of e-waste. It is noteworthy to mention that regional councils are primarily collectors. More efforts are needed at the national and state levels.
- (3) The state and federal governments should collaborate and engage more recycling companies and improve recycling technologies by encouraging investment and the introduction of new and improved technologies and best practice recycling operations.
- (4) All e-waste stakeholders (manufacturers, retailers, importers, regulators, state and federal governments, consumers, regional councils, electrical and electronics industry, waste management and resource recovery sector should make sure that there is adequate dissemination of information, and work collaboratively and in partnerships to develop funding and legislative regime that is fair and rational, which can sustainably manage the present and future streams of e-waste in Australia.
- (5) The state and federal government should work in collaboration with the manufacturers, retailers, regional councils and recyclers to come up with an action plan to: (a) prolong the life of electronic products, (b) recover extra materials and ensure they are kept in circulation in the economy (post-consumption), (c) guide and empower stakeholders in maximising waste emanating from electronic products, (d) encourage re-use and repairability, (e) increase consumer awareness and education and (f) maximise durability to achieve sustainable outcomes for electronic products.
- (6) The state and territory governments should review and adjust current policies and regulations, and initiate new reforms to prevent reusable, repairable and recyclable electronic products from going to landfills, being hoarded in homes and offices or littered in unauthorised areas, particularly in rural, regional and remote areas.

6.3. Future Research

Future research should use a quantitative approach or other research methods and increase the number of local governments in Australian states and territories to better understand e-waste management and recycling practices as well as problems and challenges, and areas where improvements are needed, particularly in regional and remote

areas. This will provide an additional viewpoint in the management, recycling, legislation and sustainable environmental management of e-waste in Australia.

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References

- Forti, V.; Balde, C.P.; Kuehr, R.; Bel, G. *The Global E-Waste Monitor 2020: Quantities, Flows and the Circular Economy Potential*; United Nations University (UNU)/United Nations Institute for Training and Research (UNITAR): Bonn, Germany; SCYCLE Programme, International Telecommunication Union (ITU): Geneva, Switzerland; International Solid Waste Association (ISWA): Rotterdam, The Netherlands, 2020.
- Balde, C.P.; Kuehr, R.; Yamamoto, T.; McDonald, R.; D'Angelo, E.; Althaf, S.; Bel, G.; Otmar, D.; Fernandez-Cubillo, E.; Forti, V.; et al. Global E-Waste Monitor 2024. Available online: https://ewastemonitor.info/wp-content/uploads/2024/03/GEM_2024_18-03_web_page_per_page_web.pdf (accessed on 2 February 2025).
- Andeobu, L.; Wibowo, S.; Grandhi, S. Artificial intelligence applications for sustainable solid waste management practices in Australia: A systematic review. *Sci. Total Environ.* **2022**, *834*, 155389. [CrossRef] [PubMed]
- Andeobu, L.; Wibowo, S.; Grandhi, S. Assessing the impact of consumer recycling behavior on the adoption of sustainable electronic waste management practices in Australia. In *2024 IEEE/ACIS 27th International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD)*; IEEE: Beijing, China, 2024; pp. 206–210.
- Islam, M.T.; Iyer-Raniga, U. Life cycle assessment of e-waste management system in Australia: Case of waste printed circuit board (PCB). *J. Clean. Prod.* **2023**, *418*, 138082. [CrossRef]
- Yang, J.; Lu, B.; Xu, C. WEEE flow and mitigating measures in China. *Waste Manag.* **2008**, *28*, 1589–1597. [CrossRef] [PubMed]
- United Nations Environment Programme (UNEP). Global Environment Outlook (GEO) 2023. Available online: <https://www.unenvironment.org/resources/global-environment-outlook> (accessed on 24 May 2024).
- Andeobu, L.; Wibowo, S.; Grandhi, S. Informal e-waste recycling practices and environmental pollution in Africa: What is the way forward? *Int. J. Hyg. Environ. Health* **2023**, *252*, 114192. [CrossRef] [PubMed]
- Sustainability Victoria. *E-Waste in Victoria*; Sustainability Victoria: Melbourne, Australia, 2020. Available online: <https://www.environment.vic.gov.au/sustainability/e-waste-in-victoria> (accessed on 27 January 2021).
- Islam, M.T.; Huda, N. Reshaping WEEE management in Australia: An investigation on the untapped WEEE products. *J. Clean. Prod.* **2020**, *250*, 119496. [CrossRef]
- Regional Australia Institute. *Circular Economy in Action: Regional Perspectives*; Regional Australia Institute: Canberra, Australia, 2024.
