TALLINN UNIVERSITY OF TECHNOLOGY
SCHOOL OF ENGINEERING
Department of Civil Engineering and Architecture

COMPARISON OF WASTE MANAGEMENT POLICY IN SOUTH AFRICA AND THE EUROPEAN UNION TO SUPPORT CIRCULAR ECONOMY

LÕUNA-AAFRIKA JA EUROOPA LIIDU JÄÄTMEKÄITLUSPOLIITIKA VÕRDLUS RINGMAJANDUSE TOETAMISEKS

MASTER THESIS

Student: Chukwuka Chinkwenye ANONYE

Student code: 214153EABM

Supervisor: Arvo Iital, Professor emeritus

Tallinn 2023

AUTHOR'S DECLARATION

Hereby I declare, that I have written this thesis independently.
No academic degree has been applied for based on this material. All works, major viewpoints and data of the other authors used in this thesis have been referenced.

23rd May 2023

Author: .....
/signature /

Thesis is in accordance with terms and requirements

23rd May 2023

Supervisor: ….....
/signature/

Accepted for defence

23rd May 2023

Chairman of theses defence commission: .....
/name and signature/

Non-exclusive Licence for Publication and Reproduction of GraduationTthesis[1]

I Chukwuka Chinkwenye ANONYE

1. grant Tallinn University of Technology (TalTech) a non-exclusive license for my thesis Comparison of Waste Management Policy in South Africa and European Union to Support Circular Economy.

supervised by Arvo Iital

1.1 reproduced for the purposes of preservation and electronic publication, incl. to be entered in the digital collection of TalTech library until expiry of the term of copyright.

1.2 published via the web of TalTech, incl. to be entered in the digital collection of TalTech library until expiry of the term of copyright.

1.3 I am aware that the author also retains the rights specified in clause 1 of this license.

2. I confirm that granting the non-exclusive license does not infringe third persons' intellectual property rights, the rights arising from the Personal Data Protection Act or rights arising from other legislation.

---

[1] *Non-exclusive Licence for Publication and Reproduction of Graduation Thesis is not valid during the validity period of restriction on access, except the university`s right to reproduce the thesis only for preservation purposes.*

_____ (*signature*)

23rd May 2023_____ (*date*)

Department of Civil Engineering and Architecture

THESIS TASK

Student: Chukwuka Chinkwenye ANONYE, 214153EABM

Study programme: EABM04/19 Environmental Engineering and Management

Supervisor(s): Professor, Arvo Iital

Thesis topic:
(in English) *Comparison of waste management policy in South African and European Union to support circular economy*
(in Estonian) Louna-Aafrika ja Euroopa Liidu jaatmekaitluspoliitika vordlus ringmajanduse toetamiseks

Thesis main objectives:

1. Comparing waste management policies between South Africa and European Union
2. Identifying areas where waste management policies could be improved
3. Identifying best practices and innovative approaches to waste management

Thesis tasks and time schedule:

No	Task description	Deadline
1.	Collection of data and selection of indicators for the comparison	03.2023
2.	Studying literature sources and compiling literature review	04.2023
3.	Result analysis with the use of selected indicators.	05.2023

Language: English **Deadline for submission of thesis:** 23rd May 2023

Student: Chukwuka Chinkwenye ANONYE ……..
/signature/

Supervisor: Arvo Iital……..
/signature/

Head of study programme: Karin Pachel ……..
/signature/

CONTENTS

List of Figures

List of Tables

PREFACE

I'd want to express my gratitude to my supervisor, Arvo Iital, for his assistance in understanding the theory, his suggestions for enhancement, and his incredibly thorough remarks and guidance.

I value the efforts made by each one of my lecturers to arm me with the required information.

I am appreciative of the assistance I received from my loved ones, friends, and co-workers throughout my master's program.

Conclusively, I want to express my gratitude to the Almighty God for loving me and supporting me up until this point.

Chukwuka Chinkwenye ANONYE

List of abbreviations and symbols

GDP	Gross Domestic Product
DEFF	Department of Environment, Forestry and Fisheries
CE	Circular Economy
MT	Million tons
PW	Plastic Waste
MSW	Mixed Solid Waste
SWM	Solid Waste Management
DEA	Department of Environmental Affair
PPWD	Packaging and Packaging Waste Directive
EPR	Extended Producer Responsibility
WEEE	Waste Electrical and Electronic Equipment
IWMPS	Integrated Waste Management Plans
NWMS	National Waste Management Strategy
EPA	Environmental Protection Agency
RCRA	Resource Concervation and Recovery Act
CERCLA	Comprehensive Environmental Response, and Liability Act

ABSTRACT

This analysis provides an in-depth comparative study of the waste management policies of the European Union and South Africa, focusing on based on their per capita waste generation, GDP, policies and practices, waste composition, and waste recycle processes. The study provides insights into the efficiency and effectiveness of waste management strategies in two regions with vastly different populations and economic development levels. The study highlights similarities and differences between the two entities in terms of per capita waste generation, GDP, policies and practices, waste composition, and waste recycle processes by adopting a desk-review research approach with evaluations and reports obtained from secondary sources of data analyzed using content analysis. The result revealed that both the European Union and South Africa prioritize waste prevention, reuse, and recycling over disposal, with the waste management hierarchy aiming to reduce the amount of waste going to landfills. However, South Africa places a greater emphasis on composting as a waste treatment process, while the European Union promotes Mechanical Biological Treatment and Anaerobic Digestion. Additionally, the South African government promotes Waste-to-Energy as a way to recover energy from waste, while the European Union has not emphasized this technology as much. The study also shows that both entities have set recycling targets for different waste streams, with the European Union targets being more ambitious than those of South Africa. However, the South African government has faced challenges in implementing these policies due to inadequate infrastructure, lack of funding, and insufficient regulatory enforcement. This analysis also highlighted the importance of effective waste management policies to promote a circular economy and reduce the negative environmental impact of waste. It is crucial for policymakers to continue developing and implementing effective waste management policies, considering regional differences in waste composition, waste-to-energy technologies, and infrastructure. The Study recommended that another study that considers additional factors such as public perception, public participation, and cultural practices that may influence waste management practices in both regions be carried out. These wide range of factors will provide a comprehensive understanding of waste management practices in both regions. The study also suggested more studies on factors that contribute to differences in waste generation, such as population density, urbanization, and consumption patterns.

1 INTRODUCTION

The need for waste management arises from the fact that human activities generate a significant amount of waste materials that can have negative impacts on both the environment and human health if not properly managed [1; 2; 3]. Waste management refers to the collection, transportation, processing, and disposal of waste materials generated by human activities [1]. It is an important aspect of environmental protection and sustainability, as improper waste management can lead to a variety of negative impacts on both human health and the natural environment [4]. According to [4] the process of waste management begins with the collection of waste materials, which can include everything from household garbage to industrial byproducts. Once collected, the waste is transported to a processing facility, where it is sorted and separated into different categories based on its composition and potential for recycling or reuse. Next, the waste is treated or processed in order to reduce its volume and potential for harm to the environment. This may involve composting, incineration, or other methods of disposal [1;5].

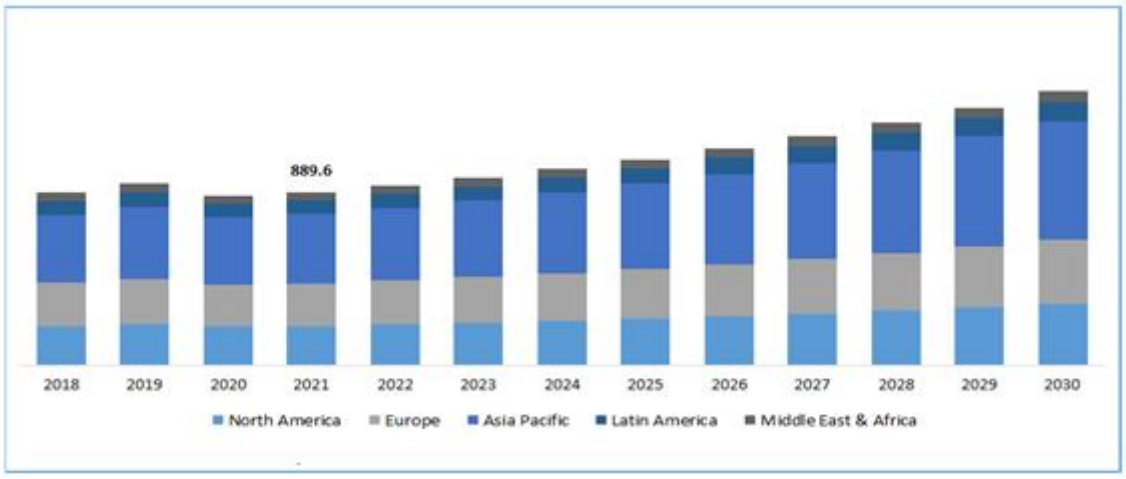

Figure 1: Global Waste Management Market 2018 – 2030 (USD in Billion) [6]

Some countries have better waste management systems than others due to a combination many factors. For example, countries like Sweden, Switzerland, and Japan have advanced waste management systems due to their high levels of resources, strong government support, and cultural values that prioritize waste reduction and recycling [7]. Other countries with less developed waste management systems may lack the resources or political will to implement effective waste management strategies. These differences calls the need to investigate countries waste management practices. According [1] comparing waste management practices

can highlight differences in waste generation patterns and waste composition between regions. This information can be used to tailor waste management strategies to the specific needs and circumstances of different regions. For example, a region with a high proportion of organic waste may benefit from investing in composting facilities, while a region with a high volume of plastic waste may prioritize initiatives aimed at reducing plastic consumption or improving recycling rates for plastic materials. Comparing waste management practices across different regions can highlight disparities in access to waste management services and infrastructure [1]. Comparing waste management practices can facilitate the sharing of knowledge and expertise between different regions, leading to improved collaboration and innovation in the waste management sector [1]. This can ultimately lead to more sustainable and effective waste management practices globally. The need for waste management arises from the environmental, resource conservation, health, and circular economic impacts of waste materials generated by human activities [7].

Circular economy and waste management are closely related as they both address the issue of managing the resources that we consume and reducing their impact on the environment [7]. A circular economy is an economic model that seeks to reduce waste and increase the use of renewable resources by creating a closed-loop system in which materials are recycled and reused instead of being discarded as waste [8]. In a circular economy, waste is seen as a valuable resource that can be repurposed and reused instead of being disposed of in landfills or incinerated. By adopting circular economy principles, waste management can be transformed from a linear model, where resources are used and then discarded, to a circular model, where resources are continuously used and reused [8]. Circular economy approaches can be applied to waste management in several ways. For example, through designing products that are durable, repairable, and reusable, reducing the amount of waste generated in the first place [7]. The circular economy offers a new perspective on waste management, one that views waste as a resource and seeks to minimize its impact on the environment [8]. By adopting circular economy principles, waste management can be transformed into a sustainable and profitable system that benefits both the economy and the environment [7].

The European Commission is the executive body of the European Union (EU) responsible for proposing and implementing policies and legislation at the EU level [10] Waste management is one of the areas that the European Commission is actively involved in, with the goal of promoting sustainable waste management practices and reducing the environmental impact of waste [4]. The European Commission's waste management policies are guided by the Waste Framework Directive, which sets out the basic principles for waste management in the EU [10]. The directive aims to

promote a circular economy, where waste is minimized and resources are used more efficiently. To achieve this goal, the directive sets out waste prevention measures, such as product design and eco-design, as well as waste reduction, reuse, and recycling targets for different waste streams [10]. The European Commission's waste management policies are aimed at promoting a more sustainable and resource-efficient economy by reducing the environmental impact of waste and promoting the circular use of resources [9].

South Africa is a country that faces many waste management challenges due to rapid urbanization, population growth, and economic development [11]. The South African government has implemented various policies and initiatives to manage the country's waste and mitigate its environmental and social impact. The Department of Environment, Forestry and Fisheries (DEFF) is responsible for implementing waste management policies. South Africa's waste management infrastructure includes landfills, waste-to-energy facilities, and recycling facilities. However, the country faces a significant challenge in terms of waste collection and disposal, particularly in rural areas and informal settlements [11]. The lack of access to proper waste management services in these areas results in illegal dumping, which poses health and environmental risks [12]. South Africa has also established partnerships with the private sector and international organizations to improve waste management practices [11]. For example, the South African Waste Pickers Association has partnered with Coca-Cola South Africa to provide waste pickers with access to collection and sorting facilities and to support their integration into the formal waste management sector.

Looking at the waste management of European Union and South Africa, it is very obvious that though have waste management policies and practices, South Africa unlike the European union is still having some challenges in managing the country waste. This study carry out comparative analysis between European Commission waste management and South Africa waste management. In order to relate the comparison to circular economy, this comparative analysis on the European Commission waste management and South Africa waste management will perhaps focus on selected indicators for the comparison, e.g per capital, per GDP, waste policy and practices, waste composition and waste recycling process. This study is essential for effective waste management across the regions and the countries.

2 LITERATURE REVIEW

2.1 Circular Economy

The circular economy (CE) has emerged as one of the most influential environmental policy concepts of the last decade [13], As a result, it has earlier been the topic of extensive inquiry and heated controversy. In general terms, the CE is defined as a 'closed loop economy,' which ought to substitute the current linear model, which relies on the inefficient 'take-make-use-discard' material flow (e.g. [14]). In a closed loop economy, resources are managed in a way that minimizes waste and pollution by designing products to be reused, repaired, or recycled. This system is in contrast to the traditional linear economy, where resources are extracted, processed into products, used, and then disposed of as waste. In a closed loop economy, the emphasis is on reducing waste, conserving resources, and maximizing the value of materials by keeping them in the economy for as long as possible. This can be achieved through practices such as recycling, remanufacturing, and composting, which can help to create a more sustainable and resilient economic system. The CE was indirectly converted from research to policy in the Western setting; rather, think-tank actors, particularly the Ellen MacArthur Foundation, were the primary designers of it as a policy notion (e.g.[15]). This CE concept has been fortunately advanced toward a policy program [15]. The CE, as a concept of change, is both ambivalent and transformational. The CE has been the subject of numerous perceptions in the literature up to this point, but a more thorough interpretation of the CE as a form of policy thought is still lacking. The aforementioned is a severe flaw because policies are required for revolutionary shifts (e.g.[16]). As a result, the goal of this perspective article is to investigate the CE's conceptual nature and provide a more complete description of how it functions as a policy change idea. This ought to improve studies of CE policy development. This ought to improve studies of CE policy formulation. We point out that there are other factors at play in the change process than the idea and its change proposals. The study of hybridity [17] is a useful tool to sort through the complex social contexts in which the concept of the CE is applied to better understand change-making processes.

2.2 Waste Management

Waste production is majorly caused by human activities [18]. The volume and diversity of industrial waste, as well as the rate at which it is generated, have recently increased [19]. As a result of the Industrial Revolution in the sixteenth century AD

[20], people began to move from the rural to the metropolis, and the amount and variety of rubbish increased, requiring authorities to explore how to appropriately dispose of the waste to protect public health. According to [21], waste's meaning is so far vague because the term can be construed in a variety of ways and is also impacted by personal viewpoint. To appropriately deal with and manage waste, it is essential to understand what comprises waste and the many sorts of waste. Industrial waste, like other types of garbage, is linked to a variety of environmental problems. Industrial solid waste is the most dangerous sort of waste and has serious detrimental effects on the environment and human health.

Waste, as described by [22], is any material or product that is not used for the intended function of the final product [23]. The theory of Waste management explains what waste is and how it can be transformed into a useful product, as well as essential waste results such as optimum waste management techniques [24]. One of the main forces behind firms adopting sustainable practices is trash management, an environmentally friendly activity that aims to reduce the harmful consequences of waste [25]; [26]. According to the studies [25]; [26], waste management is defined as the efforts taken to control all waste-related operations such as collecting, transporting, treating, recycling, or disposing of garbage to limit its negative impacts on the environment and health, as well as the ability to successfully control resources through recycling.

2.3 Global Overview of Waste Management

Analysis has shown that the amount of garbage produced positively correlates with the country's economic development, population expansion, industrialization, and urbanization [26]. By 2025, it is predicted that two-thirds of the world's population will reside in cities, in large part to the rapid growth of populations in urban areas in developing nations [27]. Around 2,010 million tons (MT) of Municipal Solid Waste (MSW) were generated globally in 2016, and by 2050, it is anticipated that this number will rise to 3,400 MT. This might result in a significant rise in MSW production of about 70% in just 34 years [28]. In 2016, the world produced 242 MT of PW or 12% of MSW. As a result of rising Plastic Waste (PW) consumption and the lack of suitable PW management systems in the majority of emerging nations, our oceans are being increasingly filled and polluted [29]; [30]. With sufficient primary Solid Waste Management (SWM) systems, several cities have been able to manage PW. For instance, the United States enforced plastic bag prohibitions on neighborhood beaches from the period of 2010 to 2017 and saw a 72% decrease in PW. Therefore, by 2050,

generated waste will have surpassed the population increase by a factor of more than two. One of the largest issues for nations throughout the world is managing such a large amount of waste sustainably. SWM is a complicated issue that calls for the right action to be taken to strive toward sustainability that is suitable from an environmental, economic, and social standpoint. Data on solid waste creation and management are crucial for local planning and governance. There are numerous waste treatment methods in use today, and each one has pros and cons. Nevertheless, policymakers must be aware of the diverse technologies and their various impacts before making their choices.

2.3.1 Waste Management in South Africa

South Africa faces significant challenges in waste management due to its rapidly growing population, increasing urbanization, and lack of adequate infrastructure and resources. The country generates an estimated 54 million tons of waste per year, and only 10% of this waste is recycled [31] . In 2019, South Africa generated 108 million tonnes of waste, with an average of 1.5 kilograms of waste per person per day. Around 60% of households in South Africa have access to formal waste collection services, while the remaining 40% rely on informal waste pickers [31]. The total amount of waste diverted from landfills through recycling and recovery in South Africa was 6.3 million tonnes. The recycling rate for paper and cardboard in South Africa is relatively high, at around 68% [32]. The e-waste recycling rate in South Africa is very low, with only an estimated 12% of e-waste being recycled. There were 1,426 registered waste management facilities in South Africa, including 827 landfills and 357 recycling facilities. Plastic pollution is a significant problem in South Africa, with an estimated 200,000 tonnes of plastic waste entering the ocean each year [33].

According to a report by the Council for Scientific and Industrial Research, the economic value of waste in South Africa is estimated to be R25 billion per year, highlighting the potential for waste to be used as a resource in the country.

To address these challenges, the South African government has implemented various policies and strategies to promote sustainable waste management practices. The National Environmental Management Waste Act (NEMWA) is the main legislation governing waste management in the country [34]. The Act outlines the responsibilities of all stakeholders, including producers, collectors, recyclers, and landfill operators, in the waste management process. One of the key objectives of the government's waste management strategy is to move towards a circular economy by promoting the use of waste as a resource. The strategy focuses on the principles of the waste hierarchy, which prioritize waste reduction, reuse, recycling, and recovery over disposal in

landfills [35]. Despite these efforts, many challenges remain in waste management in South Africa. Informal waste collectors, who are often excluded from the formal waste management system, play a significant role in collecting and recycling waste. However, they face many health and safety risks, and their work is not adequately recognized or supported by the government. Illegal dumping and littering are also significant problems in the country, with many communities lacking access to adequate waste collection services [36]. Landfills are often poorly managed, resulting in environmental and health risks for nearby communities.

Waste management in South Africa remains a significant challenge, with a need for increased investment in infrastructure and resources, as well as improved coordination between stakeholders [33]. However, the government's focus on promoting a circular economy and sustainable waste management practices is a positive step towards addressing these challenges.

2.3.2 Waste Management in European Union

The typical European citizen produces approximately 5 tons of waste per year, but only a small percentage of this (39% for 2014, out of 2 to 6 billion tons of EU waste production) is recycled [37]. This waste type includes municipal waste, industrial waste, hazardous waste, bio waste, electronic waste, medical waste etc. The EU generated a total of 2,151 million tonnes of waste in 2020, which equals to 4,808 kilograms per person. Construction was responsible for 37.1% of this waste, followed by mining and quarrying (23.4%), manufacturing (10.9%), waste and water services (10.7%), households (9.5%), and other economic activities (8.4%) such as services and energy [38]. Almost two thirds (64%) of the waste generated in the EU in 2020 was classified as major mineral waste, with the relative share varying between member states based on their economic structures. Member states with higher shares of major mineral waste tended to have larger mining and quarrying or construction and demolition activities. Waste excluding major mineral waste amounted to 781 million tonnes, equivalent to 36% of the total waste generated [38]. The EU generated an average of 1.7 tonnes per person in 2020 when excluding major mineral waste, with Estonia having the highest waste generation due to oil shale energy production. Waste and water services, households, and manufacturing activities were the largest contributors to waste generation, with different patterns of change between 2004 and 2020[38]. Waste generation by waste and water services and households increased considerably, while generation by manufacturing activities decreased significantly.

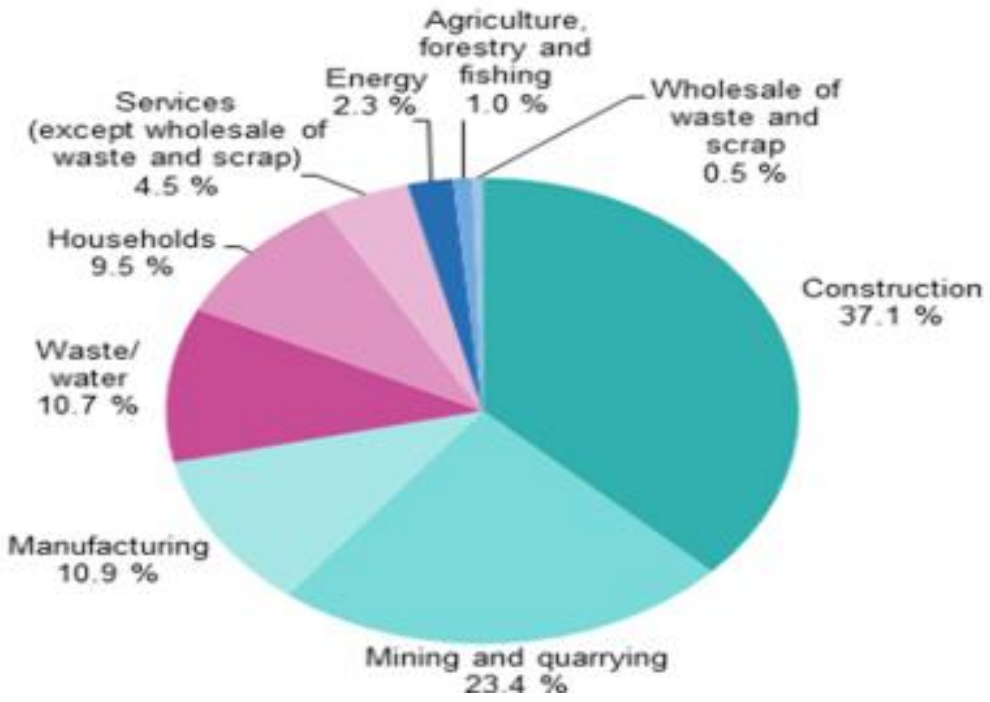

Figure 2: EU Waste Generation by household and Economic Activities in 2020 (% Share of Total Waste) [39]

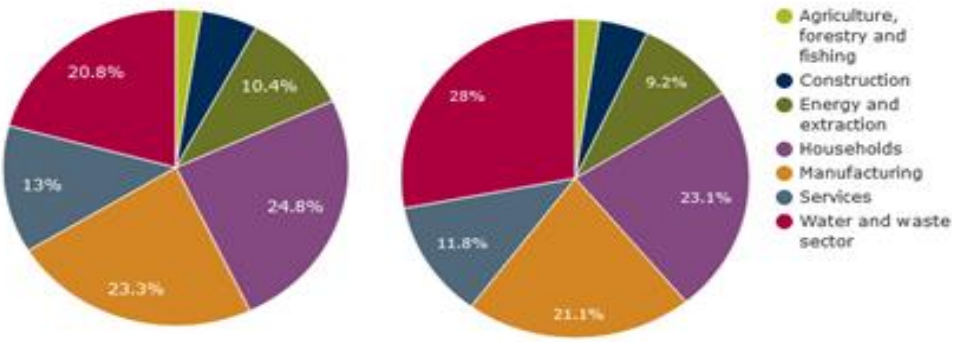

Figure 3: Generation of waste excluding major mineral wastes, EU in 2010(Left) and 2016(Right) (% Share of Total Waste) [39]

The majority of the remaining waste is sent to landfills or incinerators. Continuing with this practice is not viable for Europe, as it would waste a crucial opportunity to enhance its resource efficiency. To achieve a more sustainable, circular economy, it is necessary to prevent products and materials from becoming waste for as long as possible, and to convert unavoidable waste into a resource. This approach can have

numerous benefits, including promoting economic growth, job creation, reduced greenhouse gas emissions, and decreased reliance on imported raw materials.

The EU waste policy establishes a framework to enhance waste management, encourage innovation in separate waste collection and recycling, reduce landfill use, and incentivize changes in consumer behavior [37]. The policy also aims to reduce the amount of waste generated and the quantity of harmful substances it contains, in order to safeguard the environment and human health. The EU Waste Framework Directive has two main objectives: to prevent and reduce the negative effects caused by waste generation and management, and to improve resource efficiency. It outlines a 'hierarchy' that EU Member States must follow in waste management, with waste prevention and reuse as the preferred options, followed by recycling (including composting), energy recovery, and landfill disposal as the last resort. The EU waste legislation also sets specific targets to increase the recycling of various waste streams, such as electronic equipment, cars, batteries, construction and demolition waste, municipal waste, and packaging waste, while reducing the amount of biodegradable waste sent to landfills.

The Waste Framework Directive (2008/98/EC), which lays out a framework for the management of waste throughout the EU, is a crucial piece of legislation in this area. With the ultimate goal of achieving a more circular economy, this directive seeks to decrease the quantity of trash produced while increasing recycling and material recovery [37]. The Landfill Directive (1999/31/EC), which places restrictions on the quantity of biodegradable municipal garbage that can be dumped, is another significant component of EU waste management legislation. With the help of this order, landfill's negative environmental effects will be lessened, and composting and recycling as alternatives to land-filling will be promoted. The EU has also provided funds for waste management activities through programs like the LIFE program in addition to these legal measures. With the help of this financing, innovative waste management methods and technologies have been developed, and as well pilot studies to evaluate their viability have been carried out. Generally, the EU's waste management initiatives have helped to significantly lower the amount of waste dumped in landfills and raise recycling and recovery rates recently. There is still room for improvement, and the EU is working to achieve its objective of lowering trash levels and supporting more environmentally friendly waste disposal techniques.

2.4 Waste Management Policies

Waste management policies are a set of laws, directives, and guidelines that control how waste is managed, stored, and pre-disposed to protect the environment and public health, and to improve the efficient utilization of resources [40]. An important element of these regulations is the hierarchy of waste management, which highlights various waste management options following how they will affect the environment. The top of the hierarchy is prevention, then reuse, recycling, and disposal [40]. In the US, the federal Environmental Protection Agency (EPA) and state environmental agencies are primarily in charge of waste management policies [40]. The Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) are two programs and laws that the EPA has designed to address waste management [40]. In general, waste management regulations are essential for safeguarding the environment, promoting public health, and encouraging resource efficiency. We can guarantee that waste is correctly managed and that the harmful effects of waste are avoided by adhering to these policies.

2.4.1 Waste Management Policies in South Africa

The South African government has implemented several policies and regulations to manage waste disposal effectively. Some of these policies include [41]:

1. **National Environmental Management Act (NEMA) (1998)**: This Act provides the legal framework for the management of waste in South Africa. It requires that waste be managed in an environmentally sound and sustainable manner. It also outlines the responsibilities of various stakeholders in the waste management process, including waste generators, transporters, and disposal facilities.
2. **Waste Act (2008)**: This Act provides a regulatory framework for the management of all waste streams in South Africa. It establishes the principles of waste management and provides for the protection of health and the environment from the adverse effects of waste.
3. **Extended Producer Responsibility (EPR) policy (2021)**: This policy places the responsibility for the management of post-consumer products on the producers and manufacturers of those products. It aims to reduce the environmental impact of products throughout their life cycle and encourages the development of products that are easily recyclable or have less environmental impact.
4. **National Waste Management Strategy (NWMS) (2020)**: This strategy provides a framework for the development and implementation of waste management

plans at the national, provincial, and municipal levels. It promotes the principles of waste reduction, reuse, and recycling and encourages the use of alternative waste treatment methods.

5. **National Recycling Strategy (NRS) (2020)**: This strategy aims to promote the development of a sustainable recycling industry in South Africa. It provides guidelines for the establishment of recycling infrastructure and the promotion of recycling activities.

6. **Integrated Waste Management Plans (IWMPS) (2008)**: These plans are developed by municipalities to provide a framework for the management of waste at the local level. They outline the waste management practices to be followed and the resources required to implement them.

These policies and regulations provide a framework for the management of waste in South Africa. They encourage the use of sustainable waste management practices and provide guidelines for waste reduction, reuse, and recycling. However, there is still a need for increased investment in waste management infrastructure and the promotion of public awareness and education to achieve more effective waste management practices in the country.

2.4.1.1 The Impact of South Africa Waste Management Policies

The trend of waste generation in South Africa is on the rise, with the country producing 121 million tons of waste in 2017, as reported by the Department of Environmental, Forestry and Fisheries [42]. This figure is higher than the 108 million tons of waste generated in 2011, as documented by the DEFF in the same year. The increase in waste production may be attributed to a growing population and improved waste management policies, resulting in unaccounted-for waste that falls outside of the hazardous or general waste categories. Despite this, over 60% of general waste and around 95% of hazardous waste is still being sent to landfills, despite many of these facilities not complying with regulations, according to [31]. The lack of infrastructure and capacity to manage and pursue minimization strategies effectively is evident, with 87% of municipalities lacking these resources, and SWM being poorly funded and uncoordinated. As a result, South Africa is lagging 2-3 decades behind developed countries like Europe. Issues such as poor collection services, unlicensed SWM activities, illegal dumping, poor waste data management, and non-enforcement of existing waste regulations persist, as noted by [31]. However, the national and

municipal governments have recognized these challenges and are promoting a shift towards waste minimization, reuse, and recycling, as outlined in the National Waste Management Strategy (NMWS). With increased awareness of these issues, the focus is shifting from landfill disposal to a view of waste as a valuable resource.

Table 1: Classification of wastes and contribution in RSA to total amount in Percentage[43]

Municipal Waste		Hazardous Waste	
Type	**% Contribution**	**Type**	**% Contribution**
Municipal	8.9	Gaseous waste	8.2
Commercial and industrial	6.7	Mercury enhanced waste	0.05
Organic	56.5	Batteries	0.05
Construction and demolition	0	POP[2] waste	0.1
Paper	8.3	Inorganic waste	1.1
Plastic	4.1	Asbestos enhanced waste	0.1
Glass	2	Oils	0.1
Metals	4.6	Organics	0.7
Tyres	7.4	Bituminous and tarry waste	0.4
Other	1.5	Brine	8
		Fly dust and ash	60.4
		Bottom ash	8.2
		Slag	10.8
		Mineral waste	0.1
		WEEE[3]	0.4
		HCRW[4]	0.1
		Sewage sludge	0.8
		Others	0.4
Total	100	Total	100

Table 2: Amounts of wastes generated in RSA based on their type (million Tons) [40]

General Waste		Hazardous Waste	
Type	**Amount (Million Tons)**	**Type**	**Amount (Million Tons)**
Municipal	4.8	Gaseous waste	6
Commercial and industrial	3.6	Mercury enhanced waste	0.0001
Organic	30.5	Batteries	0.004
Construction and demolition	0	POP waste	0.0006
Paper	4.5	Inorganic waste	0.8
Plastic	2.2	Asbestos enhanced waste	0.006
Glass	1.1	Oils	0.1
Metals	2.5	Organics	0.5
Tyres	4	Bituminous and tarry waste	0.3
Other	0.8	Brine	5.8
		Fly dust and ash	44
		Bottom ash	6
		Slag	7.9
		Mineral waste	0.1
		WEEE	0.4
		HCRW	0.05
		Sewage sludge	0.6
		Others	0.3
Total	54		72.9

The South African waste management policies have had both positive and negative impacts on the country. On the positive side, the policies have contributed to a reduction in the amount of waste sent to landfills, the promotion of recycling and the creation of job opportunities in the waste management sector [41]. In South Africa, the collection of waste is primarily the responsibility of municipalities, which are overseen by the Department of Environmental Affairs (DEA) at the national level. The Municipal Solid Waste (MSW) collection service is funded by municipalities through service charges and rates, and it is their duty to provide efficient and effective waste collection services to their communities. The collection of hazardous waste, on the other hand, is regulated by the

Department of Environmental Affair (DEA) that changed to Department of Environment, Forestry and Fisheries (DEFF) which issues permits for the transportation and disposal of hazardous waste. It is worth noting that waste management in South Africa is faced with numerous challenges such as poor

infrastructure, limited financial resources, and poor waste management practices. As a result, waste collection and disposal services in some areas may be inadequate, leading to issues such as illegal dumping and poor waste management practices. The government is taking steps to address these challenges and improve waste management practices in the country through initiatives such as the National Waste Management Strategy (NWMS), which promotes waste minimization, reuse, and recycling. The country has also experienced a decrease in environmental pollution and greenhouse gas emissions, which has helped to mitigate climate change.

The policies have also played a role in the development of the waste management industry, leading to the emergence of private sector companies that provide waste management services [31]. These companies have helped to improve waste collection and disposal practices, as well as promote the use of technology and innovation in the sector. The industries used for the collection of waste in South Africa can vary widely depending on the specific municipality or region, and whether or not these industries use technologies or innovation in their waste collection practices can also vary significantly. There is an increasing need for innovation and the use of new technologies to improve waste collection, recycling, and disposal practices. In recent years, there have been efforts to encourage the development of innovative solutions and technologies in the waste management sector, such as the use of mobile applications and the adoption of smart waste management systems. Additionally, there are several private companies in South Africa that provide waste management services and may use innovative technologies in their operations

However, the implementation of the waste management policies has faced challenges such as inadequate funding, limited capacity in terms of personnel and equipment, as well as poor enforcement of regulations [33]. There have also been cases of corruption and mismanagement of waste management funds in some municipalities, leading to poor service delivery and negative impacts on the environment and public health Corruption and mismanagement can occur in various ways, such as embezzlement of funds, awarding contracts to unqualified companies or individuals, and inflating prices for services or equipment. When this happens, funds that are intended for waste management and disposal services may be diverted or misused, leading to inadequate waste collection and disposal practices. The negative impacts of such practices on the environment and public health can be significant. For example, waste that is not properly collected and disposed of can accumulate in public spaces, causing health hazards and environmental pollution. In some cases, waste is illegally dumped, leading to the contamination of water sources and soil, which can have serious health implications for nearby communities. Furthermore, corruption and mismanagement of

waste management funds can erode public trust in the government's ability to provide essential services, leading to social and economic implications. Communities that are affected by poor waste management practices may suffer from decreased property values and reduced investment in their areas. To address these challenges, there is a need for increased transparency and accountability in the management of waste management funds. This includes better oversight and monitoring of how funds are allocated and spent, as well as strict enforcement of regulations and penalties for those who engage in corrupt practices. Additionally, there is a need for increased public awareness of the importance of proper waste management practices and the negative impacts of corruption and mismanagement on the environment and public health.

Furthermore, there are concerns that the policies have not adequately addressed issues of waste reduction and prevention, and that there is still a significant amount of waste being generated in the country [35]. This highlights the need for ongoing review and improvement of waste management policies and practices in South Africa to ensure that they are effective, efficient and sustainable. South Africa, has a relatively weak waste management infrastructure and lacks proper regulations and policies to manage waste effectively. Despite the government's efforts to promote sustainable waste management practices, such as the National Environmental Management Waste Act of 2008, the country still faces significant challenges in managing its waste.

2.4.2 The European Waste Management Policies

The European Union (EU) has implemented a range of waste management policies to reduce waste generation and promote sustainable waste management practices. Some of the key policies include:

1. Waste Framework Directive (1975)[44]: This directive sets out the basic principles and definitions related to waste management in the EU, including the waste hierarchy which prioritizes waste prevention, reuse, and recycling over disposal. The Waste Framework Directive is a key policy instrument of the European Union's waste management policies. It was first adopted in 1975 and has been revised several times since then, with the most recent update being in 2018. The Directive establishes a waste hierarchy that sets out the order of priority for waste management practices, with waste prevention being the most preferred option, followed by preparation for reuse, recycling, other recovery options, and finally, disposal.

The Waste Framework Directive requires member states to take measures to prevent waste generation, promote the reuse of products and materials, and increase recycling rates. It also establishes producer responsibility for waste management, which means that producers are responsible for managing the waste generated by their products and are required to take measures to prevent waste generation and promote sustainable waste management practices. One of the key elements of the Waste Framework Directive is the requirement for member states to establish national waste management plans that outline their strategies for waste management, including waste prevention measures, recycling targets, and measures to promote sustainable waste management practices.

The Waste Framework Directive has had a significant impact on waste management practices in the European Union. It has led to a reduction in the amount of waste sent to landfill and an increase in recycling rates. It has also promoted the adoption of sustainable waste management practices and the development of the circular economy, which aims to minimize waste generation and maximize the recovery of resources.

The Waste Framework Directive is a critical policy instrument in the European Union's waste management policies, as it provides a framework for sustainable waste management practices, promotes the circular economy, and contributes to the overall sustainability of the European Union.

2. Packaging and Packaging Waste Directive (1991) [45]: This directive sets targets for the recycling and recovery of packaging waste, and establishes producer responsibility for the management of packaging waste. The European Union has taken a proactive approach towards waste management, recognizing that it is a crucial aspect of sustainability and a necessary step towards achieving a circular economy. One key policy in this area is the Packaging and Packaging Waste Directive (PPWD), which was first introduced in 1994 and has since been revised multiple times, most recently in 2018.

The PPWD is a comprehensive piece of legislation that covers all aspects of packaging waste, from prevention and reduction to recycling and recovery. It aims to reduce the environmental impact of packaging waste and promote the use of more sustainable packaging materials, while also encouraging member states to adopt a more coordinated and integrated approach to waste management. One of the key features of the PPWD is the principle of extended producer responsibility (EPR), which requires producers to take responsibility for the environmental impact of their products throughout their entire life cycle. This means that producers must design their products with the goal of reducing their environmental impact, and also take responsibility for their disposal and recycling.

The directive also sets ambitious targets for the recovery and recycling of packaging waste, with a goal of at least 55% recycling by 2025, and 65% by 2035. Member states are required to develop national waste management plans that outline their strategies for achieving these targets, and must report on their progress regularly. To support these efforts, the EU provides funding for waste management initiatives through programs such as the LIFE program, which has supported numerous waste reduction and recycling projects across the EU.

The PPWD represents an important step towards more sustainable waste management in Europe. However, there are still challenges to be addressed, including the need to improve waste collection and sorting infrastructure, as well as to promote the development of more sustainable packaging materials.

3. Waste Electrical and Electronic Equipment (WEEE) Directive (2003) [46]: This directive requires member states to establish collection and recycling systems for electronic waste. It was first introduced in 2003 and has since been revised multiple times, most recently in 2012. The WEEE Directive aims to reduce the environmental impact of electrical and electronic equipment by promoting its sustainable disposal and recycling. It requires member states to develop systems for the collection and treatment of WEEE, and sets targets for the recovery and recycling of the materials contained in these products.

One of the key features of the directive is the principle of extended producer responsibility (EPR), which requires producers to take responsibility for the environmental impact of their products throughout their entire life cycle. This means that producers must design their products with the goal of reducing their environmental impact, and also take responsibility for their disposal and recycling. The directive also requires member states to establish collection points for WEEE, and to ensure that these points are accessible to consumers. Producers are required to finance the costs associated with the collection, treatment, and recycling of WEEE, and are encouraged to promote the reuse of these products where possible. To support these efforts, the EU provides funding for waste management initiatives through programs such as the LIFE program, which has supported numerous waste reduction and recycling projects across the EU.

The WEEE Directive represents an important step towards more sustainable waste management in Europe. However, there are still challenges to be addressed, including the need to improve collection and treatment infrastructure, and to promote the development of more sustainable electronic products.

4. Landfill Directive (1999) [47]: This directive sets out minimum requirements for the operation and closure of landfills, and aims to reduce the amount of biodegradable waste sent to landfills. The Landfill Directive is an important piece of

waste management policy in Europe that was first introduced in 1999 and has since been revised multiple times, most recently in 2018. The directive aims to reduce the environmental impact of landfills by promoting sustainable waste management practices. It sets out a hierarchy of waste management options, with the priority being the prevention and reduction of waste generation, followed by preparation for reuse, recycling, and other forms of recovery, and finally disposal in a landfill. Under the directive, member states are required to reduce the amount of biodegradable waste that is sent to landfill, with a target of limiting landfilling to 10% of the total amount of biodegradable waste generated in 1995 by 2035. Member states must also establish national waste management plans that outline their strategies for achieving these targets. The directive also sets out specific requirements for the operation of landfills, including the need to prevent or minimize environmental impacts, such as water and air pollution. It requires member states to establish a system for the permitting and monitoring of landfills, and to ensure that these facilities are operated in accordance with best environmental practices. To support these efforts, the EU provides funding for waste management initiatives through programs such as the LIFE program, which has supported numerous waste reduction and recycling projects across the EU.

The Landfill Directive represents an important step towards more sustainable waste management in Europe. However, there are still challenges to be addressed, including the need to improve waste prevention and reduction strategies, and to promote the development of more sustainable waste management practices.

5. End-of-Life Vehicles Directive(2000))[48]: This directive sets targets for the reuse, recycling, and recovery of materials from end-of-life vehicles. The End-of-Life Vehicles (ELV) Directive is an important piece of waste management policy in Europe that was first introduced in 2000 and has since been revised multiple times, most recently in 2018. The directive aims to reduce the environmental impact of end-of-life vehicles by promoting their sustainable disposal and recycling. It requires member states to develop systems for the collection and treatment of ELVs, and sets targets for the recovery and recycling of the materials contained in these vehicles. One of the key features of the directive is the principle of extended producer responsibility (EPR), which requires producers to take responsibility for the environmental impact of their products throughout their entire life cycle. This means that producers must design their vehicles with the goal of reducing their environmental impact, and also take responsibility for their disposal and recycling.

The directive also requires member states to establish collection points for ELVs, and to ensure that these points are accessible to consumers. Producers are required to finance the costs associated with the collection, treatment, and recycling of ELVs, and are encouraged to promote the reuse of vehicle parts where possible. To support

these efforts, the EU provides funding for waste management initiatives through programs such as the LIFE program, which has supported numerous waste reduction and recycling projects across the EU. The ELV Directive represents an important step towards more sustainable waste management in Europe. However, there are still challenges to be addressed, including the need to improve collection and treatment infrastructure, and to promote the development of more sustainable vehicle designs.

6. Circular Economy Action Plan (2015) [49]: The European Commission's Circular Economy Action Plan aims to promote a more circular economy in the EU, where waste is minimized and resources are used more efficiently. The Circular Economy Action Plan is a key policy initiative of the European Union that was first introduced in 2015 and has since been revised multiple times, most recently in 2020.The plan aims to promote a more sustainable, circular economy, in which resources are used more efficiently and waste is minimized. It sets out a comprehensive strategy for achieving this goal, with a focus on four key areas: production, consumption, waste management, and innovation and investment. Under the plan, the EU has set a number of ambitious targets, including a 55% reduction in greenhouse gas emissions by 2030, and a goal of achieving net-zero emissions by 2050. It also aims to reduce the amount of waste generated in the EU by 50% by 2030, and to increase the share of recycled materials in products to 25%. To achieve these targets, the plan includes a range of policy measures, such as the revision of existing waste management legislation, the promotion of eco-design, the development of new market instruments to promote resource efficiency, and the support of research and innovation in the field of circular economy.

The plan also promotes the use of circular economy principles in key sectors such as textiles, plastics, and construction, with the aim of reducing waste and promoting the reuse and recycling of materials. To support these efforts, the EU provides funding for circular economy initiatives through programs such as the Horizon 2020 program, which has supported numerous research and innovation projects in the field of circular economy. The Circular Economy Action Plan represents an important step towards a more sustainable, circular economy in Europe. However, its success will depend on the commitment of member states and stakeholders to implement its measures, and to promote the development of sustainable, circular economy practices.

These policies aim to promote sustainable waste management practices, reduce waste generation, and increase the recycling and recovery of materials.

2.4.2.1 The Impact of European Waste Management Policies

The European waste management policies have had a significant impact on waste reduction, recycling rates, and the overall sustainability of waste management practices in the European Union. Some of the key impacts include :

Reduction in landfill waste: The Landfill Directive has led to a significant reduction in the 30% of biodegradable waste sent to landfills, which has reduced greenhouse gas emissions and improved soil and water quality [50].

Increase in recycling rates: The Packaging and Packaging Waste Directive and the WEEE Directive have increased the recycling rates of between 55 % and 80 % packaging waste and electronic waste, respectively [39]. This has reduced the amount of waste sent to landfill or incineration and increased the recovery of valuable resources.

Job creation: The shift towards more sustainable waste management practices has created new jobs in the recycling and resource recovery industries, contributing to the growth of the circular economy[52].

Economic benefits: Recycling and resource recovery can lead to economic benefits through the creation of new markets for recycled materials, reduced dependence on virgin materials, and reduced waste disposal costs.

Improved environmental quality: The reduction of waste sent to landfill, increased recycling rates, and promotion of sustainable waste management practices have led to improved environmental quality, including reduced pollution and improved soil and water quality [50].

The European waste management policies have had a positive impact on the environment, the economy, and society as a whole, by promoting sustainable waste management practices, reducing waste, and increasing the recovery of valuable resources. Europe has a long history of waste management practices and has implemented several policies and regulations to promote sustainable waste management practices. The European Commission (EC) is responsible for developing and implementing policies and measures to promote sustainable waste management practices across the European Union (EU). In recent years, the EU has made significant progress in reducing the amount of waste generated and increasing the rate of recycling.

3 RESEARCH METHODS AND DATA

After reviewing related materials on the topic, I developed a simplified method to compare waste management policies in the circular economy of South Africa and the European Union. The process began with the development of "theme formulations," which are general concepts or ideas related to the topic being studied. These theme formulations served as the basis for the analysis that was to follow. Once the theme formulations were developed, a set of questions was compiled based on these themes. These questions were then tested in a series of case studies to ensure that they were appropriate for the analysis being conducted. The final version of the questions underwent validation through their application in these case studies and subsequent adaptation. This means that I refined and improved based on the results of the case studies. Overall, this process ensured that the questions used in the analysis were well-developed, tested, and validated, increasing the likelihood that the results of the analysis would be accurate and reliable.

The objective of the project was to compare waste management policies in the circular economy of South Africa and the European Union, which was achieved through the use of secondary data sources such as statistical data, reports, academic journals, technical papers, and published newspapers and articles sourced through reliable internet sources for South Africa and the European Union. Although primary sources such as interviews and surveys could have filled gaps in the secondary data search, feasibility restraints may have obstructed their use in this research. The use of secondary data sources saved time and effort when gathering data that was already available in documented form. The qualitative data used were sourced as indicated in the table 3

Table 3: The Research Question, Case Study and Primary Data Sources

RESEARCH QUESTION	CASE STUDY	PRIMARY SOURCES
Compare The Waste Management Policy In Circular Economy Of South Africa And European Union?	• South Africa	• https://wesr.unep.org/cca/south-africa/environmental-performance#section-pressures • https://www.dffe.gov.za/documents/reports • https://green-cape.co.za/assets/WASTE_MIR_20200331.pdf • https://www.worldbank.org/en/region/afr/overview • https://www.statssa.gov.za/ • http://sawic.environment.gov.za/ • https://www.gov.za/documents/national-environmental-management-act
	• European Union	• https://ec.europa.eu/environment/green-growth/waste-prevention-and-management/index_en.htm • https://www.municipalwasteeurope.eu/summary-current-eu-waste-legislation • https://ec.europa.eu/eurostat/data/database • https://www.worldbank.org/

These set of questions covering the different ‘‘Waste Management Policy in Circular Economy elements’’ – which are thematic areas around issues of Waste management, Per capita and per GDP indicators between South Africa and European Union – which can be summarized as follows:

- Per capita indicators [52]: Per capita indicators measure the amount of waste generated per person in a particular region. It is calculated by dividing the total amount of waste generated by the total population of the region. This indicator helps to understand the overall waste generation rate in a region and can be used to compare waste management policies between regions with different population sizes.
- Per GDP indicators [52]: Per GDP indicators measure the amount of waste generated per unit of economic output in a particular region. It is calculated by dividing the total amount of waste generated by the region's gross domestic product (GDP). This indicator helps to understand the efficiency of waste management policies in a region, as it takes into account the level of economic activity in the region.
- Waste management policies and practice indicators [40]: Comparing the waste management practices of two countries involves examining and analyzing the

different policies and practices that are implemented by each country to manage their waste. This could involve a range of factors, such as: Comparing the amount and types of waste generated in each country, as well as the trends and patterns of waste generation over time. Examining the infrastructure and systems in place for collecting and transporting waste, including the types of vehicles and equipment used, the frequency and efficiency of collections, and the extent to which waste is segregated and sorted for recycling or disposal. Analyzing the policies, regulations, and incentives that are in place to promote sustainable waste management practices, such as extended producer responsibility (EPR), landfill taxes, and waste reduction targets. Examining the methods and facilities used for the disposal of waste, such as landfill sites, incinerators, and waste-to-energy plants, as well as the level of environmental and public health impact of these facilities.

- Waste Composition indicators [53]: Comparing the waste composition of two countries involves analyzing and comparing the types and amounts of materials found in their respective waste streams. This could include factors such as:

  1. Types of waste generated in each country, such as municipal solid waste, industrial waste, and construction and demolition waste.
  2. Proportions of organic waste, such as food and yard waste, versus inorganic waste, such as plastics, metals, and glass.
  3. Hazardous waste content, such as medical waste, e-waste, and chemical waste.
  4. Trends in waste composition over time, such as changes in packaging materials or the use of single-use plastics.

  By comparing these factors, it would be possible to evaluate the relative sustainability and environmental impact of each country's waste stream. It could also inform policy decisions related to waste reduction, recycling, and disposal. Additionally, it could help to identify opportunities for waste reduction and diversion, such as increasing composting and recycling rates, or implementing more sustainable packaging practices.

- Waste recycling process indicators [38]: Comparing the waste recycling process indicators of two countries involves analyzing and comparing the performance of each country's recycling system. This could include factors such as: the percentage of waste that is recycled, rather than sent to landfill or incineration, the percentage of recyclable materials that are collected for recycling, rather than discarded as waste, the purity and quality of materials recovered from the

recycling process, which can affect their suitability for reuse, the cost-effectiveness of recycling programs, and the ability of the recycling industry to create jobs and generate revenue and the energy consumption, greenhouse gas emissions, and other environmental impacts associated with the recycling process.

By comparing these factors, it would be possible to evaluate the strengths and weaknesses of each country's waste management system and identify areas where improvements could be made. It could also help to inform policy decisions related to waste management, recycling infrastructure investment, and public education and outreach. Additionally, it could help to identify best practices and innovative approaches to waste management that can be adopted by other countries.

My case study experience was used to define qualitative indicators that can influence project success or failure. I employed Content Analysis, also known as thematic analysis, to assess qualitative data by identifying, examining, and reporting recurring themes within a data collection. Thematic analysis is a versatile technique that can be applied to various epistemological and theoretical frameworks, study designs, questions, and sample sizes [54;55;56]. Interpretation is involved in the selection of codes and creation of themes [57;58]. To ensure an ongoing, organic, and iterative analysis of the recordings and transcripts, [55] template for thematic analysis was used, with the hope that specific themes would emerge.

4 RESULTS

4.1 Waste Generation per Capital

The analysis revealed that in 2021 EU generate approximately 502 kg of municipal waste per capita, while RSA generates around 430 kg per capita. It is worth noting that these figures only represent municipal waste and do not include other types of waste such as industrial or hazardous waste. The waste generation result for EU and RSA from 2015 to 2020 revealed that EU have higher waste generation per capita than RSA. Figure four below summarized the comparison of the Per Capita Generation of Municipal Waste trends in the European Union and South Africa in 2015-2020.

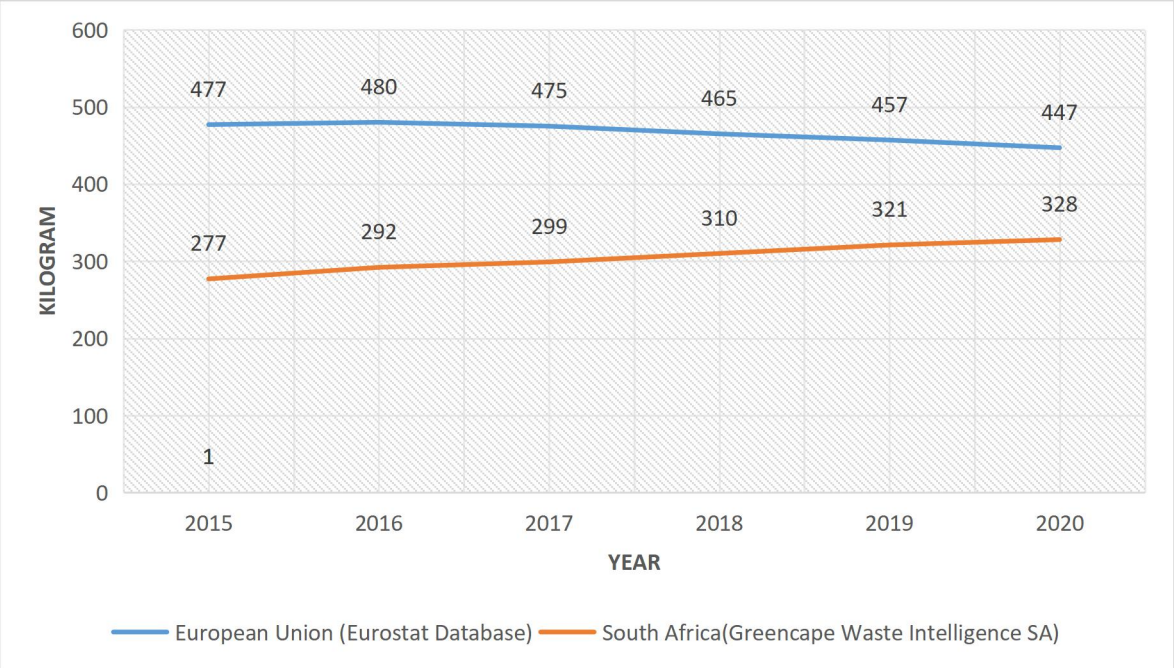

Figure 4: Comparison of Per Capita production of Municipal Waste in the European Union and South Africa in 2015-2020 (Kg).

4.2 Allocated resources per GDP

The analysis result revealed that in 2020, the ratio of allocated resources for waste management compared to GDP for Europe is 0.32%, while for South Africa, it is 0.53%. The proportion of the GDP spent on waste management could be higher in South Africa, even if the absolute amount spent on waste management is lower than that of Europe. The waste management for EU and RSA from the 2015-2019 revealed

that EU have higher waste management per GDP than RSA. Figure five below summarized the comparison of the Waste Management per GDP Ratio trends for EU and RSA for the period 2015-2019 (%)

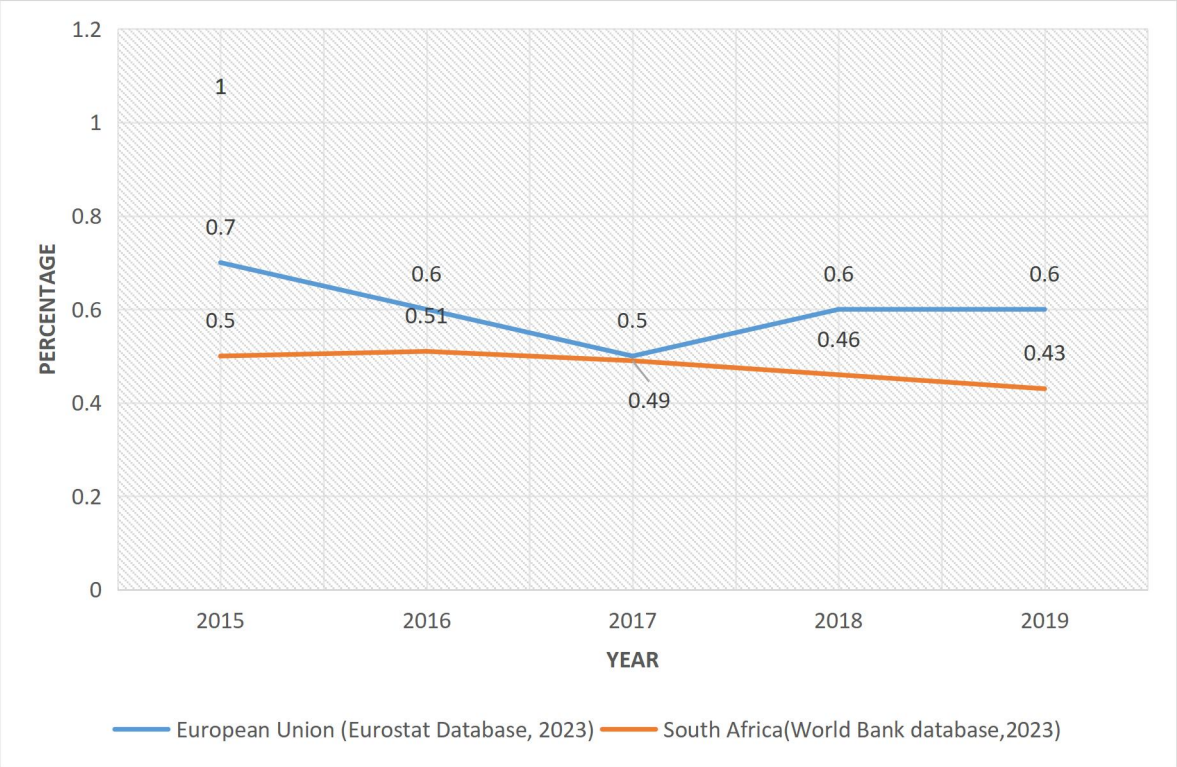

Figure 5: Comparison of the share of GDP allocated for waste management trends in EU and RSA in 2015-2019 (%)

4.3 Waste Management Policies and Practices

The result from the analysis revealed that The European Commission (EC) is responsible for developing and implementing policies and measures to promote sustainable waste management practices across the European Union (EU) while Municipalities in South Africa bear the primary responsibility for waste collection, overseen by the Department of Environmental Affairs (DEA) at the national level.

The waste management in EU is funded through a combination of EU budget allocations, national contributions, environmental taxes, public-private partnerships, international financial institutions, and dedicated circular economy funding programs while for RSA is is obtained through service charges and rates, and it is incumbent upon municipalities to provide their communities with efficient and effective waste collection services.

The EU has implemented several directives and regulations that aim to reduce waste generation and promote recycling and resource efficiency which include Waste

Framework Directive (1975), Packaging and Packaging Waste Directive (1991), Landfill Directive (1999), End-of-Life Vehicles Directive(2000), Waste Electrical and Electronic Equipment (WEEE) Directive (2003), Circular Economy Action Plan(2015). The RSA waste management policies include National Environmental Management Waste Act of 2008, Municipal Integrated Waste Management Plans (IWMPS) (2008), National Environmental Management Act (NEMA), (1998) Extended Producer Responsibility (EPR) policy (2021), National Waste Management Strategy (NWMS) (2020), National Recycling Strategy (NRS) and (2020). Table four below summarized the total waste management policies of EU and RSA.

Table 4: Summary of Comparison of Waste Management Policies and Act between EU and RSA.

COUNTRY/UNION	WASTE MANAGEMENT POLICIES AND ACT
EUROPEAN UNION (EU)	• Waste Framework Directive (1975), • Packaging and Packaging Waste Directive (1991), • Landfill Directive (1999), • End-of-Life Vehicles Directive (2000), • Waste Electrical and Electronic Equipment (WEEE) Directive (2003), • Circular Economy Action Plan (2015).
SOUTH AFRICA (RSA)	• National Environmental Management Waste Act of 2008, • Municipal Integrated Waste Management Plans (IWMPS) (2008), • National Environmental Management Act (NEMA), (1998) • Extended Producer Responsibility (EPR) policy (2021), • National Waste Management Strategy (NWMS) (2020), • National Recycling Strategy (NRS) and (2020).

4.4 Waste Composition

The analysis result revealed that the composition of waste in the EU consisted predominantly of construction waste (37.1%), followed by mining and quarrying

(23.4%), manufacturing (10.9%), waste/water (10.7%), household (9.5%), services (except wholesale of waste and scrap) (4.5%), energy (2.3%), agriculture, forestry and fishing (1.0%), and wholesale of waste and scrap (0.5%). In contrast, waste in RSA comprised a significant amount of organic waste (56.5%), followed by municipal waste (8.9%), paper waste (8.3%), tires (7.4%), commercial and industrial waste (6.7%), metals (4.6%), plastic (4.1%), glass (2%), and other waste materials (1.5%). Figure six below summarized the comparison of composition of waste composition trends of EU (Left) and RSA (Right).

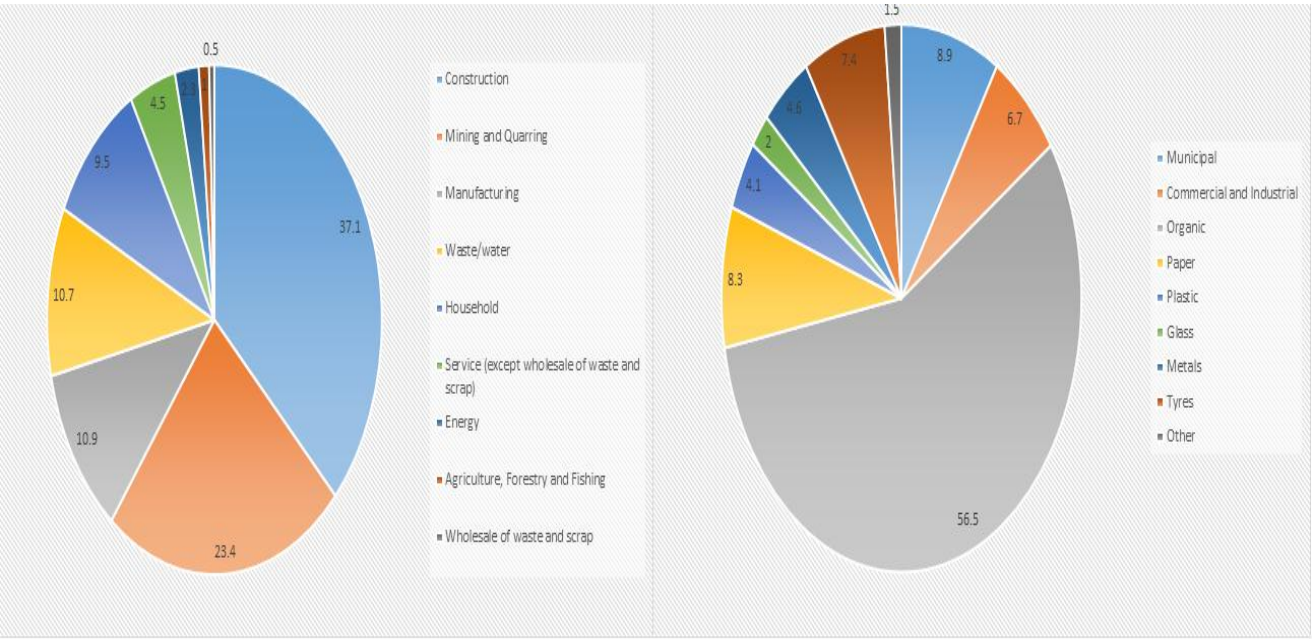

Figure 6: The comparison of Waste Composition trends of EU and RSA in 2020 (%)

4.5 Waste Recycling Process

In this analysis, the results were arranged in this order municipal waste collection rate, municipal waste recycling rate, municipal waste landfill rate and waste recycling rate target.

The result on municipal waste collection rate in 2018 revealed that the European Union has a higher rate of waste collection, with around 77% of municipal waste collected, while South Africa only collected around 64% of municipal waste in the same year.

The result on municipal waste recycling rate revealed that EU has higher recycling rates compared to South Africa in 2018. The recycling rate for municipal waste in the EU was 47%, while in South Africa, the recycling rate was only 11%.

The result on municipal waste treatment and landfill in 2018 revealed that in terms of waste treatment, both the EU and South Africa rely heavily on landfilling. In the EU, around 22% of municipal waste is landfilled, while in South Africa, the figure is around 87%. However, the EU also makes use of incineration, with around 27% of municipal waste being incinerated. In contrast, incineration is not widely used in South Africa. The result also revealed that South Africa places a greater emphasis on composting as a waste treatment process, while the European Union promotes Mechanical Biological Treatment and Anaerobic Digestion. Additionally, the South African government promotes Waste-to-Energy to recover energy from waste, while the European Union has not emphasized this technology as much.

The result on waste recycling rate target revealed that the EU aims to recycle 65% of municipal waste by 2035, while South Africa aims to recycle 25% of municipal waste by 2025. The figure seven below summarized comparison of the trends in municipal waste collection rate, municipal waste recycling rate, municipal waste landfill rate and waste recycling target of EU and RSA.

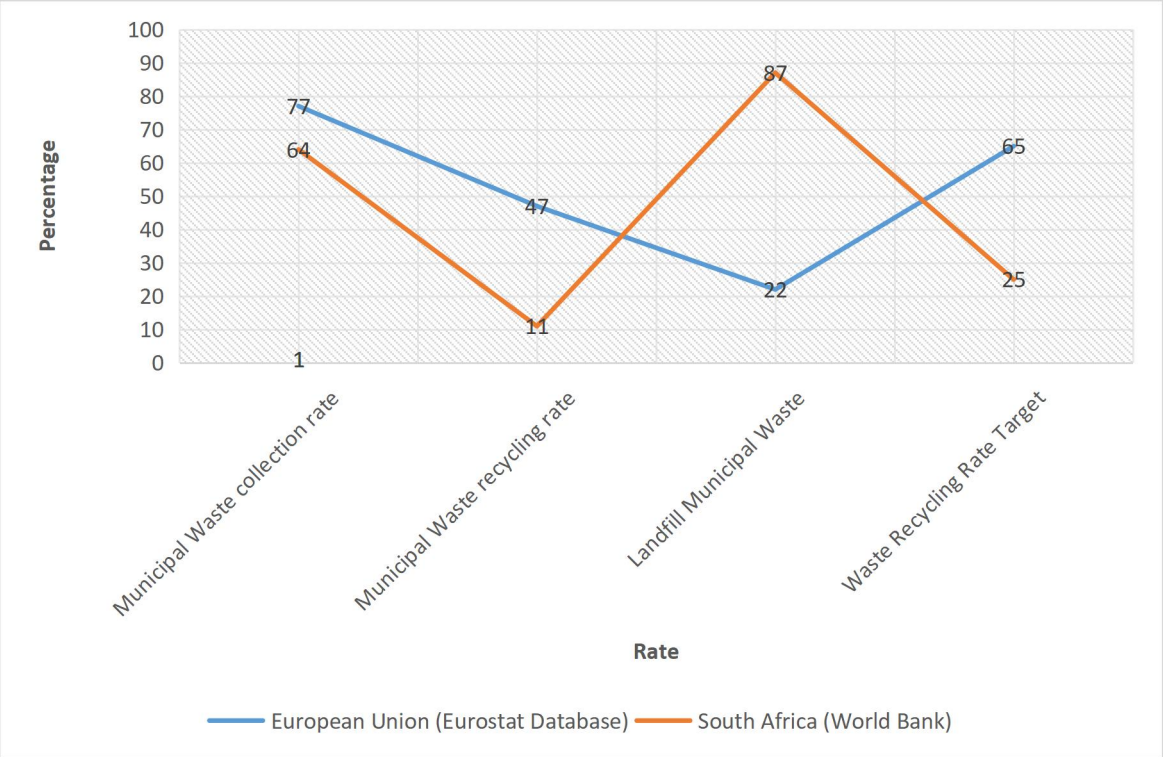

Figure 7: Graphical Representation of Waste Collection Rate, Waste Recycling Rate, Landfill Municipal Waste Rate in 2018 and Waste Recycling Rate target for 2035 for EU and RSA (%)

5 DISCUSSION OF RESULTS

5.1 Waste generation per capita

The result revealed that the EU produces more waste per person, potentially due to higher levels of consumption and affluence. However, it is worth noting that these figures only represent municipal waste and do not include other types of waste such as industrial or hazardous waste. While both the European Union and South Africa face challenges in managing their waste, the EU has made greater progress in terms of waste collection and recycling. However, both regions rely heavily on landfilling and could benefit from greater investment in alternative waste treatment technologies. There is also a need for stronger policies and regulations in South Africa to support sustainable waste management practices.

5.2 Allocated resources per GDP

This data indicates that South Africa has a higher waste management per GDP ratio compared to Europe in 2021 which means that South Africa is spending a larger proportion of its economic output on waste management. Though the result from 2019 down to 2015 revealed that EU has higher waste management per GDP ratio than RSA. However, this higher ratio RSA have in 2021 more than EU does not necessarily imply better waste management practices, as South Africa still faces significant challenges in managing its waste effectively. Europe has implemented several policies and regulations to promote sustainable waste management practices and has made significant progress in reducing waste generation and increasing recycling rates. South Africa, on the other hand, faces significant challenges in managing its waste effectively, despite the government's efforts to promote sustainable waste management practices. One possible explanation for the higher waste management per GDP ratio in South Africa could be the relatively low GDP of the country compared to Europe. South Africa is classified as a developing country, and its GDP per capita is much lower than the average GDP per capita of European countries. Therefore, the proportion of the GDP spent on waste management could be higher in South Africa, even if the absolute amount spent on waste management is lower than that of Europe.

5.3 Waste Management Policies and Practices

The waste management policies and practices in Europe and South Africa are significantly different. Europe has a well-developed waste management system with comprehensive policies and regulations that promote sustainable waste management practices, while South Africa lacks the infrastructure, resources, and public awareness necessary for effective waste management. While South Africa has made efforts to promote sustainable waste management practices, such as the National Environmental Management Waste Act of 2008, the implementation of these policies on the ground is still limited, and the country faces significant challenges in managing its waste effectively.

In recent years, the EU has made significant progress in reducing the amount of waste generated and increasing the rate of recycling. For example, the recycling rate in the EU has increased from 17% in 1995 to 47% in 2018. The EU has also set a target to recycle 55% of all municipal waste by 2025 and 65% by 2035.

South Africa, on the other hand, has a relatively weak waste management infrastructure and lacks proper regulations and policies to manage waste effectively. Despite the government's efforts to promote sustainable waste management practices, such as the National Environmental Management Waste Act of 2008, the country still faces significant challenges in managing its waste.

5.4 Waste Composition

The European Union and South Africa have different waste content. The waste content that has the largest composition of EU waste is construction while for RSA is organic. This difference in waste composition may be different in their policies and act. For example, The European Union has developed waste management policies to manage different types of waste. The EC Waste Framework Directive (2008/98/EC) sets out the waste management hierarchy that prioritizes waste prevention, reuse, and recycling over disposal. Some materials that lead to waste might be prohibited in Europe but not in RSA. These changes caused is the major cause of this difference. Also, South African government has promoted composting to divert organic waste from landfills, while the European Union has not focused on composting as a waste treatment process.

5.5 Waste Recycling Process

The European Union has a more developed waste recycling infrastructure and higher recycling rates compared to South Africa. This can be attributed to the difference in recycling infrastructure and technology, as well as the availability of resources and funding for waste management. One of the main challenges facing South Africa is the lack of infrastructure and resources for waste management. According to a report by the South African Waste Information Centre, only 44% of the country's waste is disposed of in landfill sites, and only 10% of waste is recycled. This indicates a significant gap in waste management practices compared to Europe. Another challenge facing South Africa is the lack of public awareness and education on waste management practices. This has led to poor waste management practices such as littering, illegal dumping, and the burning of waste, which have negative impacts on public health and the environment. However, both EU and RSA face challenges in their waste recycling processes, and there is a need for greater investment in recycling infrastructure and technology, as well as stronger policies and regulations to support sustainable waste management practices.

6 CONCLUSION AND RECOMMENDATION

In conclusion, the comparative analysis of waste management between the European Union (EU) and South Africa (RSA) highlights several key findings. In terms of waste generation per capita, the EU has a higher average compared to RSA. However, it's important to note that these figures only represent municipal waste and do not include other types of waste such as industrial or hazardous waste. When considering waste management per GDP, RSA allocates a higher proportion of its GDP to waste management compared to the EU. Despite the absolute amount spent on waste management being lower in RSA, the proportion of GDP allocated to waste management is higher. The EU has a well-developed waste management system supervised by the European Commission, with comprehensive policies and regulations in place to promote sustainable waste management practices. In contrast, RSA lacks proper regulations and policies, leading to a relatively weak waste management infrastructure. The waste composition differs between the EU and RSA. In the EU, construction, mining and quarrying, and manufacturing contribute significantly to waste content, while in RSA, organic waste and municipal waste dominate. The EU exhibits higher rates of municipal waste collection, recycling, and landfilling compared to RSA. The EU also utilizes incineration as a waste treatment method, while RSA emphasizes composting and waste-to-energy processes. Based on the analysis, it is evident that the EU has made significant progress in implementing effective waste management practices, supported by robust policies and regulations. In contrast, RSA faces various challenges, including inadequate infrastructure and limited financial resources, which impact waste management efforts. To achieve sustainable waste management and move towards a circular economy, RSA needs to strengthen its waste management infrastructure, enhance regulations, and allocate more resources to waste management. Learning from the EU's experience and adopting effective policies and practices could help RSA improve its waste management systems. The analysis underscores the importance of comprehensive waste management policies, proper infrastructure, and adequate resource allocation to promote sustainable waste management practices and contribute to the principles of circular economics.

Based on the analysis, these recommendations were made: firstly, policymakers in both the European Commission and South Africa should continue prioritizing waste prevention, reuse, and recycling over disposal. Secondly, The South African government should focus on improving infrastructure, increasing funding, and enforcing regulations to ensure effective policy implementation. Thirdly, the European Commission should consider promoting composting as a waste treatment process, while the South African government should explore the feasibility of using Mechanical

Biological Treatment (MBT) and Anaerobic Digestion (AD) to recover energy from waste. Finally, both entities should continue setting recycling targets for different waste streams and work towards achieving these targets to reduce waste and increase recycling rates.

List of References

1. Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. *International journal of environmental research and public health*, *16*(6), 1060. https://doi.org/10.3390/ijerph16061060
2. Manisalidis, I., Stavropoulou, E., Stavropoulos, A., & Bezirtzoglou, E. (2020). Environmental and Health Impacts of Air Pollution: A Review. Frontiers in public health, 8, 14. https://doi.org/10.3389/fpubh.2020.00014
3. Ghorani-Azam, A., Riahi-Zanjani, B., & Balali-Mood, M. (2016). Effects of air pollution on human health and practical measures for prevention in Iran. *Journal of research in medical sciences : the official journal of Isfahan University of Medical Sciences*, *21*, 65. https://doi.org/10.4103/1735-1995.189646
4. Abubakar, I. R., Maniruzzaman, K. M., Dano, U. L., AlShihri, F. S., AlShammari, M. S., Ahmed, S. M. S., Al-Gehlani, W. A. G., & Alrawaf, T. I. (2022). Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South. *International journal of environmental research and public health*, *19*(19), 12717. https://doi.org/10.3390/ijerph191912717
5. Fadhullah, W., Imran, N. I. N., Ismail, S. N. S., Jaafar, M. H., & Abdullah, H. (2022). Household solid waste management practices and perceptions among residents in the East Coast of Malaysia. *BMC public health*, *22*(1), 1. https://doi.org/10.1186/s12889-021-12274-7
6. Polaris Market Research (2022).*Waste Management Market Share, Size, Trends, Industry Analysis Report, By Type (Municipal Waste, Industrial Waste); By Services; By End-User; By Region; Segment Forecast, 2022 – 2030.* https://www.polarismarketresearch.com/industry-analysis/waste-management-market.
7. Sharma, H. B., Vanapalli, K. R., Samal, B., Cheela, V. R. S., Dubey, B. K., & Bhattacharya, J. (2021). Circular economy approach in solid waste management system to achieve UN-SDGs: Solutions for post-COVID recovery. *The Science of the total environment*, *800*, 149605. https://doi.org/10.1016/j.scitotenv.2021.149605
8. Garcés-Ayerbe, C., Rivera-Torres, P., Suárez-Perales, I., & Leyva-de la Hiz, D. I. (2019). Is It Possible to Change from a Linear to a Circular Economy? An Overview of Opportunities and Barriers for European Small and Medium-Sized

Enterprise Companies. *International journal of environmental research and public health*, *16*(5), 851. https://doi.org/10.3390/ijerph16050851

9. Greer, S.L., Rozenblum, S., and Fahy, N. (2022) Everything you always wanted to know about European Union health policy but were afraid to ask: Third, revised edition [Internet]. Copenhagen (Denmark): European Observatory on Health Systems and Policies; (Health Policy Series, No. 59.) Chapter 2, The European Union: institutions, processes and powers. Available from: https://www.ncbi.nlm.nih.gov/books/NBK590168/
10. Anuardo, R. G., Espuny, M., Costa, A. C. F., & Oliveira, O. J. (2022). Toward a cleaner and more sustainable world: A framework to develop and improve waste management through organizations, governments and academia. *Heliyon*, *8*(4), e09225. https://doi.org/10.1016/j.heliyon.2022.e09225
11. Haywood, L. K., Kapwata, T., Oelofse, S., Breetzke, G., & Wright, C. Y. (2021). Waste Disposal Practices in Low-Income Settlements of South Africa. *International journal of environmental research and public health*, *18*(15), 8176. https://doi.org/10.3390/ijerph18158176
12. Aliyu, A. A., & Amadu, L. (2017). Urbanization, cities, and health: The challenges to Nigeria - A review. *Annals of African medicine*, *16*(4), 149–158. https://doi.org/10.4103/aam.aam_1_17
13. Luo, A., Leipold, S., 2022. Chinese lessons on upscaling environmental policy concepts?

    A review of policy-oriented circular economy research. J. Clean. Prod. 333, 130047

    https://doi.org/10.1016/j.jclepro.2021.130047.

14. Nylen, E.-J., 2019. Can abstract ideas generate change? The case of the circular economy. In: Kangas, A., Kujala, J., Heikkinen, A., Lonnqvist, A., Laihonen, H., Bethwaite, J.(Eds.), Leading Change in a Complex World: Transdisciplinary Perspectives.Tampere University Press, Tampere, pp. 281–300.

15. Lazarevic, D., Brandao, M., 2020. The circular economy: A strategy to reconcile economic and environmental objectives? In: Lazarevic, D., Brandao, M., Finnveden, G. (Eds.), Handbook of the Circular Economy. Edward Elgar Publishing, Cheltenham, pp. 8–27.

16. European Commission, 2015, Closing the loop – An EU action plan for the circular economy. Retrieved from (http://eurlex.europa.eu/legal-content/EN/TXT/?qid=1453384154337&uri=CELEX:52015DC0614).

17. Johanson, J.E., Vakkuri, J., 2017. Governing Hybrid Organisations: Exploring Diversity of Institutional Life. Routledge,, London.

18. Brunner, P. H., & Rechberger, H., (2014), Waste to energy—key element for sustainable waste management. Waste Management, 37, 3-12.

19. Vergara, S. E., & Tchobanoglous, G., (2012), Municipal Solid Waste and the Environment: A Global Perspective.Environment and Resources, Vol. 37(37), 277-309.

20. Wilson, D. C., (2007), Development drivers for waste management. Waste Management & Research the Journal of the International Solid Wastes & Public Cleansing Association Iswa, Vol. 25(3), 198-207.

21. Amasuomo, E & Baird, J., (2016), 'The concept of waste and waste management', Journal of Management and Sustainability, Vol. 6, No. 4, pp. 88-96.

22. Basu, R., (2009), Solid Waste Management-A Model Study. Sies Journal of Management, 6, 20-24.

23. Singh, A., (2017), Developing a conceptual framework of waste management in the organizational context. Management of Environmental Quality: An International Journal.

24. Cordite-Rodríguez, M.; Mondéjar-Jiménez, J.A.; Meseguer-Santamaría, M.L.; Mondéjar-Jiménez, J.;Vargas-Vargas, M., (2010), Environmental behavior and selective waste management in Spanish housing. Environ. Eng.Manag. J., Vol.9, 1165–1171.

25. Ferreira, M.A.; Jabbour, C.J.C.; de Sousa Jabbour, A.B.L., (2017), Maturity levels of material cycles and waste management in a context of green supply chain management: An innovative framework and its application to Brazilian cases. J. Mater. Cycles Waste Manag, Vol.19, 516– 525.

26. Rana, R., Ganguly, R. and Gupta, A.K., (2015), "*An assessment of solid waste management system in Chandigarh City, India*", Electronic Journal of Geotechnical Engineering, Vol. 20, pp. 1547-1572.

27. UN-Habitat and UNESCAP (2015). "*The state of Asian and Pacific cities 2015, urban transformations shifting from quantity to quality [WWW document]. united nations hum. Settlements program*", United Nations Econ. Soc. Comm. Asia Pacific, available at:

www.unescap.org/sites/default/files/TheStateofAsianandPacificCities2015.pdf (accessed 26 December 2016).

28. Khandelwal, H., Dhar, H., Thalla, A.K. and Kumar, S. (2019), "*Application of life cycle assessment in municipal solid waste management: a worldwide critical review*", Journal of Cleaner Production, Vol. 209, pp. 630-654.

29. Das, S., Lee, S.H., Kumar, P., Kim, K.H., Lee, S.S. and Bhattacharya, S.S. (2019), "*Solid waste management: scope and the challenge of sustainability*", Journal of Cleaner Production, Vol. 228, pp. 658-678.

30. De Clercq, D., Wen, Z., Gottfried, O., Schmidt, F., and Fei, F. (2017), "*A review of global strategies promoting the conversion of food waste to bioenergy via anaerobic digestion*", Renewable and Sustainable Energy Reviews, Vol. 79, pp. 204-221.

31. Nyika, J.M., Onyari, E.K., Mishra, S. and Dinka, M.O (2019) Waste Management in South Africa. Doctorate Dissertation submitted in University of South Africa, South Africa.

32. Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. International journal of environmental research and public health, 16(6), 1060. https://doi.org/10.3390/ijerph16061060

33. Maisiri, W. (2016). A techno-economic evaluation of a waste-to-energy grate incineration power plant for a small South African city (MSc. Thesis). North West University, RSA

34. Tsheleza, V., Ndhleve, S., Kabiti, H., Musampa, C., & Nakin, M. (2019). Vulnerability of growing cities to solid waste related environmental hazards: The case of Mthatha. Jamba: Journal of Disaster Risk Studies, 11(1), 1–11. PMID:31205617

35. Muzenda, E. (2014). A Discussion on Waste Generation and Management Trends in South Africa. International Journal of Chemical. Environmental and Biological Sciences, 2(2), 105–113

36. UN (2021). Basel Convention. Retrieved from https://www.basel.int/TheConvention/Overview/BaselConvention/tabid/3371/Default.aspx

37. European Commission (2023) Waste prevention and management. European Commission publication. Retrieved March 25, 2023. From:

https://ec.europa.eu/environment/green-growth/waste-prevention-and-management/index_en.htm

38. Recycling Magazine (2022) EU: 4.8 tonnes of waste generated per inhabitant. Available at: https://www.recycling-magazine.com/2022/11/07/eu-4-8-tonnes-of-waste-generated-per-inhabitant/
39. Eurostat Database (2023) available at: https://ec.europa.eu/eurostat/data/database
40. EPA (2021). Waste Management. Retrieved from https://www.epa.gov/waste
41. Ferronato, N., & Torretta, V. (2019). Waste Mismanagement in Developing Countries: A Review of Global Issues. International journal of environmental research and public health, 16(6), 1060. https://doi.org/10.3390/ijerph16061060
42. Nyika, J., Dinka, M. (2023). Comparative Urban Waste Management in Developing Countries—Case Studies of Nairobi and Johannesburg Cities of Africa. In: Chatterjee, U., Bandyopadhyay, N., Setiawati, M.D., Sarkar, S. (eds) Urban Commons, Future Smart Cities and Sustainability. Springer Geography. Springer, Cham. https://doi.org/10.1007/978-3-031-24767-5_27
43. Department of Environment, Forestry and Fisheries (DEFF) (2023). Available at : https://www.dffe.gov.za/
44. EU Waste Framework Directive (1975). European Union. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31975L0442
45. Packaging and Packaging Waste Directive (1991). European Union. Retrieved from https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31994L0062:en:HTML
46. EU Waste Electrical and Electronic Equipment (WEEE) Directive (2003). European Union. Retrieved from https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32003L0108
47. EU Landfill Directive (1999/31/EC). European Union. Retrieved from https://eur-lex.europa.eu/eli/dir/1999/31/oj
48. EU End-of-Life Vehicles Directive(2000) European Union. Retrieved from https://environment.ec.europa.eu/topics/waste-and-recycling/end-life-vehicles_en
49. Circular Economy Action Plan (2015) European Union. Retrieved from https://ellenmacarthurfoundation.org/circular-examples/the-eus-circular-economy-action-plan
50. Abubakar, I. R., Maniruzzaman, K. M., Dano, U. L., AlShihri, F. S., AlShammari, M. S., Ahmed, S. M. S., Al-Gehlani, W. A. G., & Alrawaf, T. I. (2022).

Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South. International journal of environmental research and public health, 19(19), 12717. https://doi.org/10.3390/ijerph191912717

51. OECD (2021)A background report prepared for the 2021 G20 Presidency of Italy Towards a more resource-efficient and circular economy The role of the G20. Retrieved from https://www.oecd.org/environment/waste/OECD-G20-Towards-a-more-Resource-Efficient-and-Circular-Economy.pdf
52. World Bank (2023) Trends in Solid Waste Management. World bank publication. Retrieved March 22, 2023. from: https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html
53. Kofoworola O.F., (2007) Recovery and recycling practices in municipal solid waste management in Lagos, Nigeria. Waste Management 27:1139-1143.
54. Pope C, Ziebland S and Mays N.(2000) Analysing qualitative data. BMJ Clinical Research ·
55. King, N. (2004) 'Using templates in the thematic analysis of text' in Cassell, C. and Symon, G. (eds.) Essential guide to qualitative methods in organizational research. London: SAGE Publications Ltd.
56. Zamawe F. C. (2015). The Implication of Using NVivo Software in Qualitative Data Analysis: Evidence-Based Reflections. Malawi medical journal : the journal of Medical Association of Malawi, 27(1), 13–15. https://doi.org/10.4314/mmj.v27i1.4
57. Braun, V. and Clarke, V. (2012) 'Thematic analysis' in Cooper, H. et al. (eds.) APA handbooks in psychology. APA handbook of research methods in psychology, Vol. 2. Research designs: quantitative, qualitative, neuropsychological, and biological. Washington, DC: American Psychological Association, pp. 57–71.
58. Brooks, J. et al. (2015). 'The utility of template analysis in qualitative psychology research', *Qualitative Research in Psychology,* 12(2), pp. 202–222.