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entitled

Investigating the impact of ISO 14001 on waste minimisation within South Africa.

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Declaration

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I declare that:

1) The above research is my work; all used sources have been referenced thoroughly.
2) This research has not been submitted anywhere for examination.
3) This dissertation has been submitted to originality checking software and it falls under the accepted requirements for originality.

____________	19/12/2023
Signature	**Date**

Dedication

To myself for working hard and having sleepless nights. To Koko Mokgaetji Marakalla, thank you for raising me, and to my son, seeing you grow somehow gave me the courage to push harder.

Acknowledgments

Firstly, many thanks to the University of South Africa for the opportunity to study for this qualification. Secondly, I thank the National Research Foundation for the scholarship to further this journey. Thirdly, my supervisor, Dr Roelien du Plessis, thank you for your critiques, patience, words of encouragement, and professional advice. Fourthly, I appreciate all the participants; this study would be impossible without your collaboration. Lastly, and most importantly, I thank the almighty God and the Gods for spiritual guidance and strength throughout my research.

Abstract

Waste and pollution emanating from industrial activities is a primary global concern, prompting industries to seek solutions to reduce environmental impacts. Among other proposed environmental measures to reduce environmental degradation, the ISO 14001 standard was established for reducing industrial pollution and waste. The ISO 14001 environmental management system (EMS) is a voluntary management standard that assists companies in enhancing environmental performance (EP). An investigation was conducted to find measures that ISO 14001-certified companies put in place to minimise process waste and pollution, as well as hurdles they experience regarding waste minimisation and their motive to certify to the standard. Data were collected following the completion of questionnaires sent electronically and in person to people working closely on environmental issues, safety, and production processes from 32 companies across different industries in four selected provinces (Gauteng, Mpumalanga, North West, and Limpopo Province). The primary motive for companies to certify to the ISO 14001 standard was environmental concern, and they considered pollution prevention measures such as environmental awareness, green procurement policies, materials substitution, and process modification as being important to reduce environmental impacts. The companies practised sustainable waste management, i.e., source separation, onsite and offsite waste recycling, and waste shipping for reuse for another production process to circulate waste longer in the economy.

Keywords: ISO 14001; Waste minimisation; Waste management; Pollution prevention.

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List of Acronyms and Abbreviations

4Rs:	Reduce, Reuse, Recycle, and Restore
5S:	Sort, Set in Order, Shine, Standardise, and Sustain
CE:	Circular Economy
DEA:	Department of Environmental Affairs
DEFF:	Department of Environment, Fisheries and Forestry
DFFE:	Department of Forestry, Fisheries and Environment
EMS:	Environmental Management System
EP:	Environmental Performance
EU:	European Union
FSMS	Food Safety Management System
GDP:	Gross Domestic Product
ISO:	International Organisation for Standardisation
NEMA:	National Environmental Management Act
OHSMS:	Occupational, Health and Safety Management Systems
PDCA:	Plan-Do-Check-Act
QMS:	Quality Management Systems
SD:	Sustainable Development
UN:	United Nations

1. Chapter 1: Introduction

1.1. Introduction and background

Across the globe, industries are focusing on environmental issues (Wang & Zhao, 2020). Air, water, and land pollution from industrial operations and waste have negative impacts including environmental degradation (Kubanza & Simatele, 2019). That being the case, and due to global public environmental activism, industries are under strict pressure to check how their activities, products, or services affect the environment (Singh *et al*., 2015). For instance, automotive manufacturers require environmental compliance reports from their suppliers to retain their business (Wang & Zhao, 2020; Johnson, 2018). Globally, these measures compelled businesses to consider their performance to allow them to adopt the International Organisation of Standards (ISO) 14001 standard or Environmental Management System (EMS) (Boiral & Henry, 2012).

1.1.1. Waste crisis

Globally, waste management receives attention (Kubanza & Simatele, 2019). Due to the increase in the global population and rising living standards, waste volumes are increasing (Singh *et al*., 2015). The Department of Environmental Affairs (DEA, 2018) State of Waste Report, now called the Department of Forestry, Fisheries, and the Environment (DFFE) defines waste, both domestic and industrial, as anything that is no longer useful or needed and that is discarded. According to Kaza *et al*. (2018), over two billion tons of waste is discarded worldwide annually and if industries do not consider mitigation measures to minimise the waste crisis, this figure will increase by approximately 70% by 2050. Kubanza and Simatele (2019) reported an industrial waste crisis in developing countries emerges due to a shortage of waste treatment options and toxic waste disposal sites coupled with poor methods of handling waste, as well as illegal garbage dumping.

In 2017 in South Africa, approximately 55 000 000 tons of industrial, commercial, and municipal general waste was generated and only 10% was recycled (DEA, 2018; DFFE, 2020). In that year, the industrial and commercial sectors significantly contributed to waste accumulated in landfills, contributing to an estimated 3 550 505 tons of waste (DEFF, 2020). Most general waste streams - recycled or recovered -

were demolition and construction waste, organic waste, plastic, paper, glass, and metal (DEA, 2018). Moreover, only 0.2% of organic waste in South Africa was treated and converted to produce energy. In contrast, other types of waste that did not undergo recycling or treatment processes ended up in landfills, causing additional environmental stress (DEFF, 2020). Also, the DEA (2018) and DEFF (2020) highlighted that South Africa produced about 67 million tons of hazardous waste in 2017, and around 93% of that waste was deposited in hazardous landfills.

The South African waste management industry involves waste collection and landfilling, and the remaining few treatment options (i.e., incineration) to manage waste are costly compared to landfilling (DFFE, 2020). Moreover, South Africa needs more landfill space and has challenges operating and decommissioning landfills to comply with license conditions (Otto, 2020). According to Kubanza and Simatele (2019), the barriers faced by industries in developing countries, particularly in Africa, towards shifting from landfilling include a lack of recycling infrastructure and incentives to improve production processes; the growing population; production pressure from the commercial market to reduce production time so as to produce more products; and a general perception that exists among customers that a product that has a recycled and reused characteristic are of low quality compared to those manufactured from materials extracted directly from nature.

In comparison to other developing countries, South Africa has a higher rate of waste generation (Kubanza & Simatele, 2019). Local municipalities and major cities in South Africa have little or no legal land space left to issue new landfills, so much so that the Gauteng Province has not approved a new landfill facility in 24 years (Adeleke *et al*., 2021a). In addition, many landfill sites do not comply or conform to their regulatory obligations and gazetted norms and standards (Adeleke *et al*., 2021a), and existing landfill facilities in operation have almost filled and are reaching closure stage - the City of Tshwane had closed the Onderstepoort disposal site (Otto, 2020).

Waste management in African countries is a social, economic, and environmental problem and a country such as South Africa needs to put in place sustainable waste management measures to achieve the 2030 Agenda for sustainable development (SD) (DEFF, 2020). According to Kubanza and Simatele (2019), waste management problems in Africa surface due to, among other things, weak legislation and enforcement, low and inadequate budgets, inadequate skills, weak organisational structures, and corruption. Despite these pitfalls, these authors reported that some, though insufficient, social, and technological innovations have surfaced that turn waste into a secondary resource.

Dlamini *et al*. (2018) defined sustainable waste management as a measure undertaken in different sectors to minimise the quantity of refuse disposed of in dumpsites by avoiding, reusing, or recycling materials. In current linear consumption, industries generate waste before raw products can undergo manufacturing, while sustainable waste management looks at the entire lifecycle of a product to minimise the detrimental impacts associated with a product from design to the final production stage. Thus, sustainable waste management and waste minimisation rely on the waste management hierarchy system that suggests that waste generation should be avoided or reduced at the source (DEFF, 2020). When this does not happen, waste should be recycled or reclaimed, and lastly, if waste cannot undergo any of these processes, it should be safely disposed of or treated (DEFF, 2020). The principal aim of waste minimisation is to prioritise actions for the efficient utilisation of resources by positioning renewable and less wasteful practices at the top of the waste management pyramid (DEFF, 2020).

1.1.2. Environmental management systems

Environmental management dates to the 20th century (Kotzé, 2009), and the concept of EMS began in 1972 (ISO, 2015). The United Nations (UN) held a seminar on the Human Environment in Stockholm in 1972, where the United Nations Environment Programme was established, and the idea of an EMS began to take shape in the early 1990s (ISO, 2015). The main idea behind environmental management was to regulate the effects on the environment of human development, products, and services (Kotzé, 2009; ISO, 2015).

According to Singh *et al*. (2015), waste minimisation is among crucial indicators to measure the EP of businesses. Within this aspect, the adoption or certification of ISO 14001 EMS is a choice to drive the efforts of waste minimisation. The ISO 14001 standard is a voluntary EMS that is tailored to fit all types of industries and can assist corporates in designing robust and effective EMS to be more sustainable, such as facilitating the reduction of waste and aiding with compliance to legal regulations (BSI, 2015). The ISO (2015) stated that the ISO 14001 standard improves the operations of an organisation by helping it, among other things, to reduce and handle waste, make use of green procurement, improve the company image, increase environmental awareness of the employees, and increase profit. The concept of an EMS is founded on the Plan-Do-Check-Act (PDCA) system in enhancing all the parts of the corporation's environmental performance (EP) (BSI, 2015). The PDCA model emphasises that an organisation must establish internal environmental objectives, targets, and processes to meet environmental policy targets and continually improve its EP (BSI, 2015). The EMS does not stipulate a degree of EP (ISO, 2015) but entities establish their objectives and targets and measure performance considering those objectives and targets (BSI, 2015).

1.2. South African waste management policy and regulations

The DEA (2018) described various aspects of the Constitution of the Republic of South Africa in relation to legislation necessary to protect the environment. The Constitution of the Republic of South Africa is the country's foremost law. Chapter 2 of the Constitution is the first segment in South Africa that promotes the protection and safeguarding of the environment as a recognised human right. In additional, Section 24 enforces a Constitutional obligation on the government to safeguard the environment through a rational legislative framework and other actions. The Constitution advocates protecting the broad environment and public health allowing the present and future generations to flourish by introducing legislation that stipulates measures to avert pollution and ecological decline (DEA, 2018). Furthermore, the Constitution supports the conservation and sustainable consumption of raw materials while promoting improved economic and social development (DEFF, 2020).

After enacting and promulgating the Constitution, the National Environmental Management Act of 1998 (Act No. 107 of 1998) (NEMA) was introduced to enforce strict measures to regulate environmental activities. Under NEMA, specific environmental management acts were developed to regulate, among others, waste, air, and biodiversity, and the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008), also referred to in this study as the Waste Act, regulates waste management issues in South Africa (RSA, 2009).

According to the South African Waste Act (p. 2), "*the Waste Act was introduced to reform the law regulating waste management to protect health and the environment* *by providing reasonable measures for the prevention of pollution and ecological degradation and for securing ecologically sustainable development; to provide for institutional arrangements and planning matters; to provide for national norms and standards for regulating the management of waste by all spheres of government; to provide for specific waste management measures; to provide for the licensing and control of waste management activities; to provide for the remediation of contaminated land; to provide for the national waste information system; to provide for compliance and enforcement, and to provide for matters connected therewith*".

In South Africa, the objectives for sustainable environmental development are written in the Waste Act that require:

- Waste minimisation and management to be undertaken according to the waste management hierarchy.
- The safeguarding of the environment through implementing actions that minimise ecological degradation and extraction of natural resources through approaches such as cleaner production, cleaner technologies, or green manufacturing (Dlamini *et al*., 2018).

The Waste Act has evolved and is supported by the National Environmental Management: Waste Amendment Act, 2014 (Act No. 26 of 2014) and the National Environmental Management Laws Amendment Act, 2014 (Act No. 25 of 2014) (DEFF, 2020). Within the Waste Act, some industries are mandated, and some can voluntarily opt to formulate industry waste management plans that comply with its contents as outlined in Chapter 4, Part 7 of the Waste Act. The contents of industry waste management plans include:

- Industry initiatives to prevent pollution.
- Waste management measures by practising separation at the source, reusing, recycling, and recovering waste materials.
- Programs to minimise the generation and disposal of waste.
- Actions to manage waste.
- Opportunities to move towards minimisation of waste generation by changing product innovation, product processes, or packaging (DEA, 2018).

South Africa has various environmental legislation and regulations to control the operations of organisations. Therefore, this collective legislation framework ensures that companies carry out their activities sustainably to protect human health and the environment (Chauke *et al*., 2017). Although the waste management hierarchy was written in the waste management policy (Godfrey & Oelofse, 2017), waste handling or practice has not been practised inline or according to the waste management hierarchy approach; it is only used in the promulgation of the Waste Act and completion of the National Waste Management Strategy. The National Waste Management Strategy was enacted in 2011 to achieve the objectives of the Waste Act and to tackle challenges involving pollution prevention and waste management in South Africa. It was revised in 2020 to reflect achievements, pitfalls, and experiences from implementing the 2011 National Waste Management Strategy (DEFF, 2020).

Furthermore, the National Waste Management Strategy 2020 version has the circular economy (CE) model at its core (DEFF, 2020). The CE aims to minimise negative impacts on organisations by reusing and recycling waste to reduce the need to harvest natural materials from natural resources while also disposing of waste (DFFE, 2020). Furthermore, the CE reflects an improvement in product design, manufacturing, packaging, and utilisation of industrial symbiosis, by preventing and minimising waste in manufacturing processes by diverting waste from one manufacturing process to serve as raw material for another manufacturing process (DEFF, 2020).

The NEMA regulates environmental activities in South Africa, and all organisations must adhere to its requirements (DFFE, 2020). Chauke *et al*. (2017) warned that the DFFE does not apply adequate measures to track industries' environmental activities and, so it is the responsibility of industries to act responsibly and comply with environmental management regulations and conduct their operations towards the objectives of the National Waste Management Strategy.

1.3. Motivation of the study

Publications in India, Sweden, and Kenya (Singh *et al*., 2015; Johnstone & Hallberg, 2020; Mungai *et al*., 2020) have studied the effectiveness of ISO 14001 EMS considering EP and found that the standard yielded positive outcomes in industries. In South Africa, authors such as Dwarika (2015), Johnson (2018), and Szoke (2021) also agreed as to the positive outcomes of the standard, reporting that ISO 14001 EMS has resulted in financial and environmental benefits. Matela (2006) and Chauke *et al*. (2017) noted that many companies in South Africa decided to certify to ISO 14001 EMS to gain business advantage as a customer requirement, whereas the environment was a secondary consideration. Johnstone and Hallberg (2020) wrote that the performance and success of ISO 14001 EMS in businesses depends on the motives that prompted the businesses to obtain certification.

Companies that hold ISO 14001 EMS certification are audited by external auditing bodies to check their compliance and conformance with the legal requirements and ISO 14001 EMS requirements. Such environmental auditing is mandatory in the ISO 14001 standard (ISO, 2015), but not within the South African legislation (DEAT, 2004). South African legislation requires organisations to be accountable for waste management and comply with legislation or regulations (Chauke *et al*., 2017). These authors further stated that the Waste Act requires all industries to adopt initiatives towards sustainable waste management, including pollution prevention, waste minimisation, and safe disposal methods. Regardless of the promulgation of legislation to regulate waste activities, landfill disposal remains the method for many industries to manage their increased waste, and environmental pollution (Godfrey & Oelofse, 2017; DEA, 2018). Additionally, in the absence of aggressive policies and plans to avoid waste generation, the volume of waste will further increase into the future (DEFF, 2020).

The ISO 14001 standard helped industries to improve their waste management and compliance with legal and environmental requirements (Singh *et al*., 2015; Johnson, 2018; Mungai *et al*., 2020). Pinto *et al*. (2017) and Waxin *et al*. (2020) advocated that ISO 14001 EMS led to improved operational, managerial, and competitive advantage. In contrast, other studies contended that ISO 14001 EMS does not aid companies in enhancing EP (Boiral & Henry, 2012; Zobel, 2013; Zobel, 2015). Consequently, Johnstone and Hallberg (2020) called for further research to establish the relationship between the adoption and implementation of ISO 14001 EMS and EP.

In South Africa, there is a need for more studies to investigating the extent to which ISO 14001 EMS-certified companies put measures in place to prevent pollution and minimise waste. Furthermore, more research is needed to determine the relationship between the motive behind acquiring the ISO 14001 EMS certification and EP with a focus on waste management. Hence, this study sought to fill those gaps, provide recommendations for waste minimisation in industries, and add to existing studies about the performance of the ISO 14001 standards, especially as these relate to developing countries.

1.4. Problem statement

In correspondence with the motivation of the study, there is a shortage of empirical research that is directed to ISO 14001 EMS-certified manufacturers and service companies that focus on the extent to which they put measures in practice to minimise and manage waste or pollution in South Africa.

1.5. Aim and objectives

1.5.1. Aim

The aim of this study was to research the impact of ISO 14001 EMS on waste minimisation in South African manufacturing and services companies.

1.5.2. Research objectives

In addressing waste minimisation measures in the manufacturing and service sectors, the following objectives were developed:
Study objective 1: To determine the reasons for ISO 14001 certification in the manufacturing and service sectors.

Study objective 2: To identify pollution prevention measures as a waste minimisation approach in the ISO 14001-certified manufacturing and service sectors.

Study objective 3: To determine waste management measures towards waste minimisation to the final disposal of waste in the ISO 14001-certified manufacturing and service sectors.

Study objective 4: To investigate barriers to implementing waste minimisation measures in the ISO 14001-certified manufacturing and service sectors.

1.6. Methodology

To obtain a clear picture of phenomena, it is essential to employ more than one approach to appreciate their meaning (Kumar, 2011). This study employed a mixed method research approach since this provides a richer meaning of a phenomenon (Creswell, 2014) and increases data reliability and validity (Kumar, 2011).

The study used a questionnaire which was distributed electronically and in person to gather data. The questions included open and close-ended questions. The researcher's epistemology, existing literature (i.e., motivations for ISO 14001 EMS intake, its benefits and hurdles, and integration with other management systems), and correlational statistics (Spearman’s rho and Kendall’s tau-b) were used to analyse and reach study conclusions.

1.7. Significant of the study

This research adds to the literature on industrial waste and pollution reduction in South Africa as it provides insight into the production processes of industries that have ISO 14001 EMS certification. Literature on ISO 14001 EMS and environmental protection in South Africa is scant, and the recent literature has focused on economic and social performance, so that EP still needs to be adequately studied; hence, it was necessary for a study that focuses on the aspect of EP involving industrial waste.

1.8. Chapters outline

This investigation comprised of the following chapters:

Chapter 1: Introduction – This provides insights into the significant concepts that dictate waste generation in South Africa and the ISO 14001 standard. Furthermore, this chapter outlined the motivation, problem statement, study aim and objectives, and significance of the study.

Chapter 2: Literature review – This section provides an overview of the published papers and articles associated with the study’s topic, such as motivations for the ISO 14001 standard certification, other standards that can blend with the ISO 14001 standard, as well as the motivations and hurdles associated with ISO 14001 EMS.

Chapter 3: Research methodology - This chapter describes the comprehensive approach and layout of the study design, methods, and instruments used to assemble data to answer the study objectives. It also accounts for the validity and reliability of the employed study methods.

Chapter 4: Results of the survey – Data collected from responses to a survey questionnaire are presented in graph and table formats for practical interpretation and discussion.

Chapter 5: Discussion of the survey results – This chapter provides an in-depth discussion of the results of the study presented in Chapter 4 relative to published literature.

Chapter 6: Conclusions and recommendations – This section will look at interpretations and discussions of the results considering the study objectives and will also provide recommendations from the study. Moreover, it will look for gaps for further research that may benefit environmental governing organisations, manufacturers, and service companies.

1.9. Conclusion

The problems associated with waste is a growing global concern, and in Africa, are exacerbated due to the increasing population and lack of waste management or treatment facilities. South Africa has comprehensive legislation to mitigate this problem, but growing volumes of waste have prompted industries to consider the impact of industrial waste on the environmental. This, particularly because waste accumulation in landfills is increasing and negatively affecting the environment.

Fortunately, ISO 14001 EMS, is positively associated with improved environmental protection worldwide but studies in South Africa must be directed at ISO 14001 EMS, industrial waste, and EP. This study has contributed to filling that gap.

This chapter provided a background to the crisis associated with waste, South African environmental legislation, the motivation of the research, a problem statement, the study aims and objectives and methods used, the significance of the research, and an outline of the dissertation chapters.

2. Chapter 2: Literature Review

2.1. Introduction

This chapter examines international and local published reports and journal articles relevant to the aim of the study. Internationally, especially in developed countries, studies have described the advantages of the International Organisation of Standards (ISO) 14001 standard or Environmental Management System (EMS). However, few local studies have researched the influence of ISO 14001 EMS across different sectors and the recognition of this knowledge gap was the motive behind this study. Thus, it was important to fill that gap by conducting a study that could add knowledge on the influence of the ISO 14001 standard in South Africa.

Furthermore, key terms, such as the concept of sustainability, sustainable development (SD), sustainable waste management, the circular economy (CE), lean manufacturing, scenarios on industrial waste minimisation, green manufacturing, and cleaner production will be discussed. In addition, the development of ISO 14001 EMS, its certification process, and requirements from organisations will be discussed. Relevant papers on ISO 14001 EMS and environmental performance (EP), performance indicators and a comprehensive overview of the motives for adopting ISO 14001 EMS will be reviewed. In addition, this chapter will describe literature on the benefits and pitfalls of ISO 14001 EMS in companies, as well as literature that criticises the so-called advantages of ISO 14001 EMS considering EP in certified organisations. Lastly, this chapter discusses literature on integrating ISO 14001 EMS with other management standards and the benefits derived from the integration in industries.

2.2. Definition of key terms

According to Kumar (2011), it is necessary to establish a mutual understanding of key terms used in a study.

Waste

The South African National Environmental Management: Waste Amendment Act, 2014 (Act No. 26 of 2014) defined waste as anything unpleasant, trashed, discarded, or disposed of or required to be trashed or disposed of by the holder, despite its characteristics or possibilities of being reused, recycled, or recovered. This refers to all waste mentioned in Schedule 3 in the South Africa National Environmental

Management: The Waste Act 2008 (No. 59 of 2008) (RSA, 2014). Within this dissertation, this latter act is referred to as the Waste Act.

Hazardous waste

he South African National Environmental Management: Waste Amendment Act, 2014 (Act No. 26 of 2014) defined hazardous waste as any waste that has inorganic or organic substances that could, due to the inherent physical, chemical, or toxicological qualities of that waste, harm the ecosystem; this includes harmful materials, objects or substances contained in residue stockpiles, residue deposits, and business waste (RSA, 2014).

General waste

The South African National Environmental Management: Waste Amendment Act, 2014 (Act No. 26 of 2014) defined general waste as waste that does not have an instant problem on the environment and well-being of the people and other species; this includes business, domestic, inert waste and any other waste declared non-toxic waste under Section 69 of the Waste Act (RSA, 2014).

Waste minimisation

The DFFE (2020) defines waste minimisation as implementing activities, per the waste management hierarchy, to reduce, reuse, and recycle materials to minimise waste disposed of in landfills. It is often used interchangeably with pollution prevention, green manufacturing, and source reduction (Singh *et al*., 2015).

Waste management

The DEA (2018) and DEFF (2020) define waste management as managing waste from its source to its final disposal, including collection, conveying, treatment, and disposal of waste in compliance with environmental-related laws.

Waste reuse

Waste reuse is defined as a method by which materials are used again for the same purpose without altering their composition (DEA, 2018).

Waste recycling

The DEA (2018) defines waste recycling as converting waste materials into new objects.

Waste disposal

Waste disposal is defined as a method of discarding waste that is no longer useful (DEA, 2018).

Wastewater treatment

Steyn *et al*. (2021) defined wastewater treatment as a process that treats wastewater to remove excessive pollutants before discharging it.

Wastewater recycling

Steyn *et al*. (2021) defined wastewater recycling as a process that treats industrial wastewater into water that can be reused within the industrial processes.

Environmental management systems

Kotzé (2009) defined EMSs as systematic processes and procedures companies use to effectively plan and manage environmental activities to enhance their overall EP.