- Nguyen, H.T.T. Integrating the valence theory and the norm activation theory to understand consumers' e-waste recycling intention. *Chin. J. Popul. Resour. Environ.* **2023**, *21*, 26–36. [CrossRef]

13. Dhir, A.; Malodia, S.; Awan, U.; Sakashita, M.; Kaur, P. Extended valence theory perspective on consumers' e-waste recycling intentions in Japan. *J. Clean. Prod.* **2021**, *312*, 127443. [CrossRef]
14. Muthukumari, W.A.C.S.; Ahn, J.; Kim, M. Impact of information publicity on Korean residents' E-waste recycling intentions: Applying the norm activation model and theory of planned behavior. *Heliyon* **2024**, *10*, e34319. [CrossRef] [PubMed]
15. Newaz, M.S.; Appolloni, A. Evolution of behavioural research on ewaste management: Conceptual frameworks and future research directions. *Bus. Strategy Environ.* **2024**, *33*, 477–503.
16. Ozturk, A.B.; Bilgihan, A.; Salehi-Esfahani, S.; Hua, N. Understanding the mobile payment technology acceptance based on valence theory: A case of restaurant transactions. *Int. J. Contemp. Hosp. Manag.* **2017**, *29*, 2027–2049. [CrossRef]
17. Morris, A.; Metternicht, G. Assessing the effectiveness of WEEE management policy in Australia. *J. Environ. Manag.* **2016**, *181*, 218–230. [CrossRef] [PubMed]
18. Herat, S.; Pinikkar, A.K. E-waste management in Australia: Current status. In *Electronic Waste Management and Treatment Technology*; Butterworth-Heinemann: Oxford, UK, 2019; pp. 269–284.
19. Dias, P.; Bernardes, A.M.; Huda, N. Waste Electrical and Electronic Equipment (WEEE) Management: An Analysis on the Australian E-waste Recycling Scheme. *J. Clean. Prod.* **2018**, *197*, 750–764. [CrossRef]
20. Andeobu, L.; Wibowo, S.; Grandhi, S. An assessment of e-waste generation and environmental management of selected countries in Africa, Europe and North America: A systematic review. *Sci. Total Environ.* **2021**, *792*, 148078. [CrossRef] [PubMed]
21. Recycling Europe. Financing Europe's Circular Economy: EU Recyclers' Recommendations for Effective Extended Producer Responsibility (EPR) Schemes. 2026. Available online: <https://recyclingeurope.org/publication/eu-recyclers-recommendations-for-effective-extended-producer-responsibility-epr-schemes/> (accessed on 5 December 2025).
22. Aslam, M.S.; Huang, B.; Cui, L. Review of construction and demolition waste management in China and USA. *J. Environ. Manag.* **2020**, *264*, 110445. [CrossRef] [PubMed]
23. Al-Rahmi, W.; Alias, N.; Dahawi, A.A.; Yahaya, N.; Saleh, M.; Al-Maatouk, Q. Strategies to manage electronic waste approaches: An overview in Malaysia. *Int. J. Eng. Technol.* **2018**, *7*, 3276–3279.
24. Awere, C.; Obeng, P.A.; Bonoli, A.; Obeng, P.A. E-waste recycling and public exposure to organic compounds in developing countries: A review of recycling practices and toxicity levels in Ghana. *Environ. Technol. Rev.* **2020**, *9*, 1–19.
25. Akpeimeh, G.F.; Fletcher, L.A.; Evans, B.E. Exposure to bioaerosols at open dumpsites: A case study of bioaerosols exposure from activities at Olusosun open dumpsite, Lagos Nigeria. *Waste Manag.* **2019**, *89*, 37–47. [CrossRef] [PubMed]
26. Li, W.; Achal, V. Environmental and health impacts due to e-waste disposal in China—A review. *Sci. Total Environ.* **2020**, *139*, 745.
27. Patibanda, S.; Bichinepally, S.; Yadav, B.P.; Bahukandi, K.D.; Sharma, M. E-waste management and its current practices in India. In *Advances in Industrial Safety*; Springer: Singapore, 2020; pp. 191–202.
28. Otieno, I.; Omwenga, E. E-waste management in Kenya: Challenges and opportunities. *J. Emerg. Trends Comput. Inf. Sci.* **2015**, *6*, 661–665. [CrossRef]
29. Islam, M.T.; Dias, P.; Huda, N. Comparison of E-waste management in Switzerland and in Australia: A qualitative content analysis. *Int. J. Environ. Ecol. Eng.* **2018**, *12*, 610–616.
30. Salim, H.K.; Stewart, R.A.; Sahin, O.; Dudley, M. End-of-life management of solar photovoltaic and battery energy storage systems: A stakeholder survey in Australia. *Resour. Conserv. Recycl.* **2019**, *150*, 104444.
31. Cao, J.; Chen, Y.; Shi, B.; Lu, B.; Zhang, X.; Ye, X.; Zhai, G.; Zhu, C.; Zhou, G. WEEE recycling in Zhejiang Province, China: Generation, treatment, and public awareness. *J. Clean. Prod.* **2016**, *127*, 311–324. [CrossRef]
32. Chi, X.; Streicher-Porte, M.; Wang, M.Y.; Reuter, M.A. Informal electronic waste recycling: A sector review with special focus on China. *Waste Manag.* **2011**, *31*, 731–742. [CrossRef] [PubMed]
33. Kumar, A.; Li, J. Management of electrical and electronic waste: A comparative evaluation of China and India. *Renew. Sustain. Energy Rev.* **2017**, *76*, 434–447. [CrossRef]
34. Lu, C.; Zhang, L.; Zhong, Y.; Ren, W.; Tobias, M.; Mu, Z.; Xue, B. An overview of e-waste management in China. *J. Mater. Cycles Waste Manag.* **2015**, *17*, 1–12. [CrossRef]
35. Nakatani, J.; Moriguchi, Y. Resource-availability scenario analysis for formal and informal recycling of end-of-life electrical and electronic equipment in China. *J. Mater. Cycles Waste Manag.* **2017**, *19*, 599–611.
36. Qu, Y.; Wang, W.; Liu, Y.; Zhu, Q. Understanding residents' preferences for e-waste collection in China: A case study of waste mobile phones. *J. Clean. Prod.* **2019**, *228*, 52–62. [CrossRef]
37. Yao, L.; Liu, T.; Chen, X.; Mahdi, M.; Ni, J. An integrated method of life-cycle assessment and system dynamics for waste mobile phone management and recycling in China. *J. Clean. Prod.* **2018**, *187*, 852–862. [CrossRef]
38. Yu, J.; Williams, E.; Ju, M.; Shao, C. Managing e-waste in China: Policies, pilot projects and alternative approaches. *Resour. Conserv. Recycl.* **2010**, *54*, 991–999. [CrossRef]

39. Arya, S.; Kumar, S. E-waste in India at a Glance: Current trends, regulations, challenges and management strategies. *J. Clean. Prod.* **2020**, *271*, 122707. [[CrossRef](#)]
40. Awasthi, A.K.; Li, J. Assessing resident awareness on e-waste management in Bangalore, India: A preliminary case study. *Environ. Sci. Pollut. Res.* **2018**, *25*, 11163–11172. [[CrossRef](#)] [[PubMed](#)]
41. Borthakur, A.; Govind, M. Public understandings of e-waste and its disposal in urban India: From a review towards a conceptual framework. *J. Clean. Prod.* **2018**, *172*, 1053–1066. [[CrossRef](#)]
42. Chamoli, S.; Chandramauli, A.; Bahuguna, A. Comparison study of electronic waste management in India & Switzerland. *Int. J. Adv. Eng. Res. Dev.* **2017**, *4*, 485–492. [[CrossRef](#)]
43. Dwivedy, M.; Mittal, R.K. Future trends in computer waste generation in India. *Waste Manag.* **2010**, *30*, 2265–2277. [[CrossRef](#)] [[PubMed](#)]
44. Garlapati, V.K. E-waste in India and developed countries: Management, recycling, business and biotechnological initiatives. *Renew. Sustain. Energy Rev.* **2016**, *54*, 874–881. [[CrossRef](#)]
45. Joon, V.; Shahrawat, R.; Kapahi, M. The emerging environmental and public health problem of electronic waste in India. *J. Health Pollut.* **2017**, *7*, 1–7. [[CrossRef](#)] [[PubMed](#)]
46. Monika, J.K. E-waste management as a challenge to public health in India. *Indian J. Community Med. Off. Publ. Indian Assoc. Prev. Soc. Med.* **2010**, *35*, 382. [[CrossRef](#)] [[PubMed](#)]
47. Needhidasan, S.; Samuel, M.; Chidambaram, R. Electronic waste—an emerging threat to the environment of urban India. *J. Environ. Health Sci. Eng.* **2014**, *12*, 36. [[CrossRef](#)] [[PubMed](#)]
48. Pandey, P.; Govind, M. Social repercussions of e-waste management in India: A study of three informal recycling sites in Delhi. *Int. J. Environ. Stud.* **2014**, *71*, 241–260.
49. Pathak, P.; Srivastava, R.R. Assessment of legislation and practices for the sustainable management of waste electrical and electronic equipment in India. *Renew. Sustain. Energy Rev.* **2017**, *78*, 220–232. [[CrossRef](#)]
50. Ravindra, K.; Mor, S. E-waste generation and management practices in Chandigarh, India and economic evaluation for sustainable recycling. *J. Clean. Prod.* **2019**, *221*, 286–294. [[CrossRef](#)]
51. Wath, S.B.; Dutt, P.S.; Chakrabarti, T. E-waste scenario in India, its management and implications. *Environ. Monit. Assess.* **2011**, *172*, 249–262. [[PubMed](#)]
52. Andarani, P.; Goto, N. Potential e-waste generated from households in Indonesia using material flow analysis. *J. Mater. Cycles Waste Manag.* **2014**, *16*, 306–320. [[CrossRef](#)]
53. Hanafi, J.; Kristina, H.J.; Jobiliong, E.; Christiani, A.; Halim, A.V.; Santoso, D.; Melini, E. The prospects of managing WEEE in Indonesia. In *Glocalized Solutions for Sustainability in Manufacturing*; Springer: Berlin/Heidelberg, Germany, 2011; pp. 492–496.
54. Maheswari, H.; Yudoko, G.; Adhiutama, A. Government and intermediary business engagement for controlling electronic waste in Indonesia: A sustainable reverse logistics theory through customer value chain analysis. *Sustainability* **2019**, *11*, 732. [[CrossRef](#)]
55. Rochman, F.F.; Ashton, W.S.; Wiharjo, M.G.M. E-waste, money and power: Mapping electronic waste flows in Yogyakarta, Indonesia. *Environ. Dev.* **2017**, *24*, 1–8. [[CrossRef](#)]
56. Santoso, S.; Zagloel, T.Y.; Ardi, R.; Suzianti, A. Estimating the amount of electronic waste generated in Indonesia: Population balance model. In Proceedings of the 2nd International Conference on Environmental, Industrial and Energy Engineering, Bangkok, Thailand, 19–21 October 2019.
57. Yoshida, A.; Terazono, A.; Ballesteros, F.C.; Nguyen, D.Q.; Sukandar, S.; Kojima, M.; Sakata, S. E-waste recycling processes in Indonesia, the Philippines, and Vietnam: A case study of cathode ray tube TVs and monitors. *Resour. Conserv. Recycl.* **2016**, *106*, 48–58. [[CrossRef](#)]
58. Afroz, R.; Muhibbullah, M.; Farhana, P.; Morshed, M.N. Analysing the intention of the households to drop off mobile phones to the collection boxes: Empirical study in Malaysia. *Ecofeminism Clim. Change* **2020**, *1*, 3–20. [[CrossRef](#)]
59. Ismail, H.; Hanafiah, M.M. Discovering opportunities to meet the challenges of an effective waste electrical and electronic equipment recycling system in Malaysia. *J. Clean. Prod.* **2019**, *238*, 117927. [[CrossRef](#)]
60. Jaibee, S.; Abd -Rahim, A.K.; Mohamad, F.; Jamian, S.; Seiji, Y.; Muhd Nor, N.H. Review on current status of waste electric and electronic product in Malaysia. *Appl. Mech. Mater.* **2015**, *773–774*, 898–907. [[CrossRef](#)]
61. Nurul Aini, O.; Norazli, O.; Roslina, M.; Shreeshivadasan, C. Handling e-waste in Malaysia: Management, policies and strategies. In Proceedings of the 11th International Conference on Waste Management and Technology, Beijing, China, 21–24 October 2016; pp. 1–7.
62. Shumon, M.R.; Ahmed, S.; Islam, M.T. Electronic waste: Present status and future perspectives of sustainable management practices in Malaysia. *Environ. Earth Sci.* **2014**, *72*, 2239–2249. [[CrossRef](#)]
63. Suja, F.; Abdul Rahman, R.; Yusof, A.; Masdar, M.S. E-waste management scenarios in Malaysia. *J. Waste Manag.* **2014**, *2014*, 609169. [[CrossRef](#)]

64. Zainu, Z.A. Development of policy and regulations for hazardous waste management in Malaysia. *J. Sci. Technol. Innov. Policy* **2020**, *5*, 63–71.
65. Aborele, H.; Urquhart, C.; Nudurupati, S. E-waste policy in developing countries: The context of Nigeria. In *Pre-ICIS Workshop Proceedings 2015*; AIS Elibrary: Atlanta, GA, USA, 2015; pp. 1–12. Available online: https://aisel.aisnet.org/sprouts_proceedings_siggreen_2015/1 (accessed on 9 June 2026).
66. Amechi, E.P.; Oni, B.A. Import of electronic waste into Nigeria: The imperative of a regulatory policy shift. *Chin. J. Environ. Law* **2019**, *3*, 141–166. [\[CrossRef\]](#)
67. Nnorom, I.C.; Ohakwe, J.; Osibanjo, O. Survey of willingness of residents to participate in electronic waste recycling in Nigeria—A case study of mobile phone recycling. *J. Clean. Prod.* **2009**, *629*, 1637.
68. Huisman, J.; Magalini, F. Where are WEEE now? Lessons from WEEE: Will EPR work for the US? In *Proceedings of the 2007 IEEE International Symposium on Electronics and the Environment*, Orlando, FL, USA, 7–10 May 2007; pp. 149–154.
69. Schumacher, K.A.; Agbemabiese, L. Towards comprehensive e-waste legislation in the United States: Design considerations based on quantitative and qualitative assessments. *Resour. Conserv. Recycl.* **2019**, *149*, 605–621. [\[CrossRef\]](#)
70. Zeng, Z.; Huo, X.; Zhang, Y.; Xiao, Z.; Zhang, Y.; Xu, X. Lead exposure is associated with risk of impaired coagulation in preschool children from an e-waste recycling area. *Environ. Sci. Pollut. Res.* **2018**, *25*, 20670–20679. [\[CrossRef\]](#) [\[PubMed\]](#)
71. Kang, D.; Choi, M. Older Cohorts as Change Agents for Climate Change: Evidence from Waste Management Behaviors in South Korea. *J. Popul. Ageing* **2025**, 1–17. [\[CrossRef\]](#)
72. Kummer, S.; Löhle, S.; Schmiedel, U. Consumer survey on the final consumer behavior concerning the disposal of WEEE in Germany. *Waste Manag. Res.* **2022**, *40*, 538–544. [\[PubMed\]](#)
73. Akbar, S.; Bibi, A.; Zia, A. E-waste Management in Japan and Germany. *Pak. J. Chem. Chempublishers* **2025**, *15*, 6–10. [\[CrossRef\]](#)
74. Jang, Y.C. Waste electrical and electronic equipment (WEEE) management in Korea: Generation, collection, and recycling systems. *J. Mater. Cycles Waste Manag.* **2010**, *12*, 283–294. [\[CrossRef\]](#)
75. Yoshida, F.; Yoshida, H. E-waste management in Japan: A focus on appliance recycling. *Adv. Mater. Res.* **2014**, *878*, 420–423. [\[CrossRef\]](#)
76. Yazdi, M.; Moradi, R.; Nedjati, A.; Ghasemi Pirbalouti, R.; Li, H. E-waste circular economy decision-making: A comprehensive approach for sustainable operation management in the UK. *Neural Comput. Appl.* **2024**, *36*, 13551–13577. [\[CrossRef\]](#)
77. Vadoudi, K.; Kim, J.; Laratte, B.; Lee, S.J.; Troussier, N. E-waste management and resources recovery in France. *Waste Manag. Res.* **2015**, *33*, 919–929. [\[CrossRef\]](#) [\[PubMed\]](#)
78. Kahhat, R.; Kim, J.; Xu, M.; Allenby, B.; Williams, E.; Zhang, P. Exploring e-waste management systems in the United States. *Resour. Conserv. Recycl.* **2008**, *52*, 955–964. [\[CrossRef\]](#)
79. Golsteijn, L.; Valencia Martinez, E. The circular economy of E-waste in the Netherlands: Optimizing material recycling and energy recovery. *J. Eng.* **2017**, *2017*, 8984013. [\[CrossRef\]](#)
80. Wilyani, I.T.; Nugraha, J.K.; Aryadi, M.A.; Mariam, N. E-waste: An underrated hazardous waste in Indonesia. *J. Environ. Eng. Waste Manag.* **2018**, *3*, 85–94. [\[CrossRef\]](#)
81. Shinkuma, T.; Managi, S. On the effectiveness of a licensing scheme for E-waste recycling: The challenge of China and India. *Environ. Impact Assess. Rev.* **2010**, *30*, 262–267. [\[CrossRef\]](#)
82. Khatriwal, D.S.; Kraeuchi, P.; Widmer, R. Producer responsibility for e-waste management: Key issues for consideration—learning from the Swiss experience. *J. Environ. Manag.* **2009**, *90*, 153–165. [\[CrossRef\]](#) [\[PubMed\]](#)
83. Department of Climate Change, Energy, the Environment and Water (DEECCW). Product Stewardship in Australia. 2024a. Available online: <https://www.dcceew.gov.au/environment/protection/waste/product-stewardship> (accessed on 14 December 2025).
84. Department of Climate Change, Energy, the Environment and Water (DEECCW). Hazardous Waste (Regulation of Exports and Imports) Act 1989. 2024b. Available online: <https://www.dcceew.gov.au/environment/protection/hazardous-waste/about> (accessed on 3 March 2026).
85. Department of Climate Change, Energy, the Environment and Water (DEECCW). International Comparisons and Exports. 2025. Available online: <https://www.dcceew.gov.au/environment/protection/waste/publications/national-waste-resource-recovery-reporting/international-comparisons-exports-2024> (accessed on 30 June 2026).
86. Ha, N.N.; Agusa, T.; Ramu, K.; Tu, N.P.C.; Murata, S.; Bulbule, K.A.; Tanabe, S. Contamination by trace elements at e-waste recycling sites in Bangalore, India. *Chemosphere* **2009**, *76*, 9–15. [\[CrossRef\]](#) [\[PubMed\]](#)
87. Australian Broadcasting Corporation (ABC). War on Waste. 2018. Available online: <https://www.abc.net.au/ourfocus/warwaste/> (accessed on 16 June 2024).
88. State Library Victoria. Victoria’s Early History. 2024. Available online: <https://guides.slv.vic.gov.au/Victoriasearlyhistory/publishedhistories> (accessed on 26 July 2024).

89. Sustainability Victoria. Victorian E-Waste Material Flow Analysis. 2023. Available online: <https://www.sustainability.vic.gov.au/research-data-and-insights/research/research-reports/victorian-e-waste-material-flow-analysis> (accessed on 2 July 2026).
90. ABS. National, State and Territory Population. 2025. Available online: <https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/latest-release> (accessed on 2 July 2026).
91. Queensland Government. Queensland's Draft E-Products Action Plan. 2024. Available online: <https://www.qld.gov.au/environment/circular-economy-waste-reduction/strategy-plans/draft-e-products-action-plan> (accessed on 30 July 2024).
92. Queensland Government. Waste Policy and Legislation. 2023. Available online: <https://www.qld.gov.au/environment/circular-economy-waste-reduction/policy-legislation/legislation> (accessed on 5 July 2025).
93. Robinson, B.H. E-waste: An assessment of global production and environmental impacts. *Sci. Total Environ.* **2009**, *408*, 183–191. [[CrossRef](#)] [[PubMed](#)]
94. Liu, G.; Xu, Y.; Tian, T.; Wang, T.; Liu, Y. The impacts of China's fund policy on waste electrical and electronic equipment utilization. *J. Clean. Prod.* **2020**, *251*, 119582. [[CrossRef](#)]
95. Liu, Y.W.; Sheng, H.; Mundorf, N.; Redding, C.; Ye, Y.J. Integrating norm activation model and theory of planned behaviour to understand sustainable transport behaviour: Evidence from China. *Int. J. Environ. Res. Public Health* **2018**, *14*, 1593. [[CrossRef](#)] [[PubMed](#)]
96. Dagan, R.; Dubey, B.; Bitton, G.; Townsend, T. Aquatic toxicity of leachates generated from electronic devices. *Arch. Environ. Contam. Toxicol.* **2007**, *53*, 168–173. [[CrossRef](#)] [[PubMed](#)]
97. Rajesh, R.; Kanakadhurga, D.; Prabakaran, N. Electronic waste: A critical assessment on the unimaginable growing pollutant, legislations and environmental impacts. *Environ. Chall.* **2022**, *7*, 100507. [[CrossRef](#)]
98. Zeng, X.; Ali, S.H.; Tian, J.; Li, J. Mapping anthropogenic mineral generation in China and its implications for a circular economy. *Nat. Commun.* **2020**, *11*, 1544. [[CrossRef](#)] [[PubMed](#)]
99. Song, Q.; Li, J. A review on human health consequences of metals exposure to e-waste in China. *Environ. Pollut.* **2015**, *196*, 450–461. [[CrossRef](#)] [[PubMed](#)]
100. Grant, K.; Goldizen, F.C.; Sly, P.D.; Brune, M.N.; Neira, M.; van den Berg, M.; Norman, R.E. Health consequences of exposure to e-waste: A systematic review. *Lancet Glob. Health* **2013**, *1*, 350–361. [[CrossRef](#)] [[PubMed](#)]
101. Amoabeng, A.; Arko-Mensah, J.; Botwe, P.K.; Dwomoh, D.; Kwarteng, L.; Takyi, S.A. Effect of particulate matter exposure on respiratory health of e-waste workers at Agbogbloshie, Accra, Ghana. *Int. J. Environ. Res. Public Health* **2020**, *17*, E3042. [[CrossRef](#)] [[PubMed](#)]
102. Xu, L.; Huo, X.; Liu, Y.; Zhang, Y.; Qin, Q.; Xu, X. Hearing loss risk and DNA methylation signatures in preschool children following lead and cadmium exposure from an electronic waste recycling area. *Chemosphere* **2020**, *246*, 125829. [[CrossRef](#)] [[PubMed](#)]
103. Soetrisno, F.N.; Delgado-Saborit, J.M. Chronic exposure to heavy metals from informal e-waste recycling plants and children's attention, executive function and academic performance. *Sci. Total Environ.* **2020**, *717*, 137099. [[CrossRef](#)] [[PubMed](#)]
104. Decharat, S.; Kiddee, P. Health problems among workers who recycle electronic waste in southern Thailand. *Osong Public Health Res. Perspect.* **2020**, *11*, 34–43. [[CrossRef](#)] [[PubMed](#)]
105. Seith, R.; Arain, A.L.; Nambunmee, K.; Adar, S.D.; Neitzel, R.L. Self-reported health and metal body burden in an electronic waste recycling community in Northeastern Thailand. *J. Occup. Environ. Med.* **2019**, *61*, 905–909. [[CrossRef](#)] [[PubMed](#)]
106. Huo, X.; Wu, Y.; Xu, L.; Zeng, X.; Qin, Q.; Xu, X. Maternal urinary metabolites of PAHs and its association with adverse birth outcomes in an intensive e-waste recycling area. *Environ. Pollut.* **2019**, *245*, 453–461. [[CrossRef](#)] [[PubMed](#)]
107. Davis, J.M.; Garb, Y. A strong spatial association between e-waste burn sites and childhood lymphoma in the West Bank, Palestine. *Int. J. Cancer* **2019**, *144*, 470–475. [[CrossRef](#)] [[PubMed](#)]
108. Zhang, B.; Huo, X.; Xu, L.; Cheng, Z.; Cong, X.; Lu, X.; Xu, X. Elevated lead levels from e-waste exposure are linked to decreased olfactory memory in children. *Environ. Pollut.* **2017**, *231*, 1112–1121. [[CrossRef](#)] [[PubMed](#)]
109. Cong, X.; Xu, X.; Xu, L.; Li, M.; Xu, C.; Qin, Q.; Huo, X. Elevated biomarkers of sympatho-adrenomedullary activity linked to e-waste air pollutant exposure in preschool children. *Environ. Int.* **2018**, *115*, 117–126. [[CrossRef](#)] [[PubMed](#)]
110. Alabi, O.A.; Bakare, A.A.; Xu, X.; Li, B.; Zhang, Y.; Huo, X. Comparative evaluation of environmental contamination and DNA damage induced by electronic-waste in Nigeria and China. *Sci. Total Environ.* **2012**, *423*, 62–72. [[CrossRef](#)] [[PubMed](#)]
111. Nyeko, S.J.; Among, J.; Abima, B.; Ogen, C. Assessing electronic waste recycling and disposal intentions based on an extended valence theory in a developing country context. *ORSEA J.* **2022**, *12*, 58–75. [[CrossRef](#)]
112. Pham, T.T.; Lam, T.P.M.; Le Dang, H.; Pham, N.T. Consumers' willingness to pay an environmental fee for e-waste recycling in Vietnam: Integrating the theory of planned behaviour and the norm activation model. *J. Mater. Cycles Waste Manag.* **2023**, *25*, 2900–2914. [[CrossRef](#)]
113. Peter, J.P.; Tarpey, L.X. A comparative analysis of three consumer decision strategies. *J. Consum. Res.* **1975**, *2*, 29–37. [[CrossRef](#)]

114. Kim, H.W.; Chan, H.C.; Gupta, S. Value-based adoption of mobile internet: An empirical investigation. *Decis. Support Syst.* **2007**, *43*, 111–126. [\[CrossRef\]](#)
115. Li, Y.; Wang, X.; Lin, X.; Hajli, M. Seeking and sharing health information on social media: A net valence model and cross-cultural comparison. *Technol. Forecast. Soc. Change* **2018**, *126*, 28–40. [\[CrossRef\]](#)
116. Mou, J.; Cohen, J.; Dou, Y.; Zhang, B. Predicting buyers' repurchase intentions in cross-border e-commerce: A Valence framework perspective. *Eur. Conf. Inf. Syst.* **2017**. Available online: https://aisel.aisnet.org/ecis2017_rp/151 (accessed on 9 June 2026).
117. Xiao, L.; Mou, J.; Huang, L. Factors influencing Chinese online health service use: A valence framework perspective. *J. Glob. Inf. Manag.* **2021**, *29*, 138–160.
118. Heinonen, K. Positive and negative valence influencing consumer engagement. *J. Serv. Theory Pract.* **2018**, *28*, 147–169. [\[CrossRef\]](#)
119. Han, L.; Wang, S.; Zhao, D.; Li, J. The intention to adopt electric vehicles: Driven by functional and non-functional values. *Transp. Res. Part A Policy Pract.* **2017**, *103*, 185–197. [\[CrossRef\]](#)
120. He, X.; Zhan, W.; Hu, Y. Consumer purchase intention of electric vehicles in China: The roles of perception and personality. *J. Clean. Prod.* **2018**, *204*, 1060–1069. [\[CrossRef\]](#)
121. Schwartz, S.H. Elicitation of moral obligation and self-sacrificing behavior: An experimental study of volunteering to be a bone marrow donor. *J. Personal. Soc. Psychol.* **1970**, *15*, 283. [\[CrossRef\]](#) [\[PubMed\]](#)
122. Turaga, R.M.R.; Howarth, R.B.; Borsuk, M.E. Pro-environmental behavior: Rational choice meets moral motivation. *Ann. N. Y. Acad. Sci.* **2010**, *1185*, 211–224. [\[PubMed\]](#)
123. Macovei, O.I. Determinants of consumers' pro-environmental behaviour—toward an integrated model. *J. Dan. Stud. Res.* **2015**, *5*, 261.
124. Nordlund, A.M.; Garvill, J. Value structures behind pro-environmental behaviour. *Environ. Behav.* **2002**, *34*, 740–756.
125. Farrow, K.; Grolleau, G.; Ibanez, L. Social norms and pro-environmental behavior: A review of the evidence. *Ecol. Econ.* **2017**, *140*, 1–13. [\[CrossRef\]](#)
126. Harland, P.; Staats, H.; Wilke, H.A. Situational and personality factors as direct or personal norm mediated predictors of pro-environmental behaviour: Questions derived from norm-activation theory. *Basic Appl. Soc. Psychol.* **2007**, *29*, 323–334. [\[CrossRef\]](#)
127. Zhang, B.; Du, Z.J.; Wang, B.; Wang, Z.H. Motivation and challenges for e-commerce in e-waste recycling under “Big data” context: A perspective from household willingness in China. *Technol. Forecast. Soc. Change* **2019**, *144*, 436–444. [\[CrossRef\]](#)
128. Liu, Y.; Huo, X.; Xu, L.; Wei, X.; Wu, W.; Wu, X.; Xu, X. Hearing loss in children with e-waste lead and cadmium exposure. *Sci. Total Environ.* **2018**, *624*, 621–627. [\[CrossRef\]](#) [\[PubMed\]](#)
129. Van der Werff, E.; Steg, L. One model to predict them all: Predicting energy behaviours with the norm activation model. *Energy Res. Soc. Sci.* **2015**, *6*, 8–14. [\[CrossRef\]](#)
130. Bamberg, S.; Schmidt, P. Incentives, morality, or habit? Predicting students' car use for university routes with the models of ajzen, Schwartz, and triandis. *Environ. Behav.* **2003**, *35*, 264–285. [\[CrossRef\]](#)
131. Chu, H. Research methods in library and information science: Content analysis. *Libr. Inf. Sci. Res.* **2015**, *37*, 36–41. [\[CrossRef\]](#)
132. Neuendorf, K.A. *The Content Analysis Guidebook*; Sage Publications: Thousand Oaks, CA, USA, 2002.
133. Carson, D.; Gilmore, A.; Perry, C.; Gronhaug, K. *Qualitative Marketing Research*; Sage Publications: London, UK, 2001.
134. Saunders, M.; Lewis, P.; Thornhill, A. *Research Methods for Business Students*, 6th ed.; Pearson Education: London, UK, 2012.
135. Thukral, S.; Singh, M. An exploratory study on producer's perspective towards E-waste management: A case of emerging markets. *Clean. Waste Syst.* **2023**, *5*, 100090. [\[CrossRef\]](#)
136. Nisha, B.; Shajil, S.; Dutta, R.; Jain, T. Consumer awareness and perceptions about e-waste management in semi-urban area of northern Tamil Nadu: A mixed-method approach. *J. Fam. Community Med.* **2022**, *29*, 132–137. [\[CrossRef\]](#) [\[PubMed\]](#)
137. UNEP 2003. Korea Environmental Policy Bulletin-Volume-Based Waste Fee System. Available online: <https://wedocs.unep.org/items/653dc3b0-dc4c-4a14-8154-23e6d2561f25> (accessed on 29 June 2026).
138. Patton, M. *Qualitative Research and Evaluation Methods*, 3rd ed.; Sage Publications: Thousand Oaks, CA, USA, 2002.
139. Bengtsson, M. How to plan and perform a qualitative study using content analysis. *Nurs. Plus Open* **2016**, *2*, 8–14. [\[CrossRef\]](#)
140. Sutton, J.; Austin, Z. Qualitative research: Data collection, analysis, and management. *Can. J. Hosp. Pharm.* **2015**, *68*, 226. [\[CrossRef\]](#) [\[PubMed\]](#)
141. Seidel, J.; Kelle, U. Different functions of coding in the analysis of textual data. In *Computer-Aided Qualitative Data Analysis: Theory, Methods and Practice*; Kelle, U., Ed.; Sage: London, UK, 1995.
142. Srivastava, A.; Thomson, S.B. Framework analysis: A qualitative methodology for applied research note policy research. *J. Adm. Gov.* **2009**, *4*, 72–79.
143. Ritchie, J.; Lewis, J. *Qualitative Research Practice: A Guide for Social Science Students and Researchers*; Sage Publications Ltd.: London, UK, 2003.
144. Dahlen, L.; Lagerkvist, A. Pay as you throw: Strengths and weaknesses of weight-based billing in household waste collection systems in Sweden. *Waste Manag.* **2010**, *30*, 23–31. [\[PubMed\]](#)

145. Ecologic Institute. *Waste Charging System in Taipei*; Ecologic Institute: Berlin, Germany, 2014.
146. Zero Waste Europe. Cheaper and More Efficient? The Positive Effects of Pay-As-You-Throw and Kerbside Collection. 2018. Available online: <https://zerowasteurope.eu/2018/02/cheaper-more-efficient-pay-as-you-throw-kerbside-collection/> (accessed on 29 June 2026).
147. Elia, V.; Gnoni, M.G.; Tornese, F. Designing Pay-As-You-Throw schemes in municipal waste management services: A holistic approach. *Waste Manag.* **2015**, *44*, 188–195. [[CrossRef](#)] [[PubMed](#)]

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