Environmental performance

The ISO (2015) defines EP as a structured plan to evaluate organisations' environmental policies on waste, emissions, wastewater, and energy.

Circular economy

The CE is the inverse process of the current linear economy, where waste is generated before products are manufactured (DEFF, 2020). The CE is a sustainable approach that aims to circulate materials in the economy as much as is feasible in a closed loop by avoiding, reusing, and recycling materials to reduce waste accumulation and disposal (DEFF, 2020). Thus, raw materials are utilised to their maximum, reducing the need to extract new materials, and increasing the life cycle of materials (DEFF, 2020).

Pollution prevention

Pinto *et al*. (2017) defined pollution prevention as any measure that is placed in action to avoid, eliminate, and reduce pollution at its source. Along the waste management hierarchy, pollution prevention can be regarded as source reduction, and it is preferred to recycling and offers cost-effective benefits (De Oliveira *et al*., 2017).

Sustainable development

The UN (2015) defined SD as undertaking economic develop without depleting natural resources. It is about finding a balance between economic development, the environment, and the population, allowing them to sustain their necessities without impeding the next generation meeting their requirements (UN, 2015).

Cleaner production

The UN (2015) defined cleaner production as micro-scale and company-specific approaches to manufacturing products with a lower environmental impact. It aims to reduce waste generation and disposal, emissions and increase product output (UN, 2015).

Integrated management systems

Hernandez-Vivanco and Bernando (2022) defined an integrated management system (IMS) as a single structure established to oversee various facets of an organisation on the environment, safety and health, and quality of products and services.

2.3. The concept of sustainability

In 1980, the Swiss organisation, the International Union for Conservation of Nature, published a World Conservation Strategy report that urged international organisations and governments to conserve natural resources (IUCN, 1980). The report underpinned the significance of alleviating poverty among societies as a moral imperative and safeguarding the environment (IUCN, 1980). Additionally, the report emphasised the significance of sustainability, stating that the current generation did not receive the Earth from their forefathers or parents; they borrowed it from their offspring (IUCN, 1980). This statement means that people must protect natural resources now so future generations can sustainably flourish from them.

In 1987, the Brundtland Commission published a report named *Our Common Future* to address interconnected societal and environmental issues that were a danger to the then people and future generations (UN, 1987). The Brundtland report (1987) stated that people could make developments sustainable to meet the needs of their generation and allow coming generations to meet theirs. The report further stated that governments, international organisations, and people should find new ways to establish technologies and social responsibilities to improve activities involving the environment and give rise to a new model of economic growth (UN, 1987).

After the Brundtland Report sparked a wave of high-level interest in sustainability, in 1992, the United Nations (UN) held a two-week summit in Rio de Janeiro to develop sustainability goals (UN, 1992). The significance of the 1992 Earth Summit, as it was also known, can be seen in the number of participants - with 172 countries represented and 108 heads of state present, it is still regarded as the most extraordinary gathering of political leaders ever (UN, 1992). The UN drafted Agenda 21, thereby establishing discourse, controversy, spectacle, and a foundation for SD. The document further outlined various actions and objectives such as maintaining momentum, monitoring development, and noting new issues that nations must implement to meet sustainability goals (UN, 1992). The President's Council on Sustainable Development, established in 1996 in the United States (Olson, 1996), and the Sustainable Development Strategy enacted by the European Union in 2001 (EU, 2001) are two examples of how nations and regions have responded with their own goals and strategies regarding the environment.

The UN remained in charge of the sustainability issue, calling important meetings for reviewing, refining, and updating sustainable goals. For instance, in 2002, the World Summit on Sustainable Development was held in Johannesburg, South Africa, (UN, 2002), and the Rio+20 summit was held in 2012 in Rio de Janeiro, Brazil (UN, 2012). The result of these global discussions over many years was the release of the UN sustainable development goals (SDGs) in 2015 (UN, 2015). SD was broken down into 17 goals that should be met by 2030. These are illustrated in Figure 2.1

Figure 2.1: Sustainable development goals (source: UN, 2015)

According to the report by the UN (2015), governments, organisations and businesses must establish measures to ensure people receive safe water and decent sanitation, achievable by, for example, enhancing water quality. However, improving water quality cannot be viewed as a government responsibility alone. Industries must also monitor their activities and invest in innovations that will enhance their industrial activities while also reducing environmental impacts (UN, 2015). Furthermore, researchers, industries, policymakers, and consumers should shift towards sustainable production and consumption to reduce waste and enhance resource efficiency (UN, 2015). According to this report, this can be achieved by adapting to cleaner production technologies to, for instance, reduce waste, greenhouse pollution and the extraction of natural resources.

2.3.1. Sustainable waste management

sustainable waste management seeks to extend the valuable lifecycle of materials and minimise the volume of waste dumped in landfills (Singh *et al*., 2015). This system has feedback loops, is process-driven and adaptable, and diverts trash from incineration or disposal (Godfrey & Oelofse, 2017). However, according to Cheah *et al*. (2022), waste is generated in our present linear economy even before initiating the manufacturing process. These authors suggested, therefore, that a more holistic approach to sustainable waste management must focus on the whole lifecycle of a product to lessen the adverse social, environmental, and economic effects of 21stcentury consumption. According to Godfrey and Oelofse (2017), the CE revolves around sustainable waste management as it is a sustainable approach for economic growth that challenges the take-make-waste paradigm and tries to detach economic enhancement from extracting limited resources. Singh *et al*. (2015) and Godfrey and Oelofse (2017) stated that by keeping resources (materials and energy) circulating in the economy for a prolonged period and detaching economic development from resource usage, the CE model, depicted in Figure 2.2, seeks to reduce waste and resource use. This idea was developed in the late 1970s and was influenced by several disciplines, including industrial ecology, regenerative design, and cradle-to-cradle that entails production of goods and services that can stay longer in the economy (Singh *et al*., 2015).

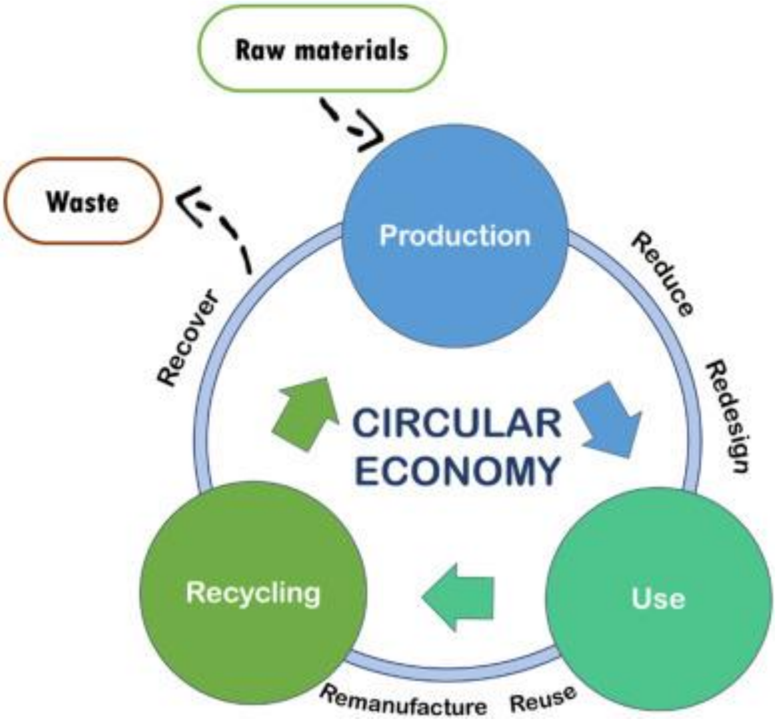

Figure 2.2: Model of circular economy (source: Cheah *et al*., 2022)

Singh *et al*. (2015) and Godfrey and Oelofse (2017) went on to state that extracting and processing natural materials and manufacturing capital goods generates waste. Therefore, the CE was established to manifest the significance of sustainable waste management to conserve the economic value of materials, by recovering and reintroducing them into the CE and thereby keeping the volumes of inevitable waste accumulation below the assimilative capacity of the natural environment (Kubanza & Simatele, 2019).

sustainable waste management provides more instant solutions to problems caused by linear consumption and waste generation (Cheah *et al*., 2022). This suggests that waste must be avoided and reused at a source; if not, it must undergo a recycling process, and if it cannot undergo all these processes, it must be recovered. In contrast, waste that cannot undergo reuse, recycling, and recovery must be safely disposed of (see Figure 2.3, which depicts the waste management hierarchy) (DEA, 2018).

Figure 2.3: Waste management hierarchy (adapted from DEA, 2018).

2.3.2. Sustainable waste management processes overview

Pinto *et al*. (2017) stated that waste avoidance could be considered as pollution prevention as it aims to minimise or stop waste production while preventing a transfer of risks from one medium to another. Therefore, this is a proactive approach to sustainably minimise waste and pollution (Pinto *et al*., 2017) and the first preferred approach along the waste management hierarchy (DEA, 2018). In addition, De Oliveira *et al*. (2017) suggested that pollution prevention measures reduce the use of materials associated with pollution by:

- Improving housekeeping.
- Improving operation and maintenance procedures.
- Substituting hazardous material with less polluting material or chemicals.
- Innovating processes.

- Innovating products through redesign and lengthening the life cycle of materials, processes, and products through reusing and recycling.
- Enhancing process and quality control by increasing the number of audits and checkpoints. For instance, introducing automated continuous monitoring devices will assist in identifying production issues before they become serious.

The DEA (2018) stated that waste if waste cannot be avoided, it must be reused by using it again for the same purpose without modifying its composition which has a positive implication towards sustainable waste management. In this regard, Pinto *et al*. (2017) suggested that waste could be reduced by:

- Resource optimisation: Improving the raw materials utilised in production is required to lower the amount of waste that organisations produce.
- Reusing scrap metal: This is a proven technique to prevent scrap from ending up in landfills, as waste is included in the early phases of manufacturing.
- Transfer waste materials from one process to be inputs in another production process.

The DEA (2018) reported if waste cannot be avoided and reused it must be recycled to reduce pollution and disposal. Oliveira *et al*. (2017) defined recycling as recovering used or abandoned materials to produce new goods. Regarding the environment and sustainable waste management, the recycling process offers the following benefits:

- Reduce trash that is landfilled or incinerated.
- Conserving natural resources and energy (DEA, 2018).

2.3.3. South African waste management problems and progress so far

According to De Oliveira *et al*. (2017), the CE and SD are connected and aimed at supporting conservation of the environment and protecting human health. In this regard, Singh *et al*. (2015) stated that environmental pollution indicates inefficient utilisation of resources and that improving production processes could provide opportunities to conserve the environment and enhance economic growth. These authors, as well as Palange and Dhatrak (2021) and Kumar *et al*. (2022), reported that industrial sustainability depends on innovations and stringent environmental regulations.

Kitila (2015) and Polasi *et al*. (2020) suggested that not all waste materials are recyclable, and such materials may end up being disposed of in landfills because there is no recycling technology. Adeleke *et al*. (2021b) investigated waste-to-energy challenges in South Africa using a survey study. They found that low landfill tax rates and cheap coal resources were the main barriers to harnessing energy from waste. Similar results were found by other developing countries in Africa. For example, Kitila (2015) collected data in 20 Ethiopian education facilities and determined that lack of legislation, recycling facilities, and environmental awareness were factors that impeded sustainable waste management. Polasi *et al*. (2020) investigated challenges to waste minimisation and management in South African municipalities and found that the challenges included a lack of a recycling culture, a shortage of skilled personnel, illegal dumpsites, and poor legislative enforcement.

Although South African waste disposal remains surging, there has been an improvement in waste that is recycled, including plastics, paper, scrap metal, and glass cullet (DEA, 2018). In addition, most recycled waste is shipped to other countries or imported into the country so that 137 490 tonnes of general waste (glass, paper, scrap metal, and plastic) were imported - sadly, this waste only accounted for about 1% of the total waste generated in 2017. To illustrate, in 2017, the following tonnes of materials were imported into South Africa: 39 928 of glass, 58 548 of paper, 6 998 of plastic, and 27 976 of scrap metals (DEA, 2018). On the other hand, South Africa exported the following tonnes of wastes: 258 557 of general waste, 129 374 of paper, 34 795 of plastic, and 68 192 tonnes of metal waste.

DEA (2018) showed that 38.3% (20.7 Mt) of general waste was recycled in 2017. That is, 45.7% of organic waste, 19.4% of construction and demolition waste, 14.6% of metals, 9.4% of glass, 6.2% of paper, and 4.7% of plastic. The South African mainstream recycling involves recycling plastic, paper, glass, and metal (Godfrey & Oelofse, 2017).

2.3.4. The concept of cleaner production

In the 1970s, industries started to be concerned about how their actions impacted the environment; this called for reducing and treating pollutants before releasing them into the environment (Van Berkel, 2002). From 1972 to 1986, the cost of evaluating compliance with strict legislation requirements increased, and in the mid-1970s, the concept of cleaner production emerged with its focus on preventing pollution rather than treatment of pollution (Van Berkel, 2002).

In 1992, to response to environmental degradation, the UN held the Rio Conference which emphasised cleaner production, by proposing continuous measures to prevent pollution caused by industrial processes, products, and services (UN, 1992). According to Hens *et al*. (2018), cleaner production strategies are microeconomic because they primarily focus on business processes, environmental sustainability, and maximising waste minimisation, reuse, and recycling in companies.

In South Africa, cleaner production is supported by the National Cleaner Production Centre of South Africa, endorsed by the Council for Scientific and Industrial Research but primarily by the Department of Trade, Industry and Competition (NCPC-SA, 2022). The National Cleaner Production Centre of South Africa was established as a program to assist in directing companies to reduce the cost of manufacturing products by reducing raw materials intake, waste, energy, water, and air pollution (NCPC-SA, 2022). In addition, the National Cleaner Production Centre of South Africa assists industries in implementing resource efficiency and cleaner production by raising awareness, providing skills and technical knowledge to transit industries to a green economy (NCPC-SA, 2022).

De Oliveira *et al*. (2017) reported that cleaner production features (i) maximising material use through source reduction and internal recycling and (ii) material reuse through external recycling. Bag *et al.* (2022) further posited that green supply chain management practices can be used as a cleaner production tool to lessen waste generation and disposal. According to Epoh and Mafini (2018), green supply chain management entails selecting, procuring, and manufacturing products with fewer environmental impacts. The primary aim of green supply chain management is to prevent and reduce hazardous substances, air emissions, energy usage, and solid waste produced by traditional supply chain activities. Bag *et al*. (2022) suggested that green supply chain management can be achieved by:

- Green procurement, which looks at a sustainable purchasing of materials from suppliers who are environmentally considerate, such as those who follow ISO 14001 EMS and ISO 9001 Quality Management System (QMS) guidelines.
- Eco-design, which is the adoption of cleaner technologies that minimise emissions of pollutants from production processes and whose products are harmless to the environment and ecosystem. Eco-design supports the

innovative 4Rs (reduce, reuse, recycle, and recover) to lessen impacts from industrial activities.

- Reverse logistics, which is a sustainable approach that manufacturers use to collect materials from customers for recycling, remanufacturing, or safe disposal.
- Collaboration and information-sharing to plan and execute measures to reduce pollution and process waste.

2.3.5. Lean manufacturing

Concern for social issues and the environment has also prompted manufacturers to adopt lean manufacturing or green manufacturing approaches (Kumar *et al*., 2022). These authors reviewed the lean manufacturing concept as follows:

- It prioritises accountability for protecting the environment. The main principle of lean manufacturing is to minimise and remove process activities that do not add value, and which generate waste.
- Lean manufacturing processes differ from each other but have the same principle: minimise waste from unnecessary processes.
- The lean manufacturing process has eight waste types: waiting, inventory, defects, overproduction, non-utilised talent, motion, transportation, and extra-processing.

Hens *et al*. (2018) wrote that lean manufacturing is flexible, and one size does not fit all so various processes can be undertaken as part of lean manufacturing. For instance, green manufacturing can be initiated to deal with toxic waste, overuse of water, water pollution, promoting separation at a source, reuse of materials, and recycling of waste.

According to Kumar *et al*. (2022), green manufacturing intends to answer the following questions: *Can a hazard be eliminated? Are there any other options? Can it be modified to lessen its effects? Can it be quarantined to prevent contact with people or the environment? Can it be avoided through engineering? Can management set rules or norms that must be strictly followed?* and, *can staff be provided with personal protective equipment?*

The ISO 14001 EMS, on the hand, is structured to make industries identify their environmental aspects and impacts (ISO, 2015). For example, regarding waste, ISO

14001 EMS wants companies to implement measures (green manufacturing, cleaner production, and pollution prevention to ensure waste management moves up the waste management hierarchy. Therefore, ISO 14001 EMS supports a CE, sustainable waste management, green manufacturing, cleaner production, lean manufacturing, and pollution prevention. In another sense, the present study evaluated how ISO 14001-certified companies put into effect measures such as sustainable waste management, green manufacturing, cleaner production, and pollution prevention to reduce environmental impacts.

2.3.6. Industrial waste minimisation efforts scenarios

Shahriar *et al*. (2022) investigated how lean manufacturing and 5S (sort, set in order, shine, standardise, and sustain) can reduce plastic waste created in waiting and motion processes in a single manufacturing company in Bangladesh. The authors stated that waste created in waiting and motion processes was associated with prolonging and slowing manufacturing time. Moreover, the manufacturing process of plastic bags included blowing, printing, and sealing. Their study was process-based in which they obtained data by evaluating a single company's manufacturing process. Therefore, they wanted to establish processes in the manufacturing process that do not add value by removing waiting time and different motions. Their results showed that after the company employed 5S, the overall operation was minimised by 8% and 18% in the blowing and printing processes, respectively. In addition, the study by Palange and Dhatrak (2021) demonstrated that companies were flexible in employing innovative methods to ensure they were environmentally responsible. The study conducted by these authors in eight Indian firms used questionnaires and interviews to gather data as to how lean manufacturing could optimise manufacturing processes. The results of the study by Shahriar *et al*. (2022) agreed with those reported by Palange and Dhatrak (2021) in that they found that implementing lean manufacturing reduced cycle or operation time and removed activities within the manufacturing process that did not add value.

The study by Dhiman & Sidhu (2020) was undertaken in a single Indian steel manufacturer and engineering company to evaluate the influence of lean manufacturing, the Internet of Things and Industry 4.0 using sensors to gather data. They found that waste handling was improved particularly with the use of Artificial Intelligence programs aided by sensing levels of scrap waste disposed into the bins and by efficiently transferring this information to the primary disposal system. According to the authors, this automated method of sorting waste has replaced the traditional method of separating waste at a source. Moreover, they stated that automated methods of sorting waste differentiated sheet and tin foil. Lastly, they concluded that waste collection was significantly minimised. Similarly, Al-Kindi and Al-Ghabban (2020) surveyed a single steel company in Iraq and found that the innovative use of 4Rs (reduce, reuse, recycle, and restore) reduced the volumes of metal wastage by 51%.

Braccini and Margherira (2019) issued a semi-structured interview to top management and used observations to investigate the effect of Industry 4.0 on environmental as well as finance performance in an Italian sanitary ceramic manufacturing company. Industry 4.0 was adopted to modify and improve the production process. On the environmental side, their results demonstrated that water, energy, and raw materials were significantly reduced. In addition, excessive waste materials were reused in their production line by bringing autonomous trucks and robots to perfect the production process.

A survey study across 138 Omani manufacturing companies was undertaken by Al-Sheyadi *et al.* (2019) to determine an association between green supply chain management and EP. A structural modelling equation demonstrated a strong link between these two variables. In addition, they found that factors such as company age, size, and industrial pollution intensity have little to no effect on EP. Similarly, a survey study conducted by Mumtaz *et al.* (2018) used factor analysis and linear regression to investigate the impact of green supply chain management practices (internal and external practices, investment recovery, and eco-design) across 70 firms in Pakistan as to the performance of enterprises, measuring operating costs, environmental pollution, and organizational flexibility. They found that green supply chain management procedures aided businesses in cutting down on operating expenses and pollutants. As with Al-Sheyadi *et al.* (2019), the present study sought to test the impact of company size on EP in South Africa.

In South Africa, Maama *et al*. (2021) found a positive relationship between cleaner production and corporate performance, i.e., environmental, and economic performance, from 323 respondents working in the sugar industry. In addition, Thekkoote (2022) gathered data using questionnaires from 210 small and medium-sized enterprise manufacturing firms and found that lean manufacturing influenced green manufacturing and sustainability. Likewise, the quantitative study involving 150 online respondents that was conducted by Bag *et al*. (2020) used partial least square-based structural equation modelling and found that Industry 4.0 can influence intelligent logistic rather than green manufacturing and dynamic remanufacturing, which had a positive effect on sustainable logistic. Bag *et al*. (2022) went on to investigate the impact of eco-innovation on green supply chain management, CE, and corporate performance in small and medium-sized enterprises. They collected data using a survey questionnaire from 240 people working in manufacturing companies and found that mimetic, normative, and coercive pressures positively associated with eco-innovation. They further found that green supply chain management had a positive association with eco-innovation and CE capabilities.

2.3.7. Conclusion

The abovementioned research scenarios depicted various tools or methods employed in different sectors to find innovative ways to reduce environmental impacts. The ISO 14001 standard requires organisations to embark on innovative methods to find what works best for them to manage aspects to conserve the environment. In addition, ISO 14001 EMS is based on a process and, hence, organisations have capacity within the standard to employ other tools to protect the environment. These tools include Artificial Intelligence, Internet of Things, Industry 4.0, and green manufacturing and have the same aim as ISO 14001 EMS to protect the natural environment. Therefore, the present study sought to investigate processes that South African companies put in place to reduce their waste and pollution.

2.4. ISO 14001

The aim of ISO 14001 EMS is to offer enterprises a structured framework to establish measures to safeguard the environment while also implementing ways of finding a balance between economy, society, and the environment (ISO, 2015). Additionally, ISO 14001 EMS provides organisations with specific requirements to achieve their objectives by assisting organisations in establishing measures to contribute to SD, CE, and sustainable waste management by:

- Reducing the potential negative impact of environmental conditions.
- Aiding in carrying out compliance requirements.

- Improving EP.
- Using the life cycle strategy to control or influence how the organisation's goods and services are manufactured, distributed, consumed, and disposed of to avoid environmental impacts being unintentionally transferred to another stage of the life cycle.
- Assisting companies to harness environmental and economic benefits by using less hazardous materials.
- Providing relevant parties with environmental information.

ISO is the world's most prominent institution of standards as it intends to make developments, manufacturing processes, and supply of services and products more effective and environmentally safe and facilitate trade among countries (ISO, 2015). Pinto *et al*. (2017) added that it intends to facilitate collaboration and exchange of ideas regarding improving process technologies internationally and locally. The ISO institution includes 151 nations with a single established member in each nation and has the Central Secretariat in Geneva, Switzerland as the system coordinator (ISO, 2015).

After the success of ISO 9000 QMS, established in 1987 to improve the quality of services and products, the ISO contemplated the need for global environmental management standards (Irivier, 2004). Thereafter, in 1991, the Strategic Advisory Group on the Environment was founded to promote the establishment of EMSs in line with QMSs to improve environmental operations, EP, and international trade (Irivier, 2004). The ISO 14000 is a family of standards established in response to global environmental concerns created from the General Agreement on Tariffs and Trade conferences at the Rio Summit in 1992 (ISO, 2004). The General Agreement on Tariffs and Trade emphasised the significance of minimising non-tariff hindrances to trading (Irivier, 2004) whereas the Rio Summit emphasised global environmental protection (UN, 1992). The Strategic Advisory Group on the Environment then advised the ISO organisation to pursue the environmental management standard, and in 1992, the technical committee was formed (ISO, 2004). Subsequently, the ISO technical committee held its first session in June 1993 to develop environmental management standards in various segments of the EMSs, namely, EP evaluation, environmental auditing, environmental labelling, and life cycle analysis (Irivier, 2004; ISO, 2004).

The ISO (2015) stated that the ISO 14000 codes have 20 series of separate EMSs. Each series is designed to help an organisation with management processes that aim to improve the organisation's EP. The most important standard for environmental issues is ISO 14001 EMS, the only standard that requires certification, whilst others in the series support it. Figure 2.4 shows the historical development of the ISO 14001 standard.

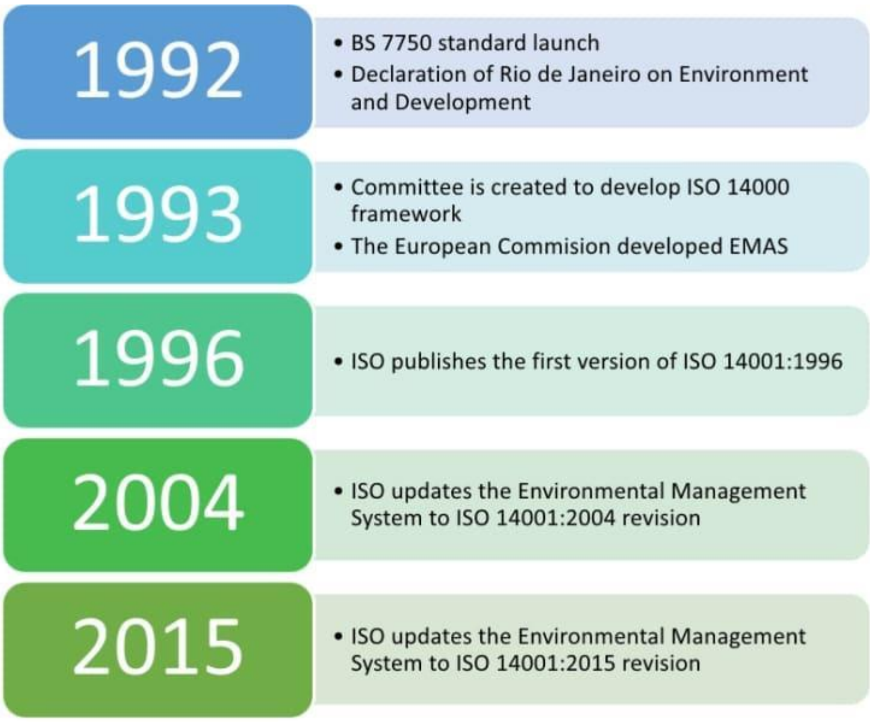

Figure 2.4: Development of ISO 14001 EMS (source: ISO, 2015).

Other standards that aid ISO 14001 EMS include:

• ISO 14004, which is designed to provide a guidebook on establishing and implementing an EMS.

• ISO 14013/5, which is designed for the management of audit programs.

• ISO 14020, which is directed at issues concerning environmental labelling.

• ISO 14030 is designed to provide a guide regarding setting targets and monitoring mechanisms of an EMS.

• ISO 14040, which is directed at life cycle of products.

• ISO 14063, which is directed at communicating environmental issues.

• ISO 14064, 14065 and 14067, which were formed to manage greenhouse gas emissions.

2.4.1. ISO 14001 certification process

The ISO 14001 EMS certification begins by identifying the third-party accredited certification body affiliated with the ISO institution, also known as the external auditor, who reassesses documentation and undertakes the first audit of the site (ISO, 2015). During this process, the auditor investigates the organisational objectives and targets for management programs and determines if they are measurable and attainable (ISO, 2015). The second phase of the certification involves a full audit to ensure that an organisation follows its procedures (ISO, 2015). Subsequently, the organisation is issued with the ISO 14001 registration certificate for a successful audit process (ISO, 2015). The certificate gives a company a competitive market advantage and reputation in the eyes of the customer and the public (Matela, 2006; Boiral *et al*., 2017; Wang & Zhao, 2020). After certification, the third-party auditor performs surveillance visits paid for by the organisation to check if it conforms to ISO 14001 EMS and complies with the legal framework (ISO, 2015). The amount charged depends on the scope of an organisation's internal activities and compliance (ISO, 2015).

2.4.2. ISO 14001 requirements

According to ISO (2015), ISO 14001 EMS requires companies to have the following before a third-party auditor can certify them:

- An environmental policy.
- A single person or a team accountable for coordinating the standard.
- A statement on how an organisation interacts with the environment and identification of potential impacts from the organisational operations.
- Applicable legal framework.
- Environmental targets, goals and programs for monitoring and measuring EP.
- Plans to revive the system, operation, and EP.
- Plans to continuously enhance EP.

2.4.3. ISO 14001 and environmental performance

Boiral *et al*. (2017) stated that in most cases, EP is defined as attaining internal objectives and targets. EP includes emissions, wastewater, energy, and waste (Zobel, 2016). Johnstone and Hallberg (2020) also stated that EP is based on internal motives to improve an organisation's operations and financial profit. These authors noted that external factors, such as legislative frameworks and industry norms, can assist in shaping and constructing EP. Boiral *et al*. (2017) argued that EP focuses on the financial benefits (outputs) rather than the sustainable use of raw materials.

Johnstone and Hallberg (2020) and Waxin *et al*. (2020) maintained that adopting and certifying ISO 14001 EMS yields social, political, environmental, and economic benefits. They also reported that ISO 14001 EMS pays more attention to processes than EP, allowing organisations to build a robust EMSs to improve their internal environmental management processes. Improved EP is posed as a secondary output of the ISO 14001 EMS implementation process (ISO, 2015; Boiral *et al*., 2017; Johnstone & Hallberg, 2020).

Zobel (2013) stated that there is a widespread belief that ISO 14001-certified companies will attain a certain level of EP; thus, this tends to be the reason why some companies request certification. However, although the ISO 14001 standard does not specify the level of EP, it provides guidelines and requirements to design, implement, maintain, and improve the environmental management processes. Thus, according to Johnstone and Hallberg (2020), the efficacy of the ISO 14001 standard is not equivalent to that of EP.

According to Vílchez (2017) and Johnstone and Hallberg (2020), ISO 14001 EMS adoption results in symbolic (external) and substantive (internal) performance. Boiral *et al*. (2017) supported the theory, stating that symbolic performance offers external legitimisation, symbolising to the external stakeholders that an organisation is sustainably conducting its activities. Vílchez (2017) and Johnstone and Hallberg (2020) further posited that ISO 14001 EMS certification by an auditor automatically generates symbolic benefits because it legitimises the organisation's internal performance. While this might improve internal processes, it does not always mean that all certified companies are considering their environmental actions, since the standard allows companies to choose aspects and impacts (Boiral *et al*., 2017). On the other hand, substantive benefits are reflected in internal activities (Vílchez, 2017; Johnstone & Hallberg, 2020). Thus, some companies can focus on waste or energy management, whereas others focus on external stakeholders' needs and expectations and expanding market share (Johnstone & Hallberg, 2020). Waxin *et al*., (2020) posited that cultural cognition or attitude within an organisation could assist in ensuring that substantial performance is enhanced.

2.4.4. Performance indicators

As per ISO (2021), ISO 14031 EP evaluation is the process of choosing indicators that will be used to make management decisions in terms of assembling and analysing data and evaluating information against EP criteria, communicating and reporting, and re-evaluating and enhancing this process. ISO 14031 classifies EP indicators as management performance indicators and operational performance indicators. Data for EP indicators involve, for example, raw materials injected, quantities of emissions and discharges that can pose significant impacts, environmental protection measures, number of incidents that can lead to non-conformance, increased costs associated with regulatory inspections, as well as volumes of waste generated (ISO, 2021).

Management performance indicators relate to the efficacy of an organisation's environmental commitments, resource allocation and procurement, human resource-related issues, detection of which objectives are being followed and attained, and compliance with regulations and audit programs.

In contrast, operational performance indicators emphasise the operational performance of an organisation, such as, among other things, inputs of energy, raw materials, and contractor services. Furthermore, operational performance indicators also relate to through-puts such as, *inter alia*, planning, installation, controlling, and maintenance of equipment and outputs such as emissions from a process, including air emissions, solid and liquid waste, and noise emissions (ISO, 2021).

2.4.5. Conclusion

This section provided an overview of ISO 14001 EMS development, history, strategic aims, certification process, requirements, and how EP is defined with ISO 14001 EMS and examples of EP indicators.

2.5. Impact of integrating management systems

This section will describe studies on the benefits and hurdles in integrating management systems, i.e., ISO 45001 Occupational Health and Safety Management System (OHSMS), ISO 9001 QMS, ISO 14001 EMS, and ISO 22000 Food Safety Management System (FSMS).

2.5.1. Background

Companies worldwide were prompted to simultaneously enhance products, services, health, safety, and the environment (Purwanto *et al*., 2020). This was because of increasing globalisation, organisational competitiveness, and the need for unceasing corporate performance improvement (Marti-Ballester & Simon, 2017). This influenced companies to integrate management systems to harness maximum benefits for the environment, quality, and safety (Purwanto *et al*., 2020).

An IMS is an overarching system meant to remove duplication of tasks in two or more management systems or placing them together to increase efficiency (Purwanto *et al*., 2020). According to Fahmi *et al*. (2021), an IMS is implemented to enhance organisational internal communication, facilitate internal and external audits, improve corporate performance, and company image, and reduce management costs associated with managing each system separately.

2.5.2. Case studies on the performance of integrating management systems

The implications of the benefits of IMS were found by several studies, including Purwanto *et al*. (2020), who investigated the impact of integrating ISO 14001:2015, ISO 9001 QMS, ISO 45001:2018 OHSMS, and ISO 2200: 2018 FSMS on corporate performance in a survey involving 426 people in 44 companies in the Indonesian food industry. They revealed that companies realised improved environmental awareness, image, production processes, entry to new markets, environmental compliance, and customer satisfaction. This agrees with the results of a quantitative study by Marti-Ballester and Simon (2017), who collected data using interviews and found that integration of ISO 14001 EMS and ISO 9001 QMS from 76 companies in Spain led to improved corporate financial performance resulting from good environmental management practices such as reusing and recycling materials.

A similar study was done by Fahmi *et al*. (2021) involving Indonesian manufacturing enterprises. These authors investigated the IMS of ISO 45001 OHSMS, ISO 9001

QMS, and ISO 14001 EMS by gathering data from 220 managers using survey questionnaires and found that IMS favoured environmental awareness, operation, and production performance. In addition, Hernandez-Vivanco and Bernando (2022) collected quantitative data between 2007 and 2020 from Thomson Reuters' Refinitiv Eikon database of 2 834 firms around the world and found that an IMS consisting of ISO 9001 QMS, ISO 14001 EMS, and OHSAS 18001 fostered eco-product manufacturing, with ISO 14001 EMS acting as a primary driver.

Regarding economic benefits, from data collected by online questionnaires from 200 Indonesian managers, Noryani *et al*. (2020) found a significant link between the integration of ISO 9001 QMS, ISO 22000 FSMS, ISO 45001 OHSAS, and ISO 14001 EMS and financial performance of companies. Likewise, Jannah *et al*. (2020) investigated the influence of IMS comprising ISO 14001 EMS, ISO 45001 OHSAS, and ISO 9001 QMS on the economic performance of 220 Indonesian manufacturing companies and found a positive association. In this regard, the present study sought to ascertain if the number of management systems in South African firms impacts EP.

However, few studies have reported on the hurdles of IMS. As with any other process, integrating management standards have drawbacks. Sherida *et al*. (2022) found that the inability to change, lack of staff training, insufficient resources, and level of companies' maturity impeded the successful integration of ISO 14001 EMS and ISO 45001 OHSAS in 15 construction companies in Columbia. A survey study carried out by Simon *et al*. (2012) in 76 companies in Spain with ISO 9001 QMS and ISO 14001 EMS accreditation also supported this and described negative factors such as a lack of resources, government support, specialised consultants and auditors, implementation, and certification, as well as variation in scope and common elements of the standards. Likewise, Abad *et al*. (2016) used questionnaires to gather data from 102 Spanish manufacturing, service, and construction companies and found that employee resistance to change was the problem in integrating OHSAS 18001, ISO 14001 EMS, and ISO 9001 QMS.

2.5.3. Conclusion

IMS provides benefits on triple bottom performance, i.e., the environment, production of quality products and services, and job-related health and safety. However, it is challenging to implement due to, among other things, a lack of resources and trained staff.

2.6. Case studies as motivation to adopt ISO 14001 and the environmental performance

This section will provide the motivations that led companies worldwide to certify or adopt ISO 14001 EMS and the impact of the standard thereof on triple bottom line.

2.6.1. Background

Stojanovic (2016) found that ISO 14001 EMS assists with establishing environmental management programmes, which are vital to aid an organisation in enhancing its EP, among other things, by setting environmental targets of minimising resource consumption, waste minimisation, and energy use. This author emphasised that the ISO 14001 standard provides a structured framework for waste handling. Singh *et al*. (2015) stated that if an organisation chooses waste as its aspect, it should activate plans and implement processes to manage and reduce its material consumption and waste handling. The ISO 14001 EMS does not list prescribed steps or the waste handling procedure, and it is up to organisations to determine the best approaches to handle and minimise waste (ISO, 2015).

Studies have provided insights regarding the motivations that influence organisations to implement ISO 14001 EMS. Boiral and Henry (2012) and Johnstone and Hallberg (2020) stated that ISO 14001 EMS adoption motives could be classified into two categories: external and internal. For instance, Johnstone & Hallberg (2020) and Waxin *et al*. (2020) asserted that companies can certify to the standard in response to external pressure from the market, customers, government, society, and legal enforcement. Several other studies also noted that some companies adopt ISO 14001 EMS because of internal pressures such as corporate image, environmental concerns, boardroom decisions, and cost reduction (Pinto *et al*., 2017; Johnson, 2018; Johnstone & Hallberg, 2020).

To be effective, the ISO 14001 EMS is affected by various factors including enterprise size, resource availability, nature of business, age of the EMS, financial capacity, age of firms, business ownership, ISO 9001 QMS, and international exposure (Singh *et al*., 2015; Johnstone & Hallberg, 2020; Mungai *et al*., 2020). Singh *et al*. (2015) further reported that some of these factors may or may not have a direct effect at a firm level as to effective implementation of ISO 14001 EMS. For instance, Johnson (2018) found no relationship between the organisation size and the effectiveness of the ISO 14001 standard. Melnyk *et al*. (2003) found that a relationship between the age of the EMS had a negligible effect on corporate performance. However, Singh *et al*. (2015) and Boiral *et al*. (2017) believe that in firms with a sizeable annual turnover, ISO 9001 QMS, and larger firms are most likely to adopt ISO 14001 EMS.

2.6.2. International case studies

In Denmark, mixed method research was conducted by Mosgaard *et al*. (2022) involving 277 ISO 14001-certified companies to investigate how they implement environmental objectives. Data were assembled using questionnaires and direct interviews. They found that companies prioritised setting objectives for waste, energy, and water consumption rather than towards biodiversity, design, and life cycle assessment, and crucial stakeholders such as customers and employees were not adequately involved.

Survey research involving 152 respondents was conducted by Singh and Chan (2022) as to the influence of green purchasing on improving supply chain performance in Malaysian ISO 14001-certified firms. These researchers found a positive association between green purchasing and firms' performance. After applying a novel grey relational analysis model, a survey study conducted by Abid *et al*. (2022) in Pakistan investigated the influence of technological innovation on the environment and found a positive link between ISO 14001 EMS and green growth and technological innovation. An intention of the present study was to find technological innovations that companies in South Africa employed to reduce waste and pollution.

The quantitative study involving 63 Indian small and medium-sized enterprises conducted by Singh *et al*. (2015) revealed that the implementation of the ISO 14001 standard positively impacted waste reduction. They found a 25% increase in waste reduction in such enterprises with ISO 14001 EMS compared to those without it. In addition, they found no influence regarding factors such as firm size (number of employees) and international exposure. However, they found that the nature of business and resource availability are associated with EP. A comparative study using structured interviews and questionnaires to assemble data was conducted by Bashir *et al*. (2022) in the United Arab Emirates involving 259 construction firms to investigate their environmental management actions. The study found that the certified companies were better at segregating waste onsite, monitoring hazardous materials, conserving energy by using photovoltaic solar panels to generate power, recapturing energy by utilising wheels for ventilation, wastewater recycling, reducing water consumption, and minimising emissions by using water that was chlorine free for use with alternating current, installing fine mesh to suppress dust, and avoiding burning waste onsite. As with Singh *et al*. (2015), these researchers found no relationship between the size of organisations and ISO 14001 EMS adoption. The present research study adopted some of the influencing factors used by Singh *et al*. (2015) - such as firm size and international exposure - to investigate their association with EP in South African companies.

The study by Bashir *et al*. (2022) was confined to construction firms suggesting further research should focus on a spectrum of companies to study the impact of ISO 14001 EMS. The present study filled that gap.

In Saudi Arabia, Pinto *et al*. (2017) used a survey questionnaire across 27 companies to investigate the hurdles, motivators, and advantages of ISO 14001 EMS. They found benefits such as enhanced corporate image, top management commitment, financial profit, and on the environment, reduction of energy, waste, and water consumption. They also noted that companies certified to the standard met regulatory requirements and improved process efficiency. Similarly, Waxin *et al*. (2020), from their exploratory qualitative study that included 14 respondents, found that companies in emerging Arab Gulf countries that were privately and publicly owned, achieved benefits such as resource efficiency, waste recycling, process efficiency, an improved company reputation with stakeholders, and employee environmental awareness. Another study reported on the motivators behind Indian corporates adopting the ISO 14001 standard (Goldar & Majumber, 2022). These researchers used annual surveys from 50 000 manufacturers for 2016, 2017, and 2018 and found that factors such as firm size, financial status, international exposure, and adequate managerial staff influenced manufacturing companies to adopt the standard.

In Sweden, the association between ISO 14001 EMS motives and EP was studied by Johnstone and Hallberg (2020) across 16 participants working in small and medium-sized enterprises using in-depth interviews to gather data. They found that legislation, pressure from customers, and environmental concerns pushed companies to adopt

ISO 14001 EMS, and they achieved enhanced internal operations. Another Swedish survey conducted by Johnstone (2020) used semi-structured interviews involving 23 respondents to research the influence of the ISO 14001 standard on small and medium-sized enterprises. Benefits such as environmental awareness, top management involvement, and performance monitoring were achieved by small and medium-sized enterprises. Johnstone and Hallberg (2020) called for further research focusing on the impact of ISO 14001 EMS as a mediator between adoption motives and EP. The present study filled that gap.

2.6.3. The African experience

In Ghana, Fel-Baffoe *et al*. (2013) studied the influence of ISO 14001 EMS using the desk approach, as well as observations and interviews from two mining companies. They found that both companies realised improvements in waste management (mostly material separation), energy, and environmental incidents. Mungai *et al*. (2020) concurred with Fel-Baffoe *et al*. (2013) by finding that adoption of ISO 14001 EMS and the United Nations Global Compact improved waste reuse, wastewater recycling, and safe waste disposal methods across 852 Kenyan firms. As with Singh *et al*. (2015), Mungai *et al*. (2020) considered the impact of the firm size and international trading and found no association between these variables on EP.

A positive outcome of ISO 14001 EMS was noted by Gazoulit and Oubal (2021) in 22 large Moroccan firms, using the mixed method design and interviews to gather data. They found that companies realised improvements in water consumption, wastewater recycling, energy, and their drive to adopt ISO 14001 was to meet international customers' demands, comply with regulations, and improve corporate image. As with Gazoulit and Oubal (2021) and Mungai *et al*. (2020), the present study also researched the motives for ISO 14001 adoption, the factors influencing its efficacy, and the resulting EP. However, Mungai *et al*. (2020) did not investigate material types and how materials were reused. Hence, the present study focused on materials from different industries and investigated measures that ISO 14001-certified companies used to minimise waste and pollution.

2.6.4. The South African case studies

There are few South African studies on ISO 14001 and EP. Using a mixed method research design and questionnaires as well as interviews to gather data from 23 companies in nine industries, Matela (2006) found that positive outcomes associated with ISO 14001 EMS were improvements in financial performance, waste minimisation practices, environmental awareness, and corporate image. However, equivocal results were found where some companies did not accrue positive outcomes - financial benefit was found to be the primary reason companies adopted ISO 14001 EMS and environment conservation was secondary. Matela (2006) did not consider waste management as an EP indicator. Hence, the present study sought to establish EP in South African companies, focusing on waste.

Other mixed-method and qualitative studies that asserted the environmental awareness benefits of ISO 14001 EMS was that of Sennoga & Ahmed (2020) conducted across 24 companies using questionnaires and Szoke (2021) across eight renewable energy companies using semi-structured interviews to gather data. In addition to Szoke's (2021) findings, compliance management and streamlined processes were attained by the companies, and they adopted the standard for financial gains. However, Szoke (2021) investigated ISO 14001 EMS adoption motives and the benefits, his study was solely on a single sector, and focused solely on environmental awareness. The present study was multi-sectoral and considered the impact of the ISO 14001 standard on waste reduction.

Other studies supporting the financial benefits of companies in South Africa were published by Dwarika (2015) and Johnson (2018), who used a mixed method study design and surveys to amass data. Dwarika (2015) investigated the advantages of having the ISO 14001 standard and responsible care across 15 chemical industries, while Johnson (2018) studied the economic benefits of ISO 14001 EMS across 12 manufacturing companies. The former researcher found that having both standards resulted in attaining environmental targets and financial benefits. The ISO 14001 standard was the most preferred tool but the most expensive to be implemented. The latter study found that ISO 14001 EMS led to environmental awareness and financial benefits from waste and energy reduction, and most companies adopted the standard to gain business advantage, meet customers' requirements, and conduct business internationally. Johnson (2018) financially quantified environmental management in manufacturing enterprises in terms of reduction in pollution and waste. Waste minimisation and management strategies should have been considered. Dwarika (2015) did not emphasise waste as an environmental aspect. Hence, the present study sought to emphasise the entire waste minimisation process and management aligned with the waste management hierarchy and quantification of EP across different sectors and not solely the manufacturing sector.

2.6.5. Conclusion

This section looked at different reasons for companies to adopt ISO 14001 EMS and the economic, social, and environmental benefits accrued from such adoption. In addition, the benefits of adopting ISO 14001 EMS with other management standards were identified. Around the world and in South Africa, ISO 14001 EMS positively impacted the environment and economy. Various gaps in the literature were identified by the researcher for inclusion in the present study.

2.7. Constraints and pitfalls of ISO 14001 EMS

This section provides studies that oppose the advantages of the ISO 14001 standard and the related hurdles with adopting the standard.

2.7.1. Background

The ISO 14001 standard has flaws (Matela, 2006; Boiral & Henri, 2012; Zobel, 2013; Johnson, 2018; Alsulamy *et al*., 2022). The standard needs more transparency since the public is only made aware of the environmental policy statement, and factors such as audit results and EP status are kept private by companies (Marsh & Perera, 2010).

According to Matela (2006), Johnson (2018), and Alsulamy *et al*. (2022), ISO 14001 EMS implementation is a long and resource-consuming process. Waxin *et al*. (2020) reported that internal costs related to ISO 14001 EMS implementation include the cost of purchasing and modifying existing equipment, while the external costs include auditing. These costs may be difficult for small and medium-sized enterprises to accrue (Boiral & Henri, 2012; Alsulamy *et al*., 2022). In addition, adoption and implementation of ISO 14001 EMS requires technical expertise, which may sometimes be unavailable within an organisation (Boiral & Henri, 2012).

2.7.2. Case studies on pitfalls of ISO 14001 EMS

There are few articles describing the pitfalls of ISO 14001 EMS compared to the benefits of the standard. The Indonesian study by Alnavis *et al*. (2021) undertaken across five food production firms using their review of environmental reports found that life cycle assessment, technological innovations, internal expertise, government support, and certification bodies needed improvement. The authors noted that financial availability was the main factor that impeded companies from fully implementing measures to improve EP. As a result, the present research was directed at studying the challenges that ISO 14001-certified firms in South Africa faced regarding pollution prevention, waste minimisation and management.

Zobel (2016) postulated that organisations could mismanage ISO 14001 EMS certification to establish a public image and business benefit instead of genuinely taking steps to reduce pollution. Boiral and Henri (2012) and Boiral *et al*. (2017) stated that ISO 14001 EMS certification does not necessarily imply environmental enhancement but, rather, companies can adopt the standard to meet the requirements of accreditation processes and conformance to external factors without initiating necessary internal actions to enhance EP. This finding was supported by two Swedish studies that found no statistical difference in EP across 116 manufacturers, i.e., 66 certified and 50 uncertified over 12 years (Zobel, 2015) and 104 manufacturers, i.e., 56 certified and 48 uncertified over six years (Zobel, 2013). These studies concentrated on waste, energy, water, air, resource use, and overall EP after a review of firms' annual environmental reports. Zobel (2015) suspected that ISO 14001 EMS might have had a negligible impact on energy and waste, whereas uncertified firms might perform better on atmospheric emissions.

Other studies that noted a negative outcome of ISO 14001 EMS were reported by Wang and Zhao (2020) across 63 Chinese firms utilising data collected from five sources - the National Certification and Accreditation Information public service platform, China Statistical Yearbook, WIND database, China Stock Market and Accounting database, and annual report of listed companies between 2003 and 2018. They found that the adoption of the standard resulted in a negative financial performance which was linked to firm size and age, as well as gross revenue. Tirgil *et al*. (2021) collected data using interviews and questionnaires and found no association across 10063 Turkish small and medium-sized enterprises between ISO 14001 EMS and environmental practices such as effective resource use and environmental awareness when certification endogeneity was considered. As reported by Wang and Zhao (2020), the present study considered the influence of firm size on EP.

According to the studies mentioned above, the influence of ISO 14001 EMS may be equivocal. Boiral *et al*. (2017) suggested that the definition of environmental indicators caused the ambiguity of ISO 14001 EMS and measurement of EP. Arimura *et al*. (2016) suggested that the cause of ISO 14001 EMS heterogeneity is influenced by the methodology used to evaluate EP and institutional or legislative pressure locally and internationally, which tends to differ across countries. The authors further asserted that countries with flexible and robust regulatory settings incur more environmental costs and must implement adequate measures to reduce environmental impacts. Pinto *et al*. (2017) justified this by stating that the main driver for firms in Saudi Arabia to adopt the standard was to improve their public image because no external or internal pressure compelled them to reduce their environmental impacts.

2.7.3. Conclusion

This section indicated that ISO 14001 EMS has downfalls and not all companies who adopt it accrue positive results since it requires resources for implementation and to be maintained.

2.8. Concluding remarks

The motivations for ISO 14001 EMS adoption, barriers, and benefits vary in different regions due to varying economic settings and priorities. These dissimilarities emerge due to factors dictating the motivations to adopt or certify the standard. The motivation behind ISO 14001 EMS implementation is influenced by external factors, such as, *inter alia*, customer requirements and regulatory pressure, among others, and internal factors, such as process productivity and waste management.

sustainable waste management requires innovation in policies and technologies to move waste up the waste management hierarchy. For instance, cleaner production, Industry 4.0, green manufacturing, and lean manufacturing can ensure waste materials are incorporated into the CE rather than disposed of in landfills. Moreover, the ISO 14001 standard is process-based, providing stipulations and procedures. Therefore, companies must invest in technology (cleaner production and Industry 4.0) to meet environmental obligations.

The adoption of ISO 14001 EMS yields environmental and economic benefits. The performance of ISO 14001 EMS can be categorised as symbolic and substantive. The standard has shown positive benefits towards EP. However, it has its downfalls and constraints, such as costs linked with the certification process.

The ISO 14001 EMS is a system that can move industries towards being sustainable as it helps to reduce waste generation, water consumption, and energy usage. The standard is flexible and blends with other management standards, such as ISO 45001 OHSMS and ISO 9001 QMS, but has drawbacks, such as when a company is faced with lack of resources, qualified personnel, and information.

In South Africa, the financial benefits derived from ISO 14001 EMS have been quantified but gaps in the literature indicate that there is a shortage of research that evaluates the efficacy of ISO 14001 EMS on the environment. The present study aimed to fill such knowledge gaps.

3. Chapter 3: Research Design and Methods

3.1. Introduction

This chapter provides a comprehensive outline of the study design, methodology and methods, and the analysis tools that were employed to investigate pollution prevention, waste minimisation and management in South African companies that had the International Organisation of Standards (ISO) 14001 standard or ISO 14001 Environmental Management System (EMS). These companies are based in North West, Mpumalanga, Limpopo, and Gauteng Province. This research utilised a mixed method research approach that is explained below.

3.2. Study design

Kothari (2004) stated that research design aims to optimise research to yield data rapidly in a cost-effective manner. In addition, it is a blueprint that dictates the research operations. Kumar (2011) stated that the primary function of research design is to elaborate on how the research objectives are addressed and that a mixed method research design yields a significant output.

3.2.1. Mixed method research design

Kothari (2004) suggested using multiple approaches to enrich the meaning and significance of a phenomenon. For this reason, this research extracted qualitative and quantitative data from ISO 14001 EMS-certified companies. According to Etikan and Bala (2017), qualitative data aims to increase understanding of the research circumstances while quantitative research provides numeric data requiring statistical analysis using software such as the Statistical Package for Social Science to ascertain relationships between variables.

3.2.2. Cross-sectional study

This study utilised a cross-sectional research design that is widely used to investigate a prevalence of a situation, experience, or issues in a population to acquire a complete picture of a phenomenon at the time of the investigation (Kumar, 2011). Since data collection occurs at a single point in time, it is cost effective to conduct a cross-sectional study, and it offers an opportunity to compare data from a pool of participants. For this reason, evidence was collected and compared describing the pollution and waste prevention measures employed by companies participating in the study.

3.2.3. Survey research

This study made use of a survey to gain insights from individuals who responded to questions regarding their experience (Etikan & Bala, 2017) on waste minimisation and pollution prevention measures. Primary data were assembled via structured questionnaires to reach the strategic intents of this study and conduct investigations.

3.2.3.1. Questionnaires

A questionnaire, the most widely used method to extract data, was used because they provided participants sufficient time to contemplate and answer the provided questions (Kumar, 2011). This data collection instrument was employed due to its low cost, anonymity, ease of access and use (Kumar, 2011), particularly as the sampled population was geographically dispersed. The survey questionnaire comprised open-ended and closed-ended questions, was distributed electronically and, where possible, was provided in person.

The researcher employed structured, face-to-face interviews where the researcher and the study participants could easily meet. The interviews involved the same questions as the questionnaire. Hence, the questionnaire remains the main data collection instrument. The researcher posed questions to the respondents and carefully completed the questionnaires according to the responses of the participants. Those participants who opted to complete the questionnaire online did so knowing that they could reach out to the researcher whenever they required clarity regarding the questions.

3.2.3.2. Justifications of questions

Section A in the questionnaire sought to ask individuals to state their occupation and to provide background information on their organisation regarding size, sector, location, service, international exposure, waste emanating from their processes, the age of their ISO 14001 EMS, and their other management systems. For quality purposes, the researchers assumed that people working closely with waste management, health and safety, ISO 14001 EMS implementation and production would produce better quality results than general workers. Hence, it was significant to include the occupation in the survey.

The dissertation literature review indicates that ISO 14001 EMS efficacy relies on factors such as the age of the EMS, international exposure, size of companies, and other management systems and resources employed by the companies (Singh *et al*., 2015; Johnson, 2018; Mungai *et al*., 2020; Wang & Zhao, 2020; Muktiono & Soediantono, 2022). Therefore, it was significant for the present study to test the impacts of these factors on the companies' environmental actions.

Section B of the survey questionnaire sought to establish motivations behind companies adopting ISO 14001 EMS. The effectiveness of ISO 14001 EMS relies on the reasons companies adopted the standard (Johnstone & Hallberg, 2020). For example, some companies might get the standard to break into international markets (Johnson, 2018) or use it to reduce pollution (Singh *et al*., 2015). Therefore, this question was vital to establish why companies adopted the ISO 14001 standard.

Section C of the questionnaire sought to investigate measures that ISO 14001 EMS-certified companies employed to reduce waste and pollution. The participants were asked to state their actions towards raw materials substitution, process modifications, environmental awareness, and green procurement policy. These aspects are vital to establish organisations' actions to reduce waste and pollution.

Section D of the survey sought to investigate measures that ISO 14001 EMS-certified companies introduced to handle waste materials up to final disposal. This information was vital to reveal companies' action to deal with waste materials which emanated from production lines and whether some factors associated with companies - mentioned in Section A - were related to waste minimisation and management.

Section E of the survey sought to investigate barriers that the participants viewed as factors hindering the effective reduction of pollution and waste in South Africa, which was essential to understand impeding factors which companies experienced towards effective pollution prevention and waste minimisation.

3.3. Study population

The target population of study participants included persons working closely with ISO 14001 EMS, waste management, or production processes in manufacturing and service companies certified to ISO 14001 EMS in South Africa. The researcher extracted the names of companies with ISO 14001 EMS from the South African

Bureau of Standards’ website. Thereafter, the researcher went to LinkedIn to search for people working in the identified companies and sent them a request to participate in the study. The researcher then sent the survey questionnaires and consent forms via e-mail to interested people. Alternatively, the researcher created a LinkedIn post with the attached survey questionnaire link before the researcher sent the consent form via LinkedIn inbox to interest persons. The study resulted in 32 responses.

The target population of this study is defined as follows:

- Element: People who worked with ISO 14001 EMS implementation, waste management or production processes.
- Sampling Unit: ISO 14001 EMS-certified manufacturers and service companies.
- Extent: Gauteng Province, North West Province, Mpumalanga Province, and Limpopo Province.

According to the ISO Survey (2019), South Africa has 855 companies that are ISO 14001 EMS certified, a relatively low number of certifications compared to other developed countries. Thus, the study population was unknown regarding the absolute number of enterprises which are ISO 14001 EMS-certified in the four selected provinces. A relatively low number of ISO 14001 EMS-certified companies in the selected provinces was expected to be found. For example, to reflect on evidence from other related studies, in South Africa, the study by Matela (2006) included a total of 23 respondents, Dwarika (2015) 15 respondents, Johnson (2018) 13 respondents, Sennoga and Ahmed (2020) 24 respondents, and Szoke (2021) eight respondents who participated in their studies.

The selection of respondents in the present study was based on their willingness to participate and if they were ISO 14001 EMS certified. The relatively low number of respondents was justified by conducting an in-depth study. For these reasons, non-probability sampling approaches, specifically judgemental and convenience sampling techniques were used, as explained below.

3.4. Sampling

As noted by Kumar (2011), a sample size represents a small proportion of the population and purposive sampling in qualitative research is not dictated by a predetermined sample size. The sample included individuals working in manufacturing and services sectors in a managerial and supervisory level whose companies had fully implemented ISO 14001 EMS. On the other hand, sampling in quantitative research is dictated by a predetermined sample size from considerations of available resources (Creswell, 2014) which are controlled by various factors such as the statistical analysis employed in the research. For this reason, since a low sample size was available, Spearman's rho and Kendall's tau correlations were utilised which are suitable for a small sample size (Fredricks & Nelsen, 2006), as explained below.

3.5. Sampling frame

The sampling of this study included individuals from four South African provinces, and the study used non-probability sampling to select individuals working in companies, i.e., a convenience sampling which is easy to undertake, cost effective, and the fact that participants were chosen based on their convenience and willingness to partake in a study, and since it allows a researcher to decide when to stop collecting data (Etikan & Bala, 2017). Participation was voluntary, and there were no financial benefits.

This study used judgmental sampling, also known as purposive sampling, which lets a researcher estimate who will present the best response for research (Etikan & Bala, 2017) and allows a researcher to select participants he/she deems appropriate for a study (Creswell, 2014). For this study, the researcher assumed that people working closely with environmental issues, ISO 14001 EMS implementation or production lines had much better knowledge of waste issues or ISO 14001 EMS implementation than general workers and so should represent a suitable target population. The participating companies were selected as they were ISO 14001 EMS certified.

3.6. Description of study area

The study included manufacturing and service companies who were ISO 14001 EMS certified by third-party certification organisations, i.e., South African Bureau of Standards across four provinces (see Figure 3.1 below). These provinces were chosen based on their proximity to the researcher's geographic location.

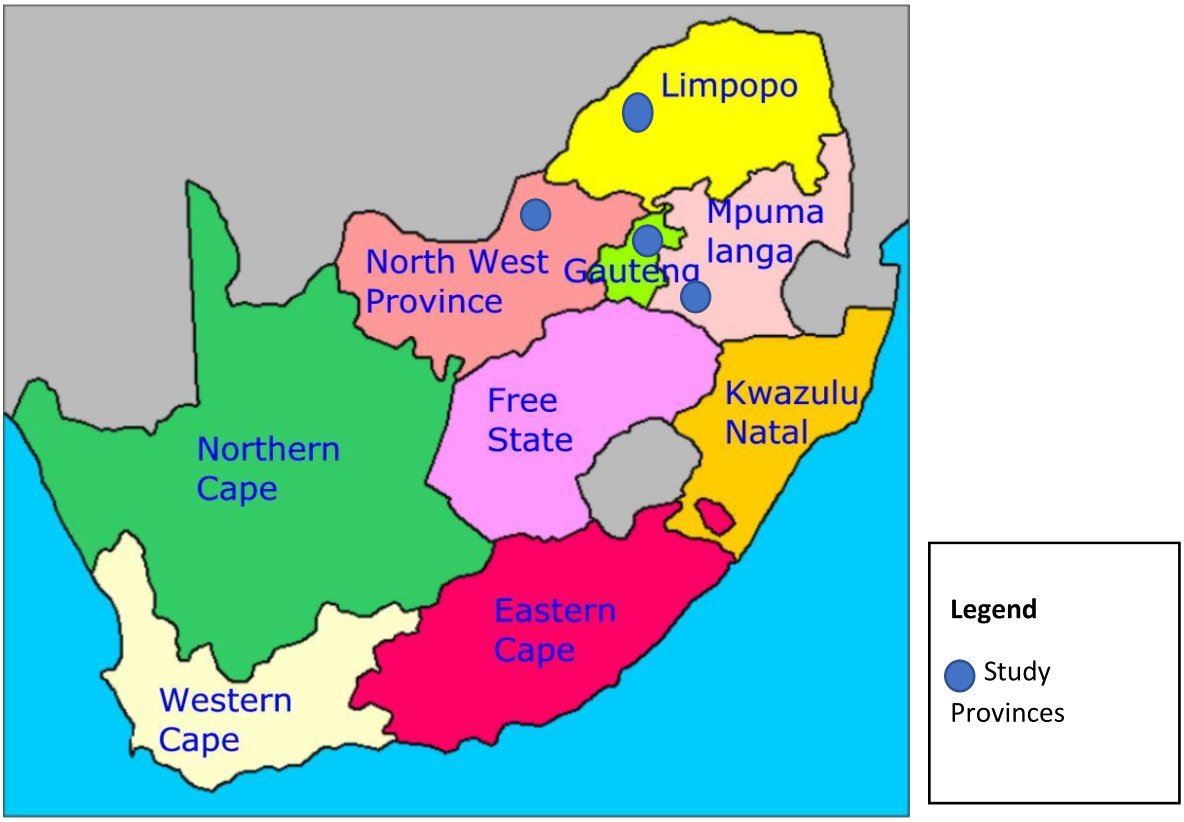

Figure 3.1: Study area (source: Stats SA, 2022)

According to Stats SA (2022), Gauteng Province is the smallest and most populous province, with an estimated population of 16.1 million as determined in mid-2022. This province contributed 33.9% of the national gross domestic product (GDP) in the third quarter of 2020, and finance, real estate, manufacturing, and general government services were the sectors that contributed the most to the GDP (Stats SA, 2020). Furthermore, Gauteng Province has three municipalities, i.e., the City of Johannesburg, City of Ekurhuleni, and City of Tshwane, as well as two district municipalities that comprise six local municipalities (Stats SA, 2020). The province has 30 facilities for recycling, 26 for electronic waste treatment, 142 for composting, and 58 wastewater treatment plant works (DEA, 2018).

The North West Province is regarded as the platinum province due to its wealth. It shares a border with Botswana, had an estimated population of 4.2 million in mid-2022 (Stats SA, 2022) and contributed six times less that the Gauteng Province of the South Africa's GDP in the third quarter of 2020 (Stas SA, 2020). Mining was the industry that contributed most to the province's GDP (Stats SA, 2020). Moreover, the province comprises four districts and 18 local municipalities (Stats SA, 2020) and has one site for recycling, six for treating electronic waste, 39 for composting, and 37 wastewater treatment plant works (DEA, 2018).

Limpopo Province is situated in the far north of South Africa, and borders Mozambique, Botswana, and Zimbabwe. The province had a population of approximately 5.9 million in mid-2022 (Stats SA, 2022) and contributed 7.7% to South Africa's GDP in the third quarter of 2020 (Stats SA, 2020). As with North West Province, the mining sector contributes most to its GDP and the Limpopo Province economy exports primary products and imports manufactured goods and services (Stats SA, 2020). It has one site for recycling, 10 for treating electronic waste, 56 for composting, and 37 wastewater treatment plant works (DEA, 2018).

Mpumalanga Province has three districts, i.e., Ehlanzeni, Nkangala, and Gert Sibande, and has 17 municipalities (Stats SA, 2022). The province had approximately 4.7 million residents in mid-2022, and the key economic sectors include mining and energy, agriculture and agro-processing, and forestry (Stats SA, 2020). This province contributed 8% of South Africa's GDP in the third quarter of 2020 (Stats SA, 2020). It has six sites for waste recycling and recovery, nine for treating electronic waste, 83 for composting, and 76 wastewater treatment plant works (DEA, 2018).

3.7. Data presentation and analysis

Data analysis involves converting and interpretating raw collected data into meaningful facts (Creswell and Creswell, 2023). In the study, Microsoft Word and Excel were used to capture data from questionnaires and present it in a readable and understandable manner. Graphs, tables, and pie charts were utilised to depict data from the questionnaire. This study used deductive thematic analysis (i.e., themes were preconceived) for qualitative analysis. Leading the analysis were existing literature, the researcher's epistemology and subject knowledge, and respondents' understanding of the subject (Kumar, 2011).

Quantitative responses were collated and statistically analysed using Statistical Package for Social Science, which was supplied by the University of South Africa. For the researcher to correlate two sets of variables, this study used Spearman's rho correlation (r), and Kendall's tau-b correlation (r)**.** These two tests imply that the correlation results will be positive and negative, ranging from +1 and -1. Furthermore, a positive correlation implies that a rank of variables is directly proportional, that is, they increase together, while a negative correlation means a rank of variables is indirectly proportional. In most cases, these two tests generate similar results and lead to similar inferences which enhance credibility and reliability of correlations (Fredricks & Nelsen, 2006).

Spearman’s rank correlation is represented by the following formulae:

$$r = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

Where:

r represents Spearman's rank correlation coefficient.

d_1 represents difference between the two ranks of each observation.

n represents the number of observations.

On the other hand, Kendall’s rank correlation is represented by the following formulae:

$$r = \frac{n_c - n_d}{\frac{1}{2}n(n-1)}$$

Where:

r represents Kendall’s rank correlation coefficient.

n represents the sample size.

n_c represents the number of concordant pairs.

n_d represents the number of discordant pairs.

These two tests are based on two hypotheses:

1) H0: There is no significant association between variables (p=0)

2) Ha: There is an association between variables (p≠0)

Whereas:

p represents the population correlation coefficient.

Decisions:

If $p<0.05$, H0 is not accepted, and Ha is, and it is deduced that the correlation is statistically significant. In contrast, if $p>0.05$, H0 is accepted, and it is concluded that the relationship between variables is not statistically significant (Fredricks & Nelsen, 2006). Table 3.1 further displays the elucidation of correlation coefficients.

Table 3.1: Interpretation of correlation coefficients

Size of Correlation (r)	Interpretation
±0.9 to ±1.0	Very positive or negative correlation
±0.7 to ±0.9	High positive or negative correlation
±0.5 to ±0.7	Moderate positive or negative correlation
±0.3 to ±0.5	Low positive or negative correlation
0.0 to ±0.3	Negligible correlation

This study correlated the following variables on pollution prevention and waste minimisation efforts:

- Company size.
- Age of the ISO 14001 EMS.
- Number of management systems.
- International exposure.

pollution prevention and waste minimisation and management efforts included:

- Materials substitution.
- Processes modification.
- Materials separation.
- Waste disposal.
- Wastewater recycling.
- Effluents discharge.

3.8. Data reliability and validity

According to Kumar (2011), reliability in a research context can be described as the intensity of constancy and reliability in an employed instrument to produce desired outcomes. In contrast, validity is the intensity or extent to which the researcher has apprised what he has pursued to measure (Creswell and Creswell, 2023). This author further argued that reliability and validity are two contrasting concepts but are interconnected.

Kumar (2011) further posited that selecting multiple research approaches offers validity in a study. For this reason, this research utilised a mixed method research design to acquire data. Creswell (2014) stipulated that selecting appropriate tools to gather data offers reliability and validity, and Kumar (2011) stated that both close-ended and open-ended questions declare the study reliable and valid.

The survey instrument was initially sent to an expert in environmental management and a person working at a company with ISO 14001 EMS certification to test the instrument's validity and to pre-test if the questionnaire was answerable. Their responses were counted as separate from the number of responses. In addition, a written consent form was sent for as part of this pilot study.

The questionnaire was developed by reviewing multiple academic-related publications, which offers credibility (Kumar, 2011; Creswell and Creswell, 2023).

According to Creswell and Creswell (2023), to ensure that reliability is achieved in research, the same method must be used throughout the data collection stage, and this study used the same questionnaire to extract data from people who worked at companies that are ISO 14001-certified. In terms of data analysis, the correlation was performed with a 0.05 confidence level, which 95% of the time the correlations are tested again will lead to the same outcomes. Since Spearman's rho and Kendall's tau correlations lead to similar inferences (Fredricks & Nelsen, 2006), their results provided reliability and validity regarding the extracted numeric data.

3.9. Ethical considerations

Research ethics refers to the way in which a study is undertaken (Kumar, 2011; Creswell, 2014), and this study was undertaken according to the principles and values as outlined in the University of South Africa policy document on ethics, particularly as to ensuring confidentiality of the study participants. The consent form was a prerequisite from the University of South Africa before the commencement of the data collection phase, and it was attached to the questionnaire to facilitate trustworthiness and legitimacy. The respondents were contacted before the questionnaire was sent to them and were notified that participation was not mandatory and that they could withdraw from the study at any stage.

The survey questionnaire did not comprise sensitive questions. Where a respondent felt a certain question was sensitive, they had the choice to cease from participating in the research or indicate that they were unsure. Moreover, data extracted from the participants were not misused or misinterpreted to harm the credibility of the participating organisations or individuals and the identity of the participants was coded, and they were provided with the researcher's contact information so that they could request the final dissertation to confirm if their answers were accurately recorded and if discretion was retained carefully.

3.10. Limitations

This study was confined to four selected provinces in South Africa and so the results of this study are not generalisable to all South African companies that have ISO 14001 EMS. In addition, the sample size was small and non-probable since South Africa has few companies with ISO 14001 EMS certification.

3.11. Conclusion

This chapter outlined the summary of the study design, methods and instruments which were used to address the aim and objectives of the study. A mixed method study approach was followed. The cross-sectional study used a survey questionnaire compiled by the researcher from similar published instruments to gather data from the respondents. The study involved 32 respondents, and their companies were situated in four South African provinces. The study could not predetermine the sample size; therefore, it used a non-probability approach, i.e., convenience and purposive sampling.

This chapter presented data collection and analysis procedures, and discussed reliability, validity, and ethical considerations surrounding the study. Microsoft Word and Excel were used to collate data in a readable format and Statistical Package for Social Science was used to test relationships between variables using Kendall's tau-b and Spearman's rho correlation (r).

Lastly, a description of the study areas and study limitations was explained. The major limitation was that the study's findings are not generalisation across South Africa.

4. Chapter 4: Presentation of Results

4.1. Introduction

This chapter displays the data collected by means of a survey questionnaire distributed in person, online via LinkedIn or via email between March and September 2022. The survey included 32 manufacturing and service companies. Section A of the survey included the background details of the companies and Section B focussed on motivations behind the companies to certify to the International Organisation of Standards (ISO) 14001 standard or Environmental Management System (EMS). Section C focussed on pollution prevention measures that the companies employed to reduce pollution, and Section D focussed on waste minimisation and management measures used by participant companies. Lastly, Section E involved barriers and hurdles in realising effective pollution prevention, waste minimisation and management.

4.2. Section A: Background of companies

The effectiveness of ISO 14001 EMS relies upon various factors, such as technological innovations in a company (Abid *et al*., 2022) and employees' education (Johnstone, 2020; Waxin *et al*., 2020; Szoke, 2021). These factors also apply to waste minimisation and management, which require organisations to fully understand their waste streams before minimising them.

Section A presents the location, service classification, waste stream, and size of the participating companies.

4.2.1. Location of companies

The participants were asked to state the province in which their organisation was located. The percentage of the participating company location sites is depicted in Figure 4.1. The study was restricted to four provinces within South Africa, namely North West Province, Mpumalanga Province, Limpopo Province, and Gauteng Province.

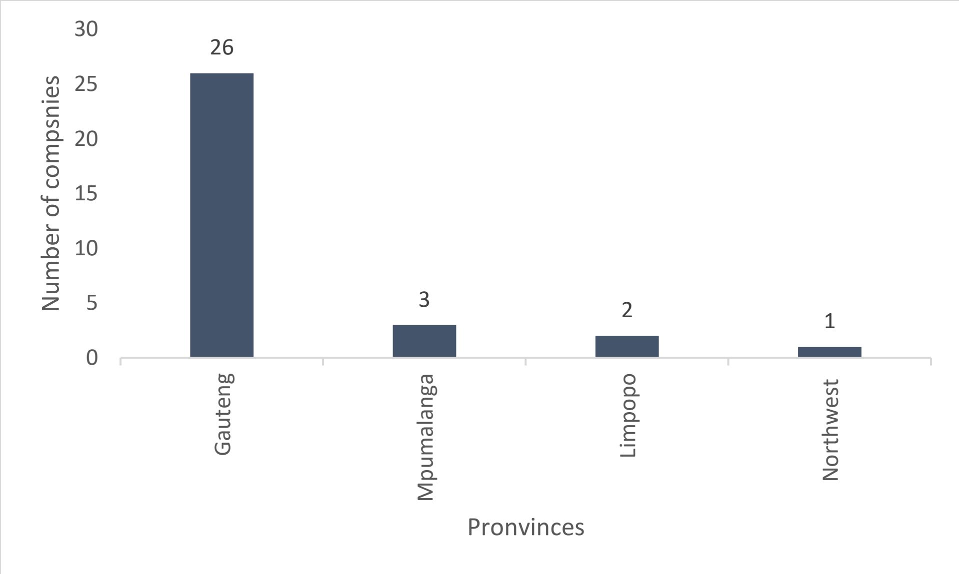

Figure 4.1: Location per province of companies

Most 26 (81%) of the companies were situated in Gauteng Province, three (9%) in Mpumalanga Province, two (6%) in Limpopo Province, and one (3%) in North West Province. In Gauteng Province, eight companies were situated in the Rosslyn industrial area, three in Pretoria West, three each in Springs and Johannesburg, two in Wadesville, and one each in Silverton, Sunninghill, Hermanstad, Olifansfontein, Three Rivers, Vereeniging, and Germiston. In Limpopo Province, one company was situated in Letsitele and another in Amandelbuilt. In North West Province, one company was situated in Brits while in Mpumalanga Province, all three companies were situated in Delmas.

4.2.2. Occupation of respondents

For quality purposes, the participants were asked to state their occupation, as displayed in Figure 4.2.

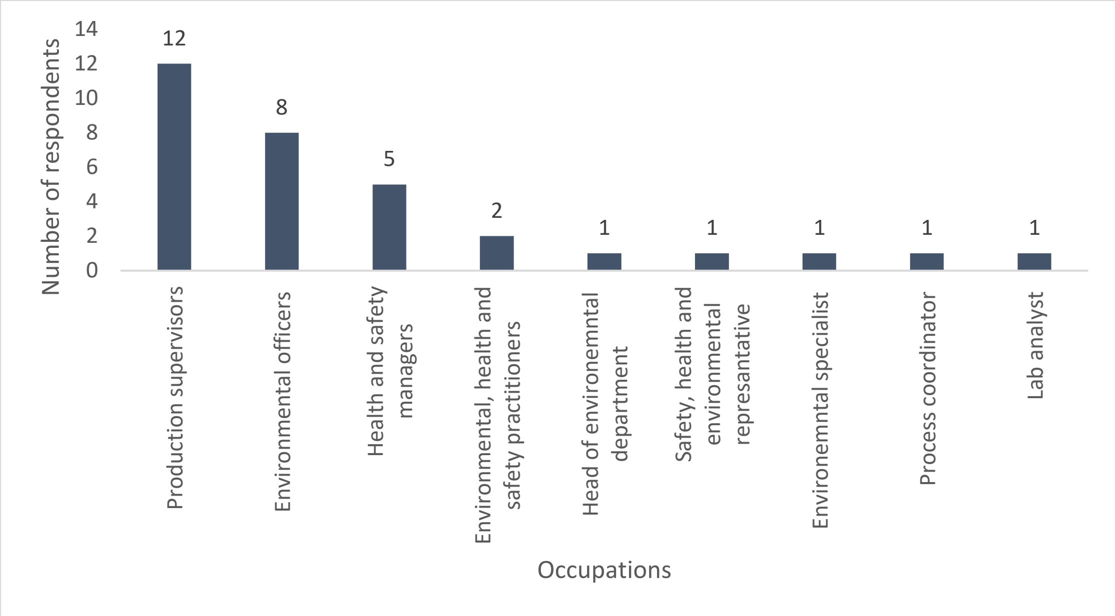

Figure 4.2: Occupations of the study participants

Of the participants, 12 (38%) worked as production supervisors, eight (25%) were environmental officers, five (16%) were health and safety managers, two (6%) were environmental, health and safety practitioners, one (3%) each headed an environmental department; or was a safety, health, and environmental representative; an environmental specialist; a process coordinator; or a laboratory analyst.

4.2.3. Industry classification

This section classifies or categorises participants' organisations in terms of sectors and sizes represented by the number of employees and company annual turnover. The classification further indicates whether an industry conducted business outside South Africa.

4.2.3.1. Industry classification: Sector

The companies' classification per the South African Industrial Classification is shown in Figure 4.3 below. The companies differed as to their primary business, ranging from manufacturing to service providers.

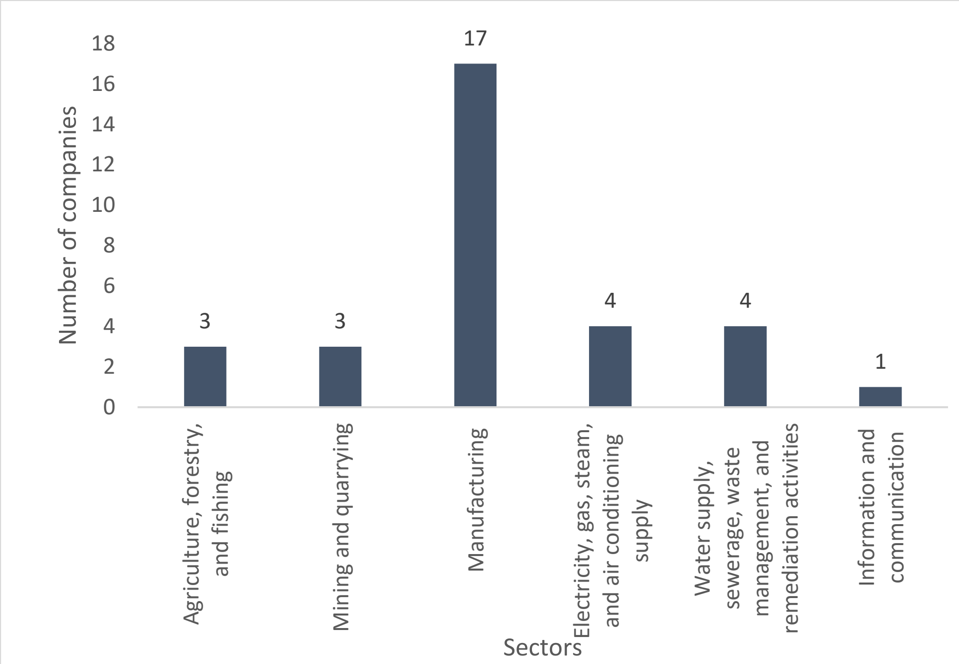

Figure 4.3: Industry classification: Sector

Of the 32 participating companies, three (9%) each were in the agriculture, forestry, and fishing sector, or the mining and quarrying sector; over a half (53%; n=17) were involved in manufacturing; four (13%) each belonged to the electricity, gas, steam, and air conditioning supply or to water supply, sewerage, waste management, and remediation activities, and one company (3%) was involved in information and technology.

Further classification of companies that participated in the research is shown in Table 4.1. This indicates the variety of subcategories of industries in terms of services they rendered

Table 4.1: Industrial classification: Products and services

Agriculture, forestry, and fishing companies		Number of companies	Mining & quarrying	Number of companies	Manufacturing	Number of companies		Electricity, gas, and air conditioning supply	Number of companies	Water supply, sewerage, waste management, and remediation activities	Number of companies	Information and communication	Number of companies
Manufacturing of Simba chips		**1**	**Platinum metal**	**1**	**Heat shield or long fibre underbody parts**	**1**		**Electricity generation**	**4**	**Water purification**	**3**	**Network installation**	**1**
Production and distribution of food		**1**	**Iron ore**	**1**	**Beverages**	**2**				**Waste management**	**1**		
Agricultural services		**1**	**Silica sand**	**1**	**Ammunition, mining drill pits, brass products, and power cartridge**	**1**							
					Glass	**1**							
					Maize and flour	**1**							

					Auto catalysts	**1**							
					Cement	**1**							
					Fibre and paper	**2**							
					Plastics	**2**							
					Automotive and metals	**5**							

- Of the companies classified in the agriculture, forestry, and fishing category, one each offered agricultural services, manufactured Simba chips for other companies, and manufactured and distributed different food products.
- Of the companies classified as mining and quarrying, one each involved mining and processing silica sand, iron ore, and platinum metals.
- Of the total manufacturing companies, the majority (n=5) manufactured automotive parts, two each produced plastic, papers, or fibres, or produced beverages. In addition, one each manufactured glass; cement; maize and flour; heat shields or long fibre thermoplastic underbody parts; auto catalysts; and ammunitions, mining drill pits; brass products, or power cartridges.
- All the companies classified as electricity, gas, steam, and air conditioning supply generated electricity.
- Of the companies classified as water supply, sewerage, waste management, and remediation activities, one offered waste management activities, and three were in the water purification sector.
- Lastly, one company rendered network installation services within the information and communication category.

4.2.3.2. Industrial classification: Size and international exposure

The literature review (Chapter 2) indicated that often the effectiveness of the ISO 14001 standard is associated with company size, and some adopt the standard to enter international market (Singh *et al*., 2015; Johnson, 2018; Mungai *et al*., 2020; Wang & Zhao, 2020; Muktiono & Soediantono, 2022). Industrial classification in terms of international market exposure and the size of companies expressed as the number of employees and annual turnover is displayed in Figure 4.4. The number of employees in companies ranged from 51 to more than 250, and the annual turnover of the companies ranged from R10 million to more than R170 million.

Figure 4.4: Industrial classification: Size and international exposure

Based on the South African Standard Industrial Classification, six (19%) companies were small and medium sized enterprises with between 51 and 250 employees while 26 (81%) were large enterprises with over 250 employees.

In addition to the industry classification, two (6%) companies had an annual turnover of fewer than 10 million rands, three (9%) 10 million rands but not more than 50 million rands, four (13%) 50 million rands but not more than 170 million rands, 12 (38%) more than 170 million rands, and 11 (34%) were unsure about their annual turnover. Most (75%; n=24) companies were involved in international trading.

4.2.4. Waste minimisation objectives

The literature review indicated that the process of ISO 14001 EMS certification starts with setting targets and goals to improve environmental conditions (ISO, 2015; Stojanovic, 2016).

All (100%) of the study participants believed that their organisations set targets or objectives for waste minimisation.

4.2.5. Types of waste emanating from industrial processes

Types of waste that emanated from the companies' production, operation or manufacturing processes are shown in Figure 4.5.

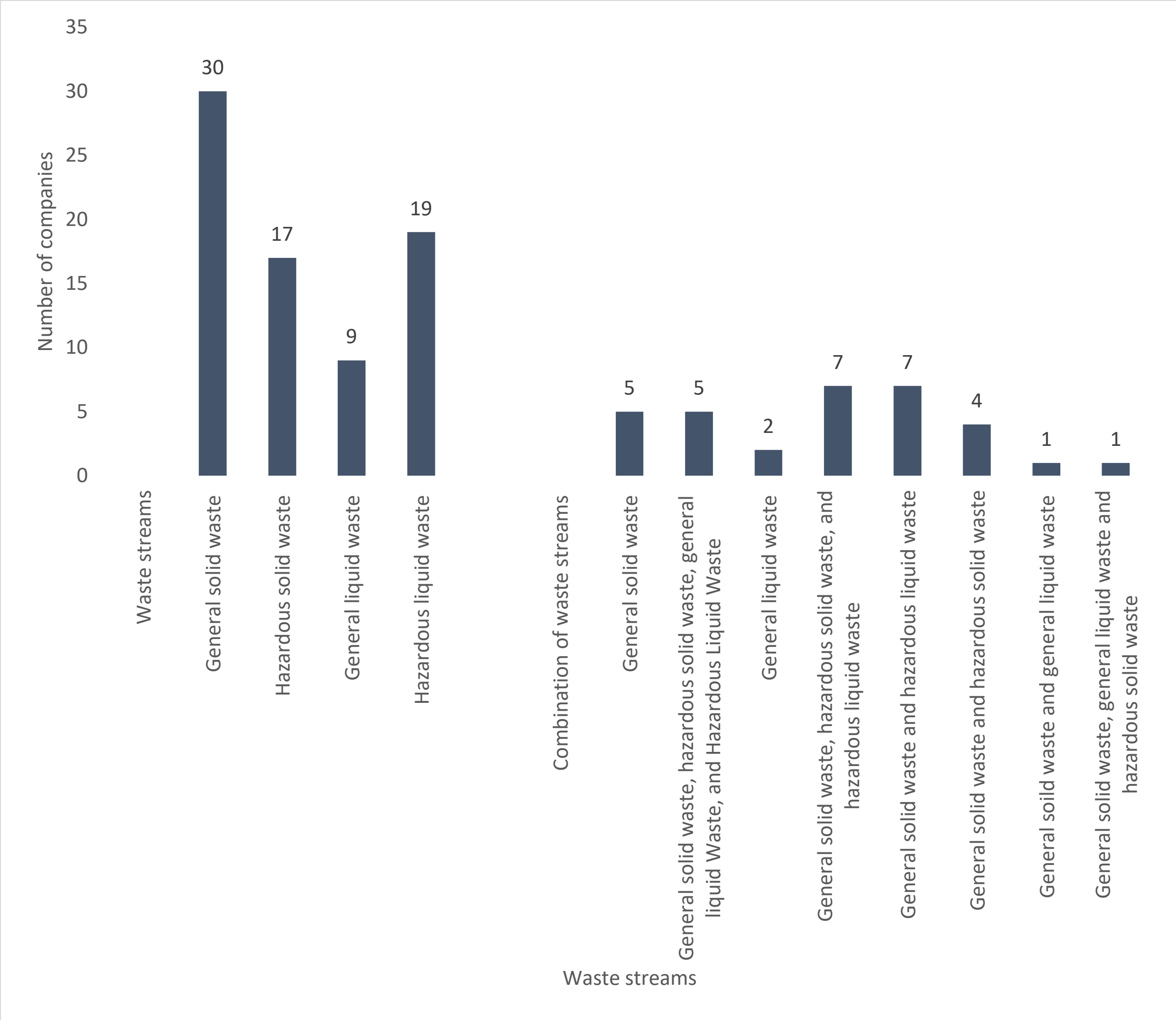

Figure 4.5: Waste streams

The companies' waste streams were counted independently from each other, that is, some companies generated a combination of waste streams. Therefore, of the 32 participating companies, 30 (94%) generated general solid, 17 (53%) hazardous solid, nine (28%) general liquid, and 19 (59%) hazardous liquid waste.

The industries generated different combinations of waste streams, from general solid or liquid to general or toxic solid or liquid waste. Five (16%) each generated general solid, or a combination of general solid, hazardous solid, general liquid, and hazardous liquid waste. Two (6%) generated general liquids, seven (22%) each a combination of general solid, hazardous solid, and hazardous liquid, or hazardous liquid and general solid waste. Four (12%) generated general solid and hazardous solid waste, and one

(3%) each general solid and general liquid; or general solid, hazardous solid, and general liquid waste.

Figure 4.6 below depicts the types of waste streams generated by companies varying from general to hazardous in their composition and from solid to liquid in their state.

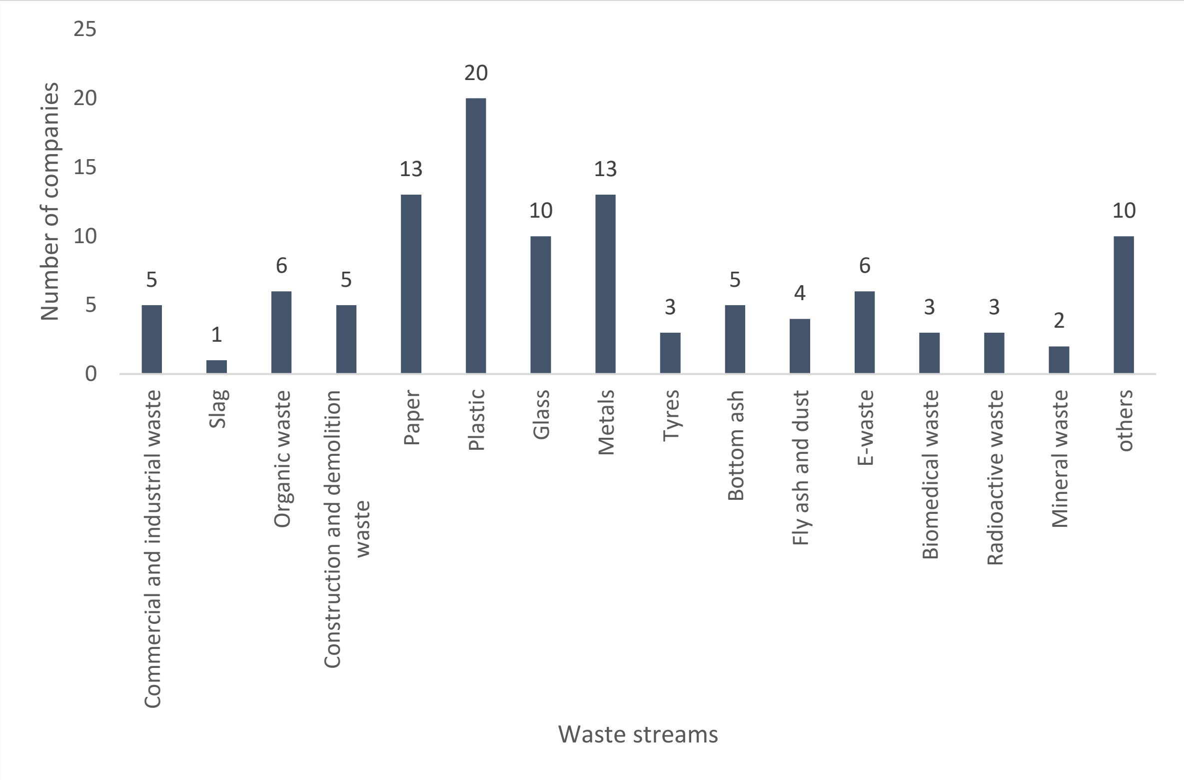

Figure 4.6: Types of waste streams generated by companies.

Out of 32 companies, five (16%) generated commercial and industrial waste, one (3%) slag, six (19%) organic waste, five (16%) construction and demolition waste, 13 (41%) paper, 20 (63%) plastics, 10 (31%) glass, and 13 (41%) metals waste. In addition, three (9%) generated tyre waste, five (16%) bottom ashes, four (13%) fly ash and dust, six (19%) e-waste, three (9%) each biomedical or radioactive waste, and two (6%) mineral wastes. Lastly, 10 (31%) generated other waste, such as sludge, slime, and fibre.

4.2.6. Duration of ISO 14001 EMS certification

How long companies had been certified to the ISO 14001 standard is displayed in Figure 4.7 below. In the literature review (Chapter 2) it was indicated that the impact of ISO 14001 EMS is often associated with the duration of time that the standard has been in operation (Mungai *et al*., 2020).

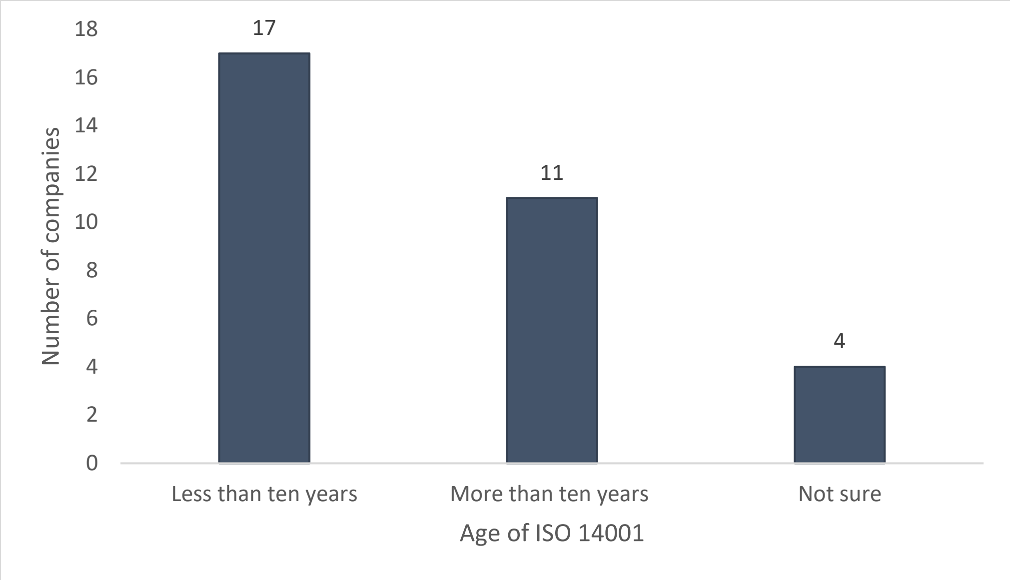

Figure 4.7: The age of ISO 14001 EMS certification

Of the 32 participating companies, 17 (53%) were ISO 14001 EMS certified for less than 10 years, 11 (34%) had attained ISO 14001 EMS certification for a minimum of 10 years, and four (13%) were unsure about the length of time since they attained their ISO 14001 EMS certification.

Of the 17 companies which had attained ISO 14001 EMS certification in the last 10 years, five (28%) had attained this certification within the last three years, three (18%) within the last four years, two (12%) within the last five years, three (18%) in the last seven years, two (12%) in the last eight years, and one (6%) each within the last two or six years.

Of the 11 companies that reported more than 10 years since they attained ISO 14001 EMS certification, five (46%) had attained this certification for more than 10 years, one (9%) each for 21 or 20 years, two (18%) for precisely 10 years, and one (9%) each for 24 or 21 years.

4.2.7. Other certification and number of management systems or resources for companies

Since ISO 14001 EMS is a flexible process, it can be merged with other standards to produce enhanced results for companies (Marti-Ballester & Simon, 2017; Purwanto *et al*., 2020). Other certifications that companies have implemented, and the number of management systems or resources (other than ISO 14001 EMS) are displayed in Figure 4.8.

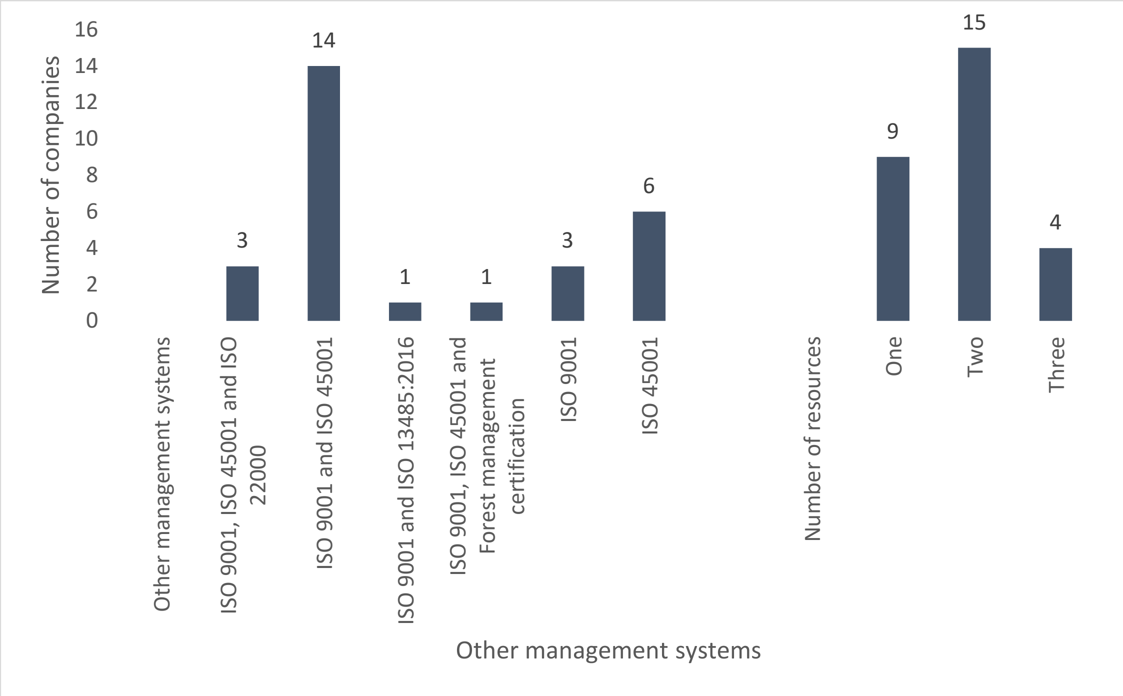

Figure 4.8: Other management systems and number of resources

The management systems or resources of the companies were counted independently from each other, so that some companies had more management systems in addition to ISO 14001 EMS. Therefore, of the total number (n=28) of companies which answered this question, 24 (86%) had ISO 45001 Occupational Health and Safety Management System (OHSMS) (previously known as 18001 OHSMS), 22 (79%) had ISO 9001 Quality Management System (QMS), three (11%) had the ISO 2200 Food Safety Management System (FSMS), four (14%) had no other certifications other than ISO 14001 EMS, and two (7%) companies had other certifications, i.e., Forest Management certification and ISO 13485:2016 QMS.

Three (11%) companies had the collection of the ISO 9001 QMS, ISO 45001 EMS, and ISO 2200 FSMS; 14 (50%) ISO 9001 QMS and ISO 45001 OHSMS; one (4%) each had ISO 9001 QMS and ISO 13485 QMS; or ISO 9001 QMS, ISO 45001 OHSMS, and Forest Management certification. Three (11%) had solely ISO 9001 QMS, and six (20%) only ISO 45001 OHSMS.

The survey results showed that nine (32%) companies had one internal certification or resource, 15 (54%) two, and four (14%) three, to aid the ISO 14001 standard.

4.3. Section B: Reason/s for ISO 14001 EMS certification

Section 2.3.3 of the literature review (Chapter 2) described various motives behind why companies certify to ISO 14001 EMS. For example, companies certify to ISO 14001 EMS due to internal (environmental concerns, boardroom decisions, pressure from stakeholders) and external pressures (such as government regulation, global trading, and requirement from customers) (Johnson & Hallberg, 2020). Figure 4.9 depicts reasons why participating companies are certified to ISO 14001 EMS.

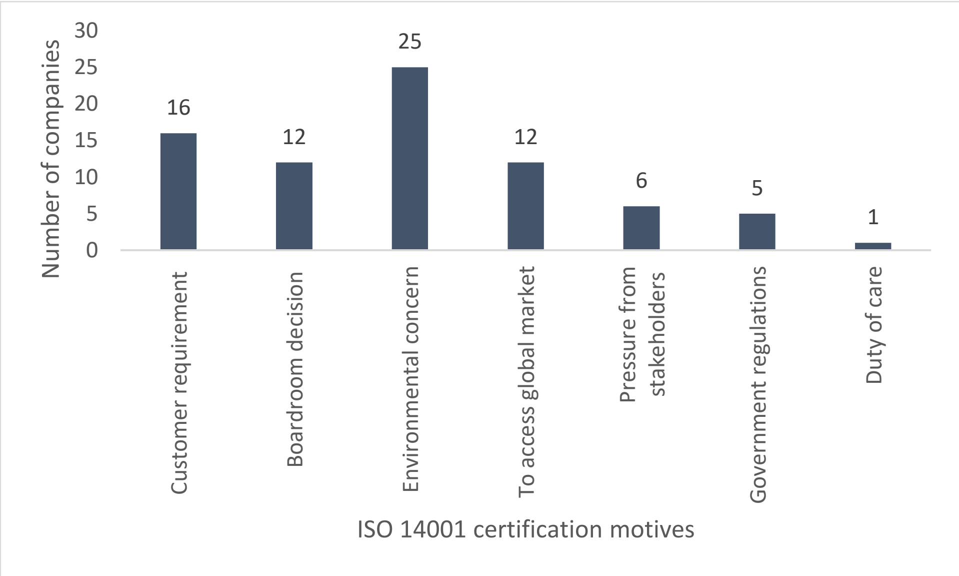

Figure 4.9: Motives behind ISO 14001 EMS certification

The companies' motives to certify to ISO 14001 EMS were counted independently from each other, that is, some companies certified to the standard for more than one reason. The survey results showed that out of 32 of the participating companies, 16 (50%) were certified to the ISO 14001 standard in response to customer requirements, 12 (38%) on the grounds of boardroom decisions, 25 (78%) due to environmental concerns, 12 (38%) to gain access to global market, six (19%) resulting of pressure from stakeholders, five (16%) due to government regulation, and one (3%) as a duty of care.

4.4. Section C: Measures for pollution prevention as a waste minimisation approach in the ISO 14001-certified manufacturing and service sectors

4.4.1. Green procurement policy and environmental awareness education

The literature review (Chapter 2) showed that environmental awareness education and green procurement can be used to reduce companies' environmental impacts (Pinto *et al*., 2017; Singh & Chan, 2022). For the ISO 14001 standards to be adequate, it starts with equipping employees and contractors with the necessary education to align them with what is expected from them to reduce environmental impacts (ISO, 2015). Study participants were asked whether their company had a green procurement policy and implemented environmental awareness education in their organisation and their responses are displayed in Figure 4.10.

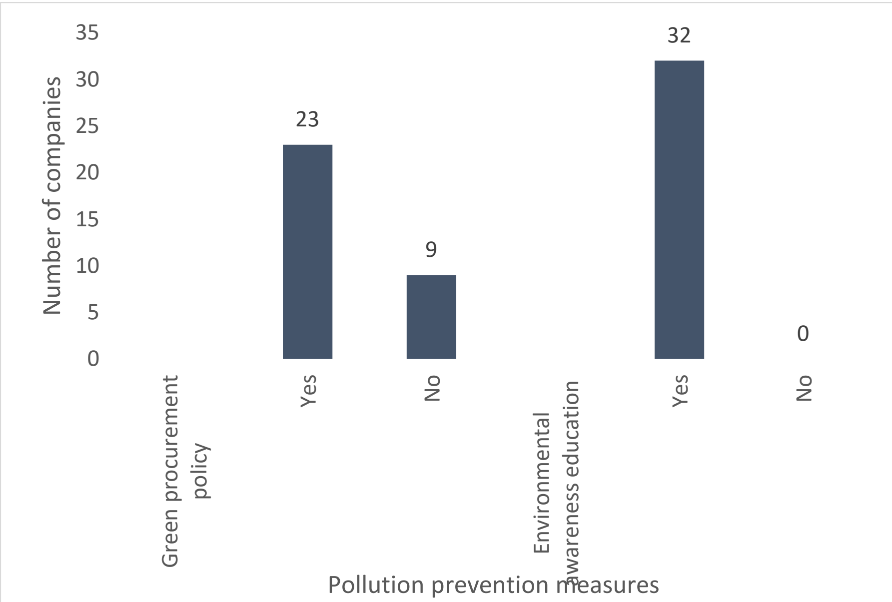

Figure 4.10: Pollution prevention measures: Green procurement policy and environmental awareness education

Of the 32 participating companies, 23 (72%) had a green procurement policy embedded in their logistic processes. All the respondents (100%) stated that their companies hosted environmental awareness education campaigns.

4.4.2. Substitution of raw materials for eco-friendly materials

Singh *et al*. (2015) reported that substituting hazardous materials with less polluting materials is a viable alternative to reduce pollution and environmental degradation. Figure 4.11 displays the number of companies that replaced raw materials since they received ISO 14001 EMS certification and their motivations for initiating such a change.

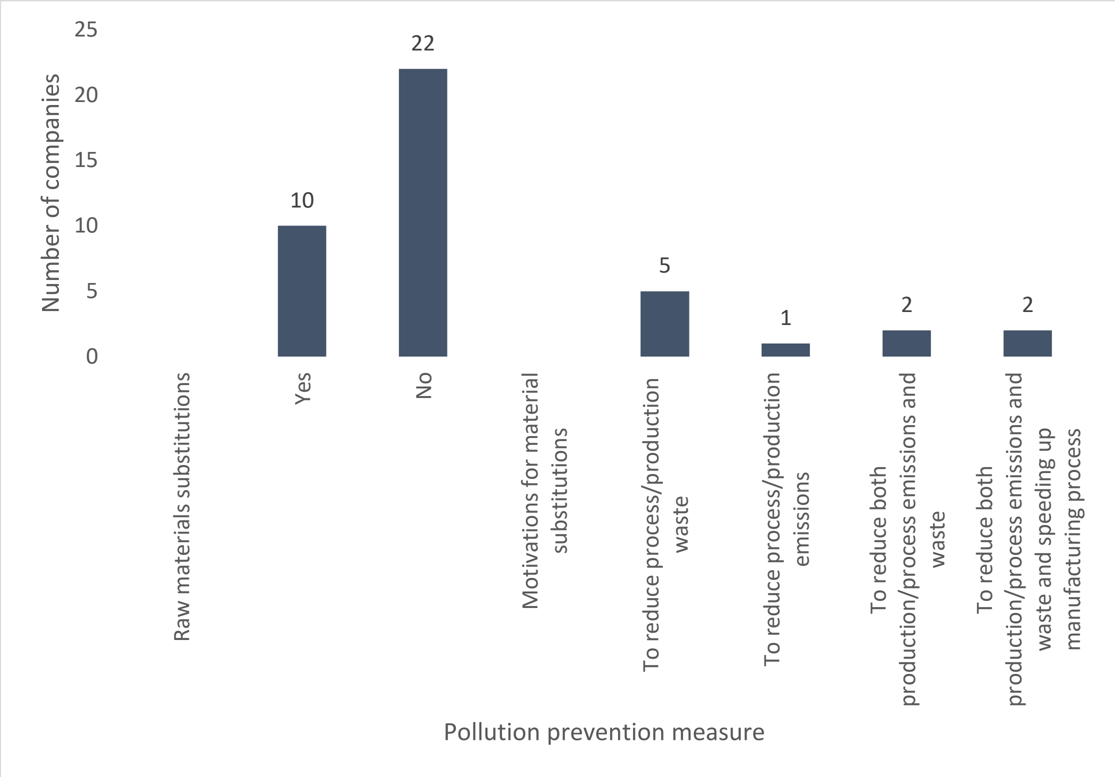

Figure 4.11: Pollution prevention measure: Raw materials substitution

Of the 32 participating companies, only 10 (31%) had substituted raw materials. Of these companies, five (50%) substituted raw materials to reduce waste, one (10%) to reduce emission, and two (20%) each to reduce a combination of emissions and waste, or emissions and to speed up the production process.

The respondents were asked to give a brief account of the materials that they substituted. Table 4.2 below indicates the responses of the participants.

Table 4.2: Materials substitution

Raw materials substitution	Responses
R1	Previously we used trees and now are using recycled paper and boxes. We used to use fresh water for production, now we use process water that we recycled.
R2	We replaced coloured bottles with clear bottles which are easy to recycle. We are in the process of moving from ACL plastics to paper labels which are biodegradable increasing the use of recycled content in our packaging.

R3	We started using natural gypsum instead of synthetic gypsum and we were using used/reworked oil instead of diesel.
R4	We were buying metal and aluminium that has recycling content from certified suppliers.
R5	Our then bottles were polluting the environment, we then started using eco-twist bottles which can easily be recycled and are lightweight.
R6	We started sourcing materials from suppliers that also had ISO 14001 or ISO 9001 certifications. We sourced materials that had less impact on the environment. we started sourcing sustainable natural rubber, mica, copper, and cobalt. We replaced trichloroethylene with aqueous degreasers. We started buying sustainable materials including soy foam, wheat straw, rice hulls, tree-based cellulose, coconut fibre, and coffee chaff.
R7	We removed ferrous and nonferrous metals from end-of-life vehicles.
R8	We used to use virgin paper, but now we are using a dual-performer liner that is 100% recyclable. It saves us money and reduced our environmental impacts.
R9	We started using hemp, kenaf and flax on our cars as they were lightweight and absorb carbon dioxide emissions. We also replaced synthetic adhesives with wood foams since it is renewable.

4.4.3. Technological, process, or product modification

The literature review described how some companies use Artificial Intelligence, Industry 4.0, and cleaner production to improve processes and reduce environmental impacts (Dhiman & Sidhu, 2020; Al-Kindi and Al-Ghabban, 2020). Therefore, the study participants were asked if they had modified a technology since they attained ISO 14001 EMS certification. Figure 4.13 shows the number of companies that modified processes, products, services, or technologies after implementing ISO 14001 EMS and their motivations for implementing such a change.

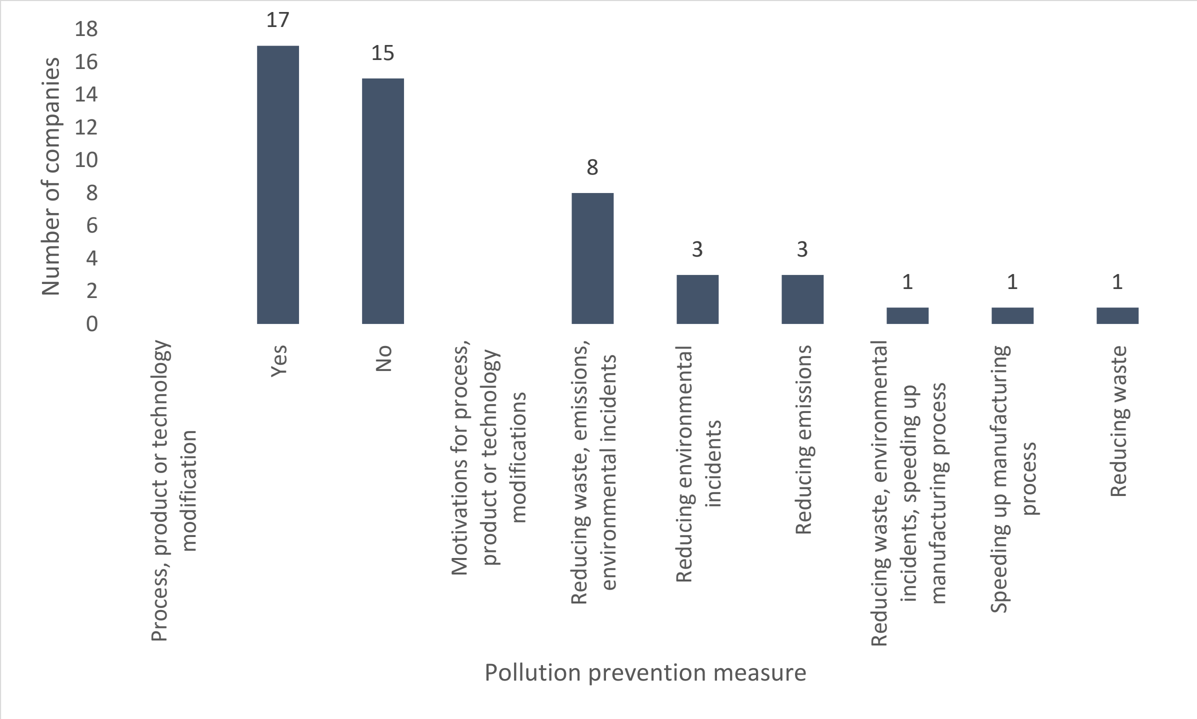

Figure 4.12: Pollution prevention measure: Technological, process, or product modification

Just over a half (53%; n=17) of the 32 study participants stated that their companies had modified a technology, process, or product. Of these companies, eight (46%) implemented such change to reduce a combination of waste, emissions, and environmental incidents, three (18%) each to reduce environmental incidents or emissions, and one (6%) each to reduce a combination of waste, environmental incidents, and to speed up production, or solely to speed up production process or to reduce waste reduction.

The participants were asked to provide details regarding modifications they had brought into their organisations after attaining ISO 14001 EMS certification. Table 4.3 below indicates the responses of the participants.

Table 4.3: Process modification

4.5. Section D: Waste management measures towards waste minimisation to the final disposal of waste in the ISO 14001-certified manufacturing and service sectors

4.5.1. Solid waste

4.5.1.1. Separation at source initiative

As per the waste management hierarchy, effective or improved waste management begins with avoiding and sorting waste so that sorted materials can be reused, transferred, or recycled (DEA, 2018). Therefore, the participants were asked to state if they had a separation at a source initiative active in their organisations, and their responses are displayed in Figure 4.13.

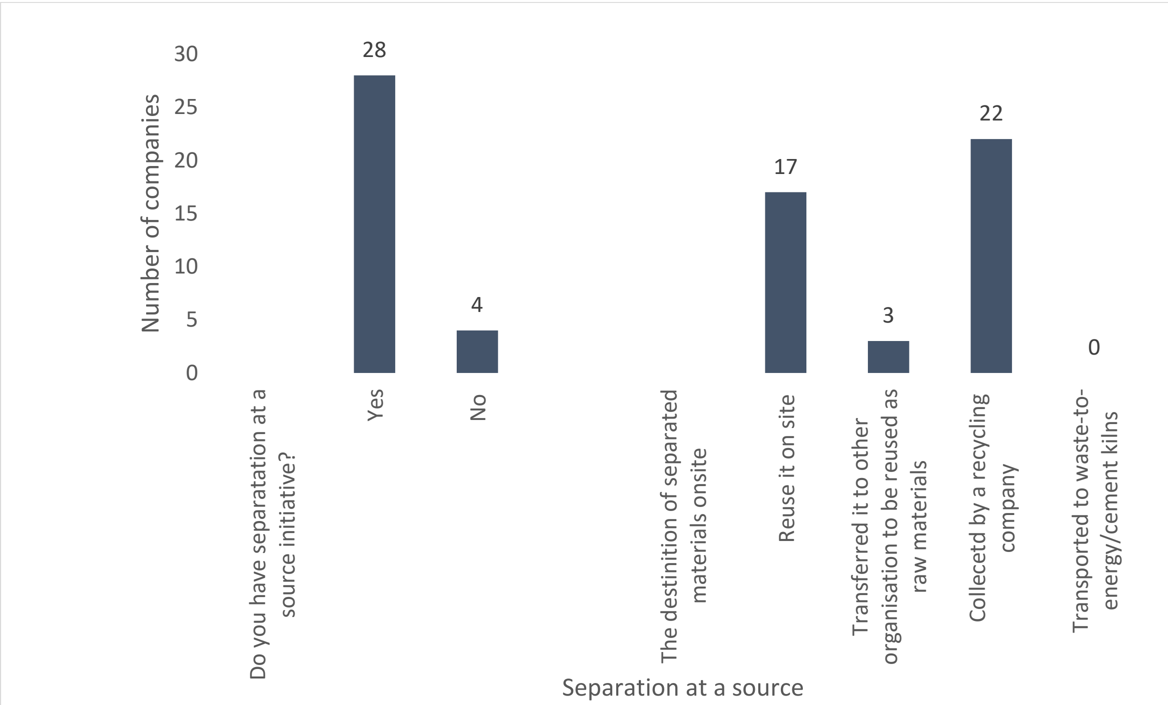

Figure 4.13: Separation at a source

Of the 32 participants, 28 (88%) indicated that their company had initiatives to separate materials onsite as part of their operations processes. The companies' waste minimisation efforts were counted independently from each other, as some companies practiced more than one waste minimisation measure. Therefore, of the 88% companies that separated waste onsite, 17 (61%) reused it onsite, three (11%) shipped it to other organisations to be reused as a raw material, and 22 (79%) had it collected by recycling companies. No company shipped waste to a waste-to-energy plant.

4.5.1.2. Quantities of materials reused, transferred, and recycled

Figure 4.14 below expresses in percentages, the amount of waste per month that companies separated materials onsite to be reused, transferred, and recycled.

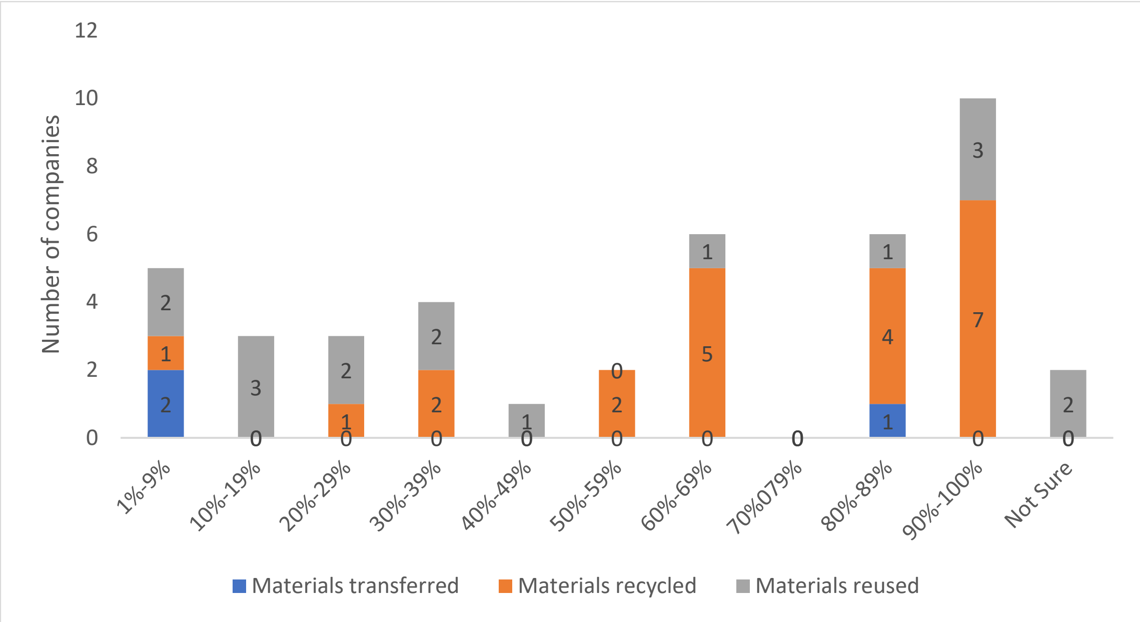

Figure 4.14: Quantities of materials reused, transferred, and recycled.

Of the 17 companies that reused waste onsite and from the total of 100% of waste they reused monthly, two (12%) claimed that they reused 1%-9%, three (16%) 10%-19%, two (12%) each 20%-29% or 30%-39%, one (6%) each 40%-49%, 60%-69%, or 80%-89%, and three (18%) 90%-100%. Two (12%) were unsure about materials reuse.

The participants were asked to give brief details of the type of waste materials that they reused in their companies. One each stated they reused ash; pallets; aluminium cans and plastics; ammunition powder; residual cement; residual fertilisers and plastic traces; a collection of bottles, card boxes, papers, iron, copper, and e-waste; e-waste; paper and boards; timber and drums; or pallets and e-waste by returning them to the production process. Three companies reused maize, flour, and other food spills, and four reused plastics and glasses by returning them to the production process. A closed-loop recycling technology was used to reuse plastic, aluminium, and steel without changing their qualities and glass was crushed to make it reusable.

According to DEA (2018), waste accumulation can be avoided in several ways, such as by shipping materials to another process to be reused as raw materials. The survey results revealed that of the three companies that transferred materials to be reused for other manufacturing processes outside their organisations, two (67%) transferred 1%-9%, and one (33%) 80%-100%. In addition, the respondents were asked to briefly describe the type of materials they shipped to other organisations to be reused as raw materials. The results showed that materials such as metal scraps, batteries, e-waste, coal ash, fluorescent tubes, and polyethene terephthalate plastics were transferred to other organisations to be reused for a different manufacturing process.

If waste cannot be avoided and reused, the following feasible and safe method to protect the environment would be to recycle it (DEA, 2018). Of the 22 companies that recycled waste, one (5%) each recycled 1%-9% or 20%-29%, two (9%) each 30%-39% or 50%-59%, five (22%) 60%-69%, four (18%) 80%-89%, and seven (32%) 90%-100% of monthly waste accumulation. The participants were asked to specify or give details of waste materials collected by recycling companies. The waste materials taken by recycling companies were steel, plastic, paper, aluminium, fibre, glass, old pallets, cans, cardboard, used oil, painted bumper, coil stools, thermoplastic scrap, and tyres.

4.5.1.3. Landfilling

Landfilling waste is an unfavourable option along the waste management hierarchy (DEA, 2018). Therefore, the participants were asked if they transferred their waste to landfills and to state how much they disposed of monthly, shown in Figure 4.15.

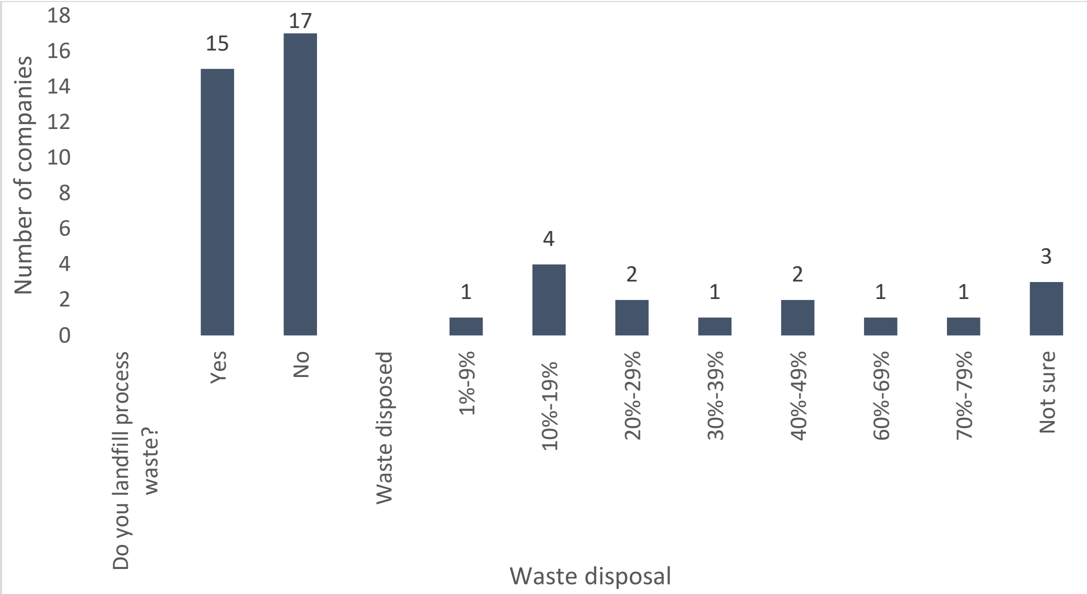

Figure 4.15: Waste disposal

Of the 32 surveyed companies,15 (47%) shipped waste to landfills. Of these companies, one (7%) landfilled 1%-9%, four (26%) 10%-19%, two (13%) 20%-29%, one (7%) 30%-39%, two (13%) 40%-49%, and one (7%) each 60%-69% or 70%-79% of their monthly waste accumulation. Lastly, three (20%) companies were unsure how much waste they disposed of in landfills. The survey results revealed that toxic metals with grease, non-recyclable content, e-waste, empty chemical containers, chip waste, oily rags, and aluminium metals were of the waste materials taken to landfills by companies.

4.5.2. Wastewater

Water is one of the essential raw materials for many manufacturers (Bashir *et al*., 2022). The participating persons were asked if their organisations used water for production processes and to specify the amount of water they used per month (in litres). This is depicted in Figure 4.16.

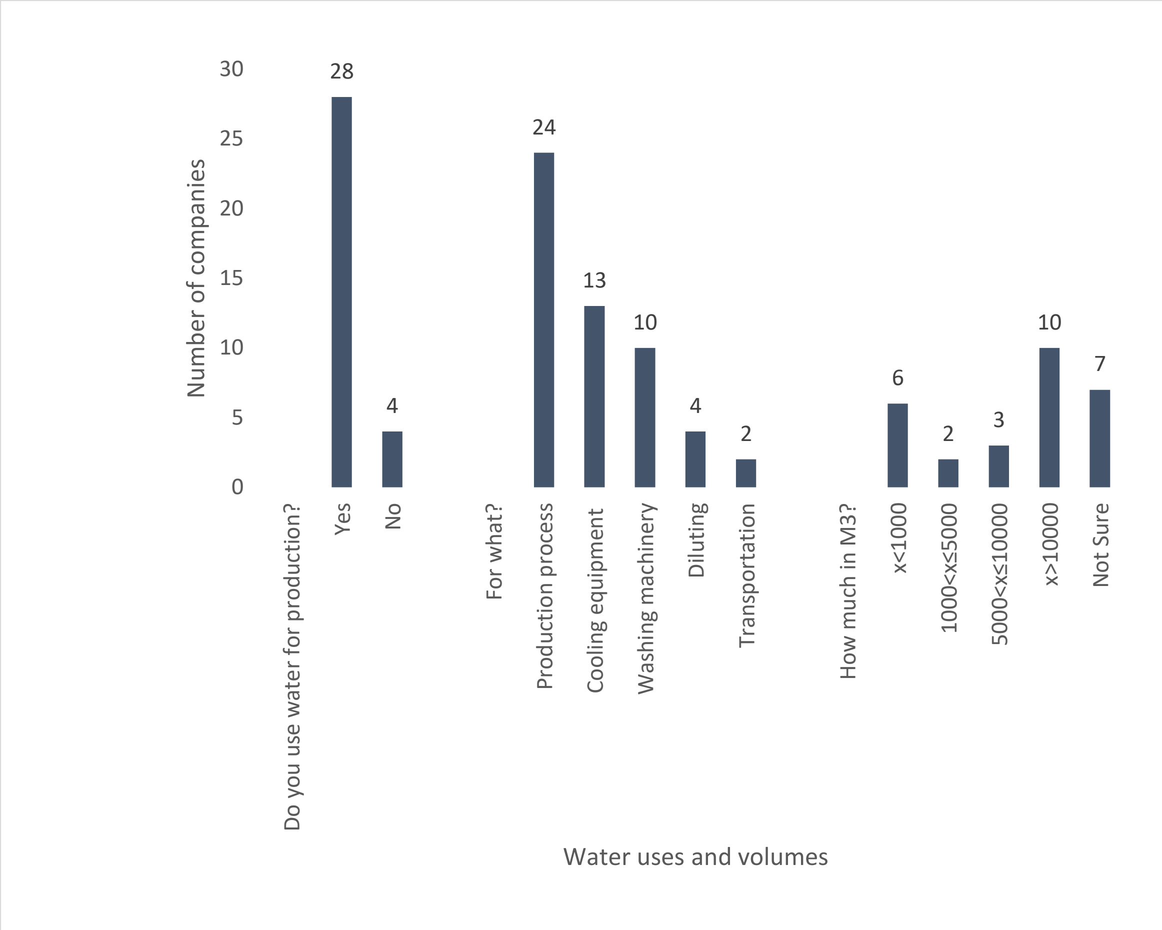

Figure 4.16: Water use and volume

Of the 32 participating companies, 28 (88%) used water for production processes. The companies' water usage was counted independently from each other, that is, some companies used water for more than one purpose. Therefore, out of these companies, 24 (86%) used it directly for production processes, 13 (46%) for cooling equipment, 10 (36%) for washing machinery, four (14%) for dilution, and two (7%) for transporting products.

The survey revealed that six (21%) companies consumed less than 1 000, two (7%) 1 000 but less than 5 000, three (11%) 5 000 but not more than 10 000, and 10 (36%) more than 10 000 cubic meters of water per month. Lastly, seven (25%) companies were unsure about the amount of water they consumed.

4.5.2.1. Wastewater recycling

The study participants were asked to state if their company recycled wastewater, the amount of wastewater recycled monthly. Their responses are displayed in Figure 4.18.

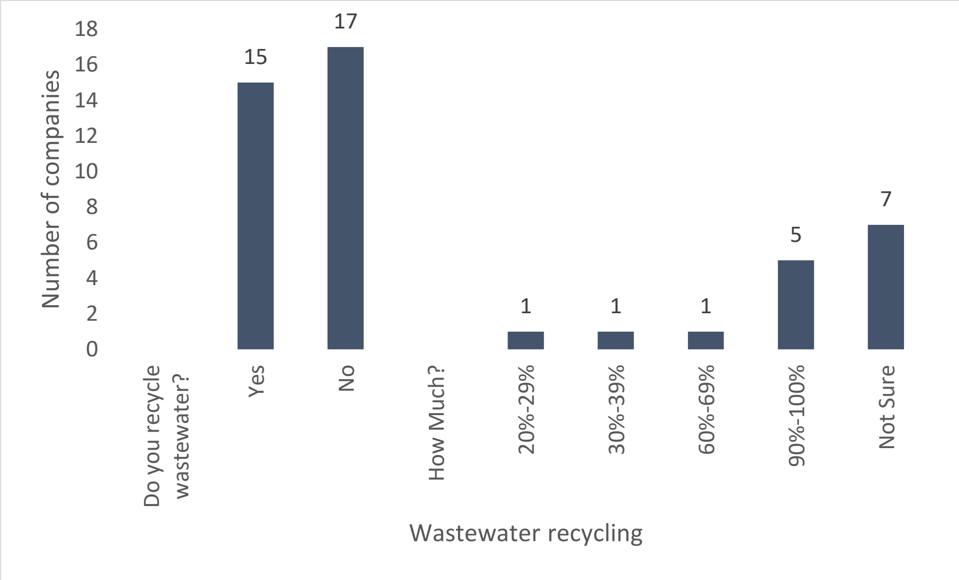

Figure 4.17: Wastewater recycling

Of the 32 participating companies, under a half (47%; n=15) recycled wastewater. The participants were asked to specify the process they used to treat and recycle wastewater. Processes such as reverse osmosis, LED process (for water disinfection), and clarifiers to recirculate water were used by some companies to treat wastewater. Four companies specified that they had installed a mini treatment plant internally to treat wastewater, which was reused for flushing toilets and washing machinery. One participant said they pumped back wastewater to a quarry as slimes. The slimes were allowed to settle where the sand remained, and water flowed back into the quarry dam. Therefore, water was pumped back to the processing plant for reuse. Another respondent stated that they used a closed-loop system where water was used several times in boilers to form steam.

Of the total number of companies that recycled wastewater, one (7%) each recycled 20%-29%, 30%-39% or 60%-69%, and five (32%) 90%-100% of their total monthly wastewater accumulation. Seven (47%) companies were unsure about how much wastewater they recycled per month.

In addition, the participants were asked if they discharge their process effluent out of their organisation, depicted in Figure 4.18.

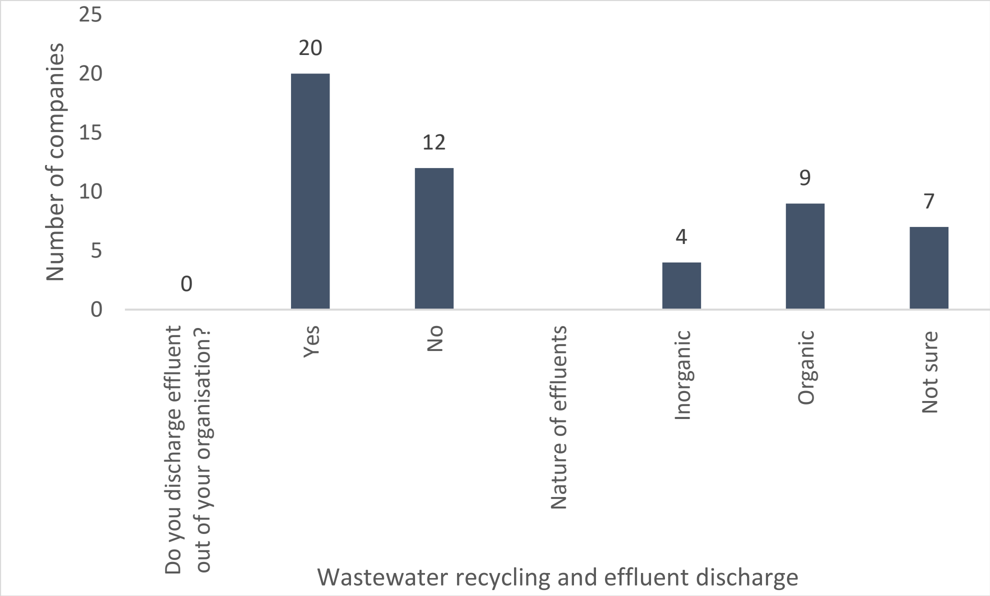

Figure 4.18: Wastewater recycling and effluent discharge

Of the 32 participating companies, 20 (63%) released effluents outside their organisations. Four (20%) and nine (45%) companies released inorganic and organic effluents, respectively, and seven (35%) were not sure about the nature of their effluents.

The participants were asked to estimate the volume of effluents they had discharged outside their organisations per month and the channels they discharged their effluents, displayed in Figure 4.19 as percentages.

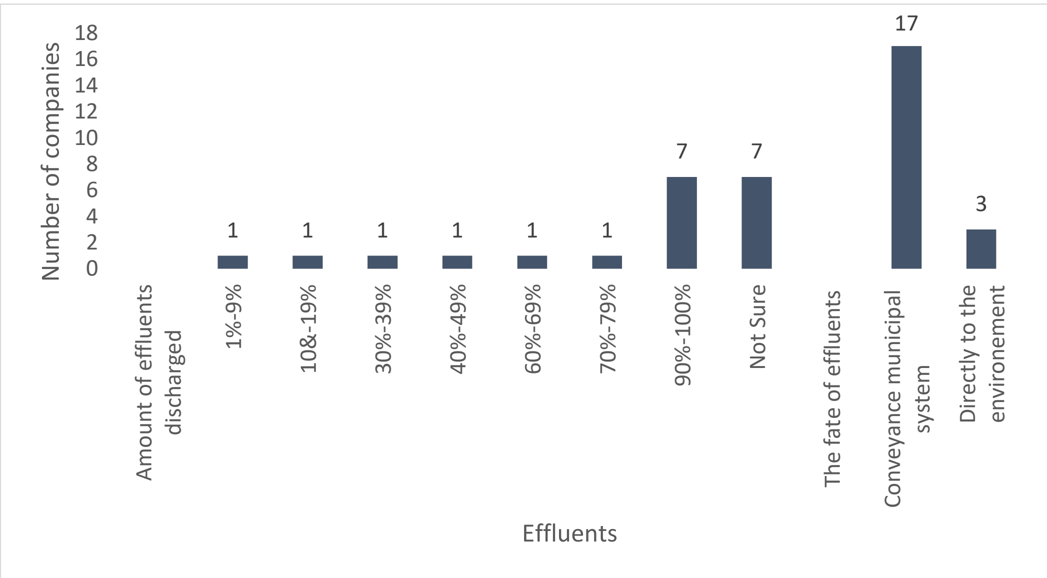

Figure 4.19: Amount and destination of effluents discharged.

Of the 20 companies that discharged effluent outside their organisations, one (5%) each released 1%-9%, 10%-19%, 30%-39%, 40%-49%, 60%-69%, or 70%-79%, and seven (35%) discharged 90%-100% of their monthly wastewater accumulation. Seven (35%) companies were unsure about the amount of wastewater they released. Most (85%; n=17) companies used a municipal conveyance system to discharge their effluents to wastewater treatment plants, and three (15%) discharged directly to the environment.

4.6. Section E: Barriers to implementing waste minimisation in the ISO 14001-certified manufacturing and service sectors

4.6.1. Internal technical knowledge, green procurement, and environmental awareness programs

The effectiveness of pollution and waste prevention is associated with the level of expertise and sustainable practices, such as green procurement and environmental education to plan and undertake actions to reduce waste and other forms of pollution (Pinto *et al*., 2017; Palange & Dhatrak, 2021; Kumar *et al*., 2022). Figure 4.20 displays participants' views considering the barriers influencing waste minimisation and pollution prevention.

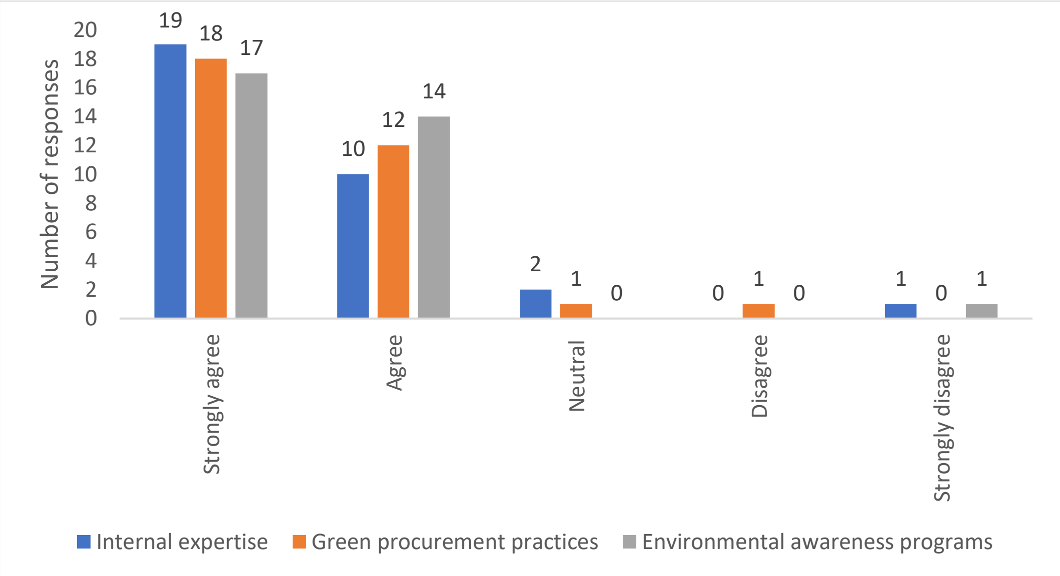

Figure 4.20: Barriers to effective pollution prevention and waste minimisation and management.

Of the 32 participants, 19 (60%) strongly agreed, 10 (31%) agreed, two (6%) were neutral, and one (3%) strongly disagreed that lack of internal expertise was the barrier to effectively minimising waste and pollution.

Of the 32 participants, 18 (56%) participants strongly agreed, 12 (38%) agreed, and one each (3%) was neutral or disagreed that lack of green procurement was a barrier to effectively minimising pollution and waste.

Of the 32 surveyed companies, 17 (53%) participants strongly agreed, 14 (44%) agreed, and one (3%) strongly disagreed that the lack of environmental awareness programs was a barrier to effectively minimising and managing waste and preventing pollution.

4.6.2. Poor legislation enforcement, low value of recyclables and low cost of landfilling as well as absence of waste treatment options

Pollution prevention, waste minimisation and management require stringent laws and regulations (Palange & Dhatrak, 2021; Kumar *et al*., 2022). In addition, to move up the waste management hierarchy, private and public sectors must invest more in technology that effectively treats waste and reduces pollution (Pinto *et al*., 2017). Figure 4.21 below depicts participants' views regarding barriers to pollution prevention, waste minimisation and management barriers.

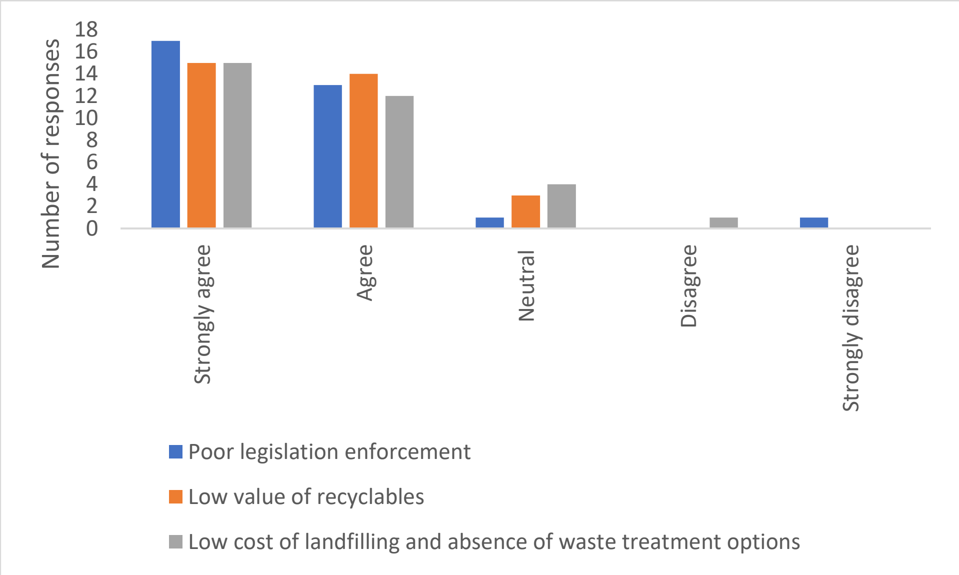

Figure 4.21: Barriers to effective pollution prevention and waste minimisation and management

Of the 32 respondents who partook in this research, 17 (53%) strongly agreed, 13 (41%) agreed, and one (3%) each was neutral or strongly disagreed that poor legislation enforcement was the barrier to effectively minimising pollution and waste.

Of the 32 surveyed companies, 15 (47%) participants strongly agreed, 14 (44%) agreed, and three (9%) were neutral in considering that the low value of recyclables was the factor that impeded effective waste minimisation and management.

Of the 32 participants, 15 (47%) participants strongly agreed, 12 (38%) agreed, four (12%) were neutral, and one (3%) disagreed that the low cost of landfilling waste and lack of waste treatment options impede effective waste minimisation and management.

4.7. Impact of ISO 14001 on organisations and their waste minimisation & management and pollution prevention ratings

The literature review discussed the ISO 14001 standard as having various impacts on organisations, such as economic and environmental impacts (Fel-Baffoe *et al*., 2013; Pinto *et al*., 2017; Johnson, 2018; Waxin *et al*., 2020). Figure 4.22 shows the impact that ISO 14001 EMS has on the participating companies and their rating of actions towards avoiding and minimising waste and pollution.

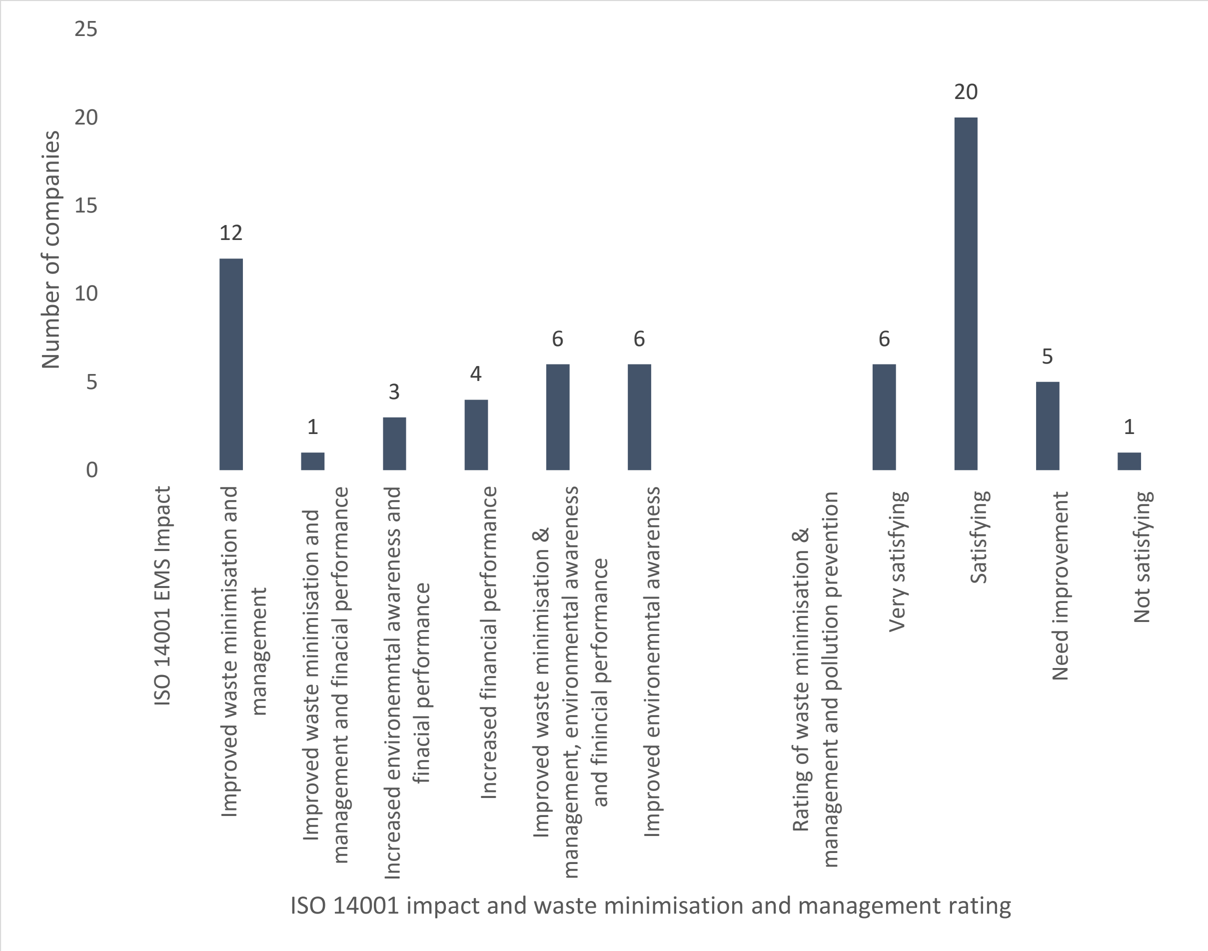

Figure 4.22: Impact of ISO 14001 EMS and pollution prevention, waste minimisation and management rating

Of the 32 surveyed companies, 12 (38%) stated that ISO 14001 EMS enhanced their waste minimisation and management, whereas one (3%) enjoyed improved waste minimisation, management, and financial gains from the standard. In addition, three (9%) companies experienced enhanced environmental awareness and financial benefits, four (13%) experienced financial gains, and six (19%) realised improvement in waste minimisation and management, environmental awareness, and financial profit. Lastly, six (19%) companies had improved environmental awareness.

Six (19%) participating companies were very satisfied, and 20 (63%) were satisfied with their waste minimisation and management efforts. However, five (16%) stated that their waste minimisation measures need improvement, and one (3%) was not satisfied with its efforts towards waste minimisation efforts.

4.8. Statistical correlations

Often the effectiveness of ISO 14001 EMS is related with various factors such as company size (e.g., Mungai *et al*., 2020; Wang & Zhao, 2020), international exposure (Singh *et al*., 2015; Johnson, 2018; Muktiono & Soediantono, 2022), and integration with other management standards (Marti-Ballester & Simon, 2017; Purwanto *et al*., 2020; Fahmi *et al*., 2021).

Large corporates have a sizable annual turnover compared to small and medium-sized enterprises, which can be a drawback for them to accumulate money to bring in technological innovation to improve their processes regarding the environment and realise the benefits associated with technology (Waxin *et al*., 2020). Companies, especially those within the international market, adopt management standards to keep up with global competitors (Singh *et al*., 2015; Mungai *et al*., 2020).

The duration of certification with ISO 14001 EMS reflects the experience that companies have in managing their environmental activities. The ISO Institute wants companies to produce high-quality products that do not immediately impact the environment and people (ISO, 2015). Therefore, they created ISO 45001 OHSMS, ISO 9001 QMS, and ISO 14001 EMS to regulate safety, quality, and environmental issues (ISO, 2015). All these management systems can be blended to improve safety, health, environment, and quality in industries, but they require funds to be implemented and maintained (ISO, 2015). Materials substitution, process modifications, materials reuse, and wastewater recycling are measures companies can employ to reduce pollution (Pinto *et al*., 2017).

The study correlated nonparametric variables using Kendall's tau-b and Spearman's rho to test relationships of some factors explained above to check their significance on waste minimisation and management efforts. Table 4.4 shows the correlations between company size versus international exposure, number of management systems, materials substitutions, process modifications, and wastewater recycling.

Table 4.4: Statistical correlations

Variables		N	Kendall's tau_b		Spearman's rho	
			Correlation coefficient	Sig. (2-tailed)	Correlation coefficient	Sig. (2-tailed)
Number of employees	**International exposure**	32	.131	.466	.131	.475
	Number of management systems	32	.090	.591	.096	.599
	Materials substitution	32	-.065	.719	-.065	.725
	Process modifications	32	-.024	.893	-.024	.896
	Wastewater recycling	32	-.043	.812	-.043	.817

*. Correlation is significant at the 0.05 level (2-tailed).

The research found no significant relationship between firm size (number of employees and annual turnover) versus international exposure, the number of management systems, materials substitution, process modification, and wastewater recycling. This means that companies, regardless of their size, can participate in international trading, small and medium-sized enterprises can bring in other management systems to improve their operations and processes, and the viability of companies to effectively implement strategies or bring in technology to recycle their wastewater does not depend on the size of the companies, but this stems from management decisions and commitment. Lastly, these findings imply that companies trading locally can bring in management systems of their choice to improve their operations and products.

In addition, the research correlated number of management systems companies had with international exposure, age of ISO 14001 EMS, materials substitution, process modifications, materials substitutions, waste disposal, wastewater recycling, and effluent discharge. This is shown in Table *4.5*.

Table 4.5: Statistical correlations

Variables		N	Kendall's tau_b		Spearman's rho	
			Correlation coefficient	Sig. (2-tailed)	Correlation coefficient	Sig. (2-tailed)
Number of management systems	**International exposure**	32	.117	.484	.126	.493
	Age of ISO 14001 EMS	28	.127	.416	.171	.383
	Materials substitution	32	**-.337***	**.044**	**-.363***	**.041**
	Process modifications	32	-.096	.565	-.103	.574
	Materials separation	32	-.128	.446	-.137	.455
	Waste disposal	32	-.034	.840	-.036	.844
	Wastewater recycling	32	-.054	.746	-.058	.752
	Effluent discharge	32	-.087	.602	-.094	.610

*. Correlation is significant at the 0.05 level (2-tailed).

It was determined that no significant association ties the number of management systems versus international exposure, the age of ISO 14001 EMS, process modification, waste disposal, wastewater recycling, and effluent discharge. These findings mean that companies that do not certify to formal management systems can implement measures to improve production. Even companies that have newly adopted ISO 14001 EMS can instantly invest in bringing in other management standards if they have the financial capacity to do so, and they do not have to wait long to find other alternatives to improve operations.

In addition, a weak significant link (r≈-0.3) existed between the number of management systems and materials substitution; this means that there is a chance that when companies increase their effort to substitute materials with less polluting ones, they will experience a lesser need to bring in more management systems since operations will be producing less waste or impacts to manage. Therefore, their overall production process will be enhanced.

The study further correlated the age of ISO 14001 EMS versus materials substitution, process modifications, materials separations, waste disposal, wastewater recycling, and effluent discharge. This is displayed in Table 4.6.

Table 4.6: Statistical correlations

Variables		**N**	**Kendall's tau_b**		**Spearman's rho**	
			Correlation coefficient	Sig. (2-tailed)	Correlation coefficient	Sig. (2-tailed)
Age of ISO 14001 EMS	**Materials substitution**	28	-.211	.205	-.244	.211
	Process modifications	28	-.309	.064	-.357	.062
	Materials separation	28	.069	.680	.079	.688
	Waste disposal	28	-.120	.470	-.139	.481
	Wastewater recycling	28	-.086	.606	-.099	.615
	Effluent discharge	28	**.345***	**.039**	**.398***	**.036**

*. Correlation is significant at the 0.05 level (2-tailed).

The study found no significant relationship between the age of ISO 14001 EMS certification versus materials substitution, process modification, materials separation, waste disposal, and wastewater recycling. These results imply that companies that have newly adopted the standard can also implement measures to reduce pollution and accrue the environmental benefits associated with the standard.

The research found a positive but weakly significant association (r≈0.3) between the age of ISO 14001 EMS certification and effluent discharge; this means there is a likelihood that once companies certify to ISO 14001 EMS, they are compelled to comply with the objectives they pre-stated and the condition of the ISO 14001 standard. This positive relationship between the age of ISO EMS certification and effluent discharge shows that there is a likelihood that the more companies use ISO 14001 EMS, eventually they will find innovative ways to reuse their wastewater and reduce volumes of discharged effluent.

Lastly, a correlation between materials substitution and process modification, wastewater recycling and effluent discharge, and material separation and waste disposal were established and displayed in Table 4.7.

Table 4.7: Statistical correlations

Variables		**N**	**Kendall's tau_b**		**Spearman's rho**	
			Correlation coefficient	Sig. (2-tailed)	Correlation coefficient	Sig. (2-tailed)
Material substitution	**Process modifications**	32	.465*	.010	.465*	.007
Wastewater recycling	**Effluent discharge**	32	.081	.653	.081	.660
Material separation	**Waste disposal**	32	**.355***	**.048**	**.355***	**.046**

*. Correlation is significant at the 0.05 level (2-tailed).

The study found a significant moderate positive association (r≈0.5) between materials substitution and process modification; this means that there is a likelihood that when companies take initiatives to replace materials that adversely impact the environment, they are likely to modify their processes to reduce pollution since materials substitution and process modifications are pollution prevention measures.

The study found a weak inverse significant relationship (r≈-0.3) between materials separation and waste disposal; this means there is a likelihood that when companies practice waste segregation on site, which is one of the effective measures of waste minimisation, their waste disposal volumes may decrease.

The study found no significant relationship between wastewater recycling and effluent discharge; this means that companies can treat their wastewater to reuse it onsite or as a pre-treatment to improve effluent standards before discharging it.

4.9. Conclusion

The study included 32 companies that were situated in four provinces in South Africa. Among these companies, most were situated in Gauteng Province, and they were manufacturers. The participating companies were small and medium-sized enterprises and larger firms as per the South African Industrial Classification, and most were trading outside South Africa. The study participants who filled out the survey were working closely with environmental and production issues in the companies.

The companies had set objectives for waste minimisation. General solid waste (plastics, metals, paper, and glass) was prominent, followed by hazardous liquid waste.

Most companies (n=24) had attained ISO 14001 EMS certification for more than 10 years and had more than two management systems embedded in their operations. The companies' other management systems included ISO 45001 OHSMS, ISO 9001 QMS, ISO 2200 FSMS, ISO 13485 QMS, and Forest Management certification.

There were various motivations behind companies’ certifying to the ISO 14001 standard, the leading reason being environmental concern, followed by customer requirements, boardroom decisions, access to the global market, pressure from stakeholders, and government regulations.

Most companies (n=23) had green procurement policies embedded in their supply chain process, and all had environmental awareness campaigns to reduce pollution. A minority of the companies (n=10) practised raw materials substitution, and most (n=17) modified technologies, processes, or products to reduce waste, emissions, and environmental incidents and speed up production processes. Different approaches were implemented for such substitutions and modifications.

Most companies (n=28) had the initiative to separate waste onsite; 17 reused it onsite, three transferred it to other organisations for reuse, and 22 recycled it. A few companies (n=7) reused, most (n=18) recycled, and one transferred over 49% of its monthly waste. Almost half of the companies (n=15) landfilled waste, and five landfilled over 49% of their monthly waste.

Most companies (n=28) used water as raw material in the production line, i.e., manufacturing, transportation, cooling and washing equipment, and diluting. Under a half (n=13) used over 4999 M^3 of water monthly. Almost half (n=15) of the companies recycled wastewater, and six recycled over 50% of their monthly water. A total of 20 companies discharged either pre-treated or untreated wastewater outside their organisations via either municipal wastewater channels (n=17) or deposited directly onto the environment (n=3). The state of effluents discharged included inorganic (n=4), organic (n=9), and others were unsure (n=7). The companies employed different processes to treat and recycle wastewater, such as reverse osmosis, LED process and installed mini-treatment plants. Nine companies discharged over 50% of their monthly wastewater.

Lack of internal technical knowledge, green procurement, environmental awareness programs, poor legislation enforcement, low value of recyclables and landfilling, and absence of waste treatment options were barriers impeding effective waste and pollution reduction.

The ISO 14001 EMS improved the companies' waste minimisation and management, environmental awareness, and financial performance, and over 50% of the companies were satisfied with their waste and pollution prevention efforts.

The firm size had no association with any investigated factor. The number of management systems was associated only with materials substitution, and the age of ISO 14001 EMS certification with effluent discharge, materials substitution with process modifications, and materials substitution with waste disposal. However, these relationships were represented by a weak association.

5. Chapter 5: Analysis and Discussion

5.1. Introduction

This chapter provides insights gained from analysis of the research data. These are discussed in relation to the research objectives and the literature review.

It is mandatory within the International Organisation of Standards (ISO) 14001 standard or Environmental Management System (EMS) for companies to set environmental objectives and targets (ISO, 2015). Published studies suggested that different companies have various motivations behind their ISO 14001 EMS certification and so their performance according to the standard may vary (Pinto *et al*., 2017; Vílchez, 2017; Johnstone & Hallberg, 2020; Waxin *et al*., 2020; Muktiono & Soediantono, 2022). Thus, the standard does not always provide positive results (Zobel, 2013; Boiral *et al.,* 2017; Wang & Zhao, 2020; Tirgil *et al.,* 2021). In contrast, other researchers stated that the standard had helped companies both economically and environmentally (Matela, 2006; Pinto *et al.,* 2017; Vílchez, 2017; Johnson, 2018; Johnstone & Hallberg, 2020; Waxin *et al.,* 2020; Muktiono & Soediantono, 2022).

In South Africa, the impact of ISO 14001 EMS on monetary benefit was studied by Johnson (2018), who found a positive link between the standard and economic gains. However, there are few studies describing the relationship between waste minimisation efforts and ISO 14001 EMS in South Africa. Therefore, the present study intended to fill that gap by investigating if the ISO 14001 standard benefited companies in helping them execute pollution prevention, waste minimisation and management measures.

5.2. Background of the companies

This section discusses Section A of the survey questionnaire. Most of the companies were situated in Gauteng Province, primarily since it is the central economic hub in South Africa (Stats SA, 2022). The study participants who completed the survey were responsible for undertaking environmental activities in the companies, which makes their responses very pertinent to the study objectives and investigation.

The study covered a wide range of industries: most were manufacturing companies which significantly adopted ISO 14001 EMS certification, more so than any other industrial sector globally (Johnson, 2018). In addition, over 50% of the companies were large firms that employed more than 250 people, had an annual turnover exceeding R170 million, and conducted business internationally, making them large enough to afford to bring in technological innovations and resources to help them implement measures to manage environmental actions effectively (Boiral & Sala, 2012; Waxin *et al*., 2020; Alsulamy *et al*., 2022).

In accordance with ISO 14001 EMS, all the participating companies had goals and targets for waste minimisation, and with this proactive approach, waste minimisation and pollution prevention are obtainable. General solid wastes such as plastics, metals, paper, and glass were found to have a high recycling rate in South Africa (DEA, 2018), particularly involving those materials which most companies generated at the end of production processes.

Although all the participating companies were ISO 14001 certified, only a minority of the companies had been certified for more than 10 years. Almost half of the companies had more than two management standards to assist ISO 14001 EMS indicating that ISO 14001 EMS blends well with different management standards to produce enhanced outcomes that benefit companies environmentally and economically (Marti-Ballester & Simon, 2017; Purwanto *et al*., 2020; Fahmi *et al*., 2021).

Standards that the companies blended with ISO 14001 EMS were ISO 45001/OHS 18001 Occupational, Health and Safety Management System (OHSMS), ISO 2200 Food Safety Management System (FSMS), ISO 9001 Quality Management System (QMS), ISO 13485:2016 QMS, and Forest Management.

5.3. Motivation of the companies to certify to ISO 14001

This section describes the results obtained from Section B of the questionnaire. The motivation behind the participating companies certifying to the ISO 14001 standard can be thematically classified as internal or external (Johnson & Hallberg, 2020). Most companies certified to the ISO 14001 standard because of internal adoptive motives, i.e., over 70% certified in response to environmental concerns, half to customers' pressure, and over 30% to boardroom decisions. The first is in contrast with the results published by Zobel (2016) and Boiral *et al*. (2017), who stated that companies certified to the standard to open doors for international trading. Szoke (2021) suggested that

South African companies certified to the standard for financial gain and so environmental issues were secondary motivators.

Other reasons, such as government regulations, customer requirements and access to international markets, influenced a few companies to certify to the ISO 14001 standard. This is because trading customers require their suppliers to have ISO 14001 EMS certification as a pre-requisite in their trading deals (Gazoulit & Oubal, 2021). This result agrees with Johnson (2018) and Gazoulit and Oubal (2021), who found that international customers required companies to be certified to ISO 14001 EMS and to comply with necessary regulations. One of the essential conditions of the ISO 14001 standard is that companies must develop and maintain a protocol to pinpoint and provide access to the legal and other regulations to which they subscribe and that are appropriate to the environmental aspects of their operations, goods, or services (ISO, 2015).

5.4. Pollution prevention measures as a waste minimisation approach in the ISO 14001-certified manufacturing and service sectors

This section discusses Section C of the survey questionnaire regarding the different measures the participating companies employed to reduce or prevent pollution.

5.4.1. Green procurement policy and environmental awareness campaigns

Over 70% of the participating companies had green procurement policies embedded in their purchasing processes - a vital sustainable approach in ensuring that products are purchased from environmentally considerate suppliers such as those certified with ISO 14001 EMS and ISO 9001 QMS and which reduces waste and pollution (Bag *et al*., 2022).

To improve the safety, health, environment, and quality in the internal operations of a company, ISO 14001 EMS wants organisations to source their equipment or materials from environmentally considerate suppliers (ISO, 2015). Therefore, a green procurement policy was viewed as the internal approach towards sustainable waste management, pollution prevention, the circular economy (CE), and cleaner production. It encourages a green supply chain to ensure that eco-friendly materials are used in the production line to produce products with a lower environmental impact (ISO, 2015).

Results from the present study also showed that all the companies hosted environmental awareness education campaigns to educate employees on environmental issues related to production processes. It requires that employees have proper knowledge or awareness to avoid or reduce impacts emanating from production processes (Waxin *et al*., 2020). Environmental education is vital to employees because it promotes their understanding of the environmental regulatory concerns of their company leading to an increase in the degree of ecological understanding which will help companies comply with regulations. Therefore, as with green procurement, increased environmental education was considered an internal pollution prevention measure. This result confirmed research conducted by Matela (2006), Johnstone (2020), Sennoga and Ahmed (2020), Waxin *et al*. (2020), Fahmi *et al*. (2021), Szoke (2021), and Muktiono and Soediantono (2022) who reported that ISO 14001-certified companies that host environmental awareness campaigns increase the ecological education of employees.

5.4.2. Materials substitution

Over 30% of the companies substituted raw materials with eco-friendly materials, a positive waste and pollution minimisation approach. On waste minimisation, this supports the findings of Fel-Baffoe *et al*. (2013), Pinto *et al*. (2017), Johnson (2018), and Waxin *et al*. (2020), and on emission reduction (Bashir *et al*., 2022). Therefore, ISO 14001 EMS made some companies realise the need to substitute materials with those of a lower environmental impact and, at the same time, shorten the production process time.

5.4.3. Technological, process, or product modification

The companies used various process modifications to improve operations and environmental performance (EP). Over 50% considered this approach as their way of reducing process waste and pollution. This supports the finding by Braccini and Margherira (2019) that companies introduced robotics to separate and sort waste, and those of Dhiman and Sidhu (2020) that companies used the Internet of Things, lean manufacturing, and Industry 4.0 to minimise waste generation and disposal.

Within the ISO 14001 standard, organisations must be innovative and consider aspects and impacts arising from the production process (ISO, 2015). Hence, modifications such as introducing machines to perfect production processes reduce waste and pollution. Furthermore, due to the flexibility of the standard, some companies can decide which innovation best suits their operations and budget and bring it on-site (ISO, 2015). This finding agrees with Bashir *et al*. (2022), who stated that firms used various ways to reduce their emissions – they switched to using photovoltaic solar panels to generate power to save energy, recaptured energy by utilising wheels for the ventilation, heating, and air-conditioning systems, installed fine mesh to suppress dust, avoided burning waste on-site, and used water that was chlorine-free for the alternating current. Likewise, Abid *et al*. (2022) found a positive association between technological innovation and ISO 14001 EMS.

The participating companies implemented this approach to reduce process waste, emissions, and environmental incidents and speed up production processes. These findings were in agreement with several studies which found that ISO 14001 EMS has an impact on reducing environmental incidents (Fel-Baffoe *et al*., 2013), waste (Fel-Baffoe *et al*., 2013; Pinto *et al*., 2017; Johnson, 2018; Waxin *et al*., 2020), energy conservation (Fel-Baffoe *et al*., 2013; Zobel, 2013; Zobel, 2015; Pinto *et al*., 2017; Johnson, 2018; Braccini & Margherira, 2019; Gazoulit & Oubal, 2021; Bashir *et al*., 2022) and emissions (Bashir *et al*., 2022).

5.5. Waste management measures towards waste minimisation to the final disposal of waste in the ISO 14001-certified manufacturing and service sectors

5.5.1. Solid waste

This section discusses measures that participating companies employed to prevent, minimise, and manage solid waste.

5.5.1.1. Separation at a source initiative

Various materials were separated on-site and had different destinations, such as on-site and offsite recycling, transfer to other manufacturers to be reused, and landfill disposal. On-site materials separation is an example of good housekeeping and the most critical approach within the CE, waste management hierarchy, and sustainable waste management, as it allows materials of an exact nature to be sorted and circulated in the economy before they can be classified as waste or as useless (DEA, 2018). This is because the ISO 14001 standard encourages repurposing and categorising waste into recyclables and non-recyclables and focuses on recovering energy from waste (ISO, 2015). In the present study, over 80% of the companies practised this approach, and as noted by Fel-Baffoe *et al*. (2013), ISO 14001-certified companies practised waste segregation at a source.

5.5.1.2. On-site recycling

Over 60% of the companies reused waste they separated on-site to reduce the need to buy additional raw materials. This is a practical financial and environmental approach to reduce pollution and waste while saving money to purchase raw materials for production (Johnson, 2018). On-site recycling requires technological innovation (Hens *et al*., 2018; Braccini & Margherira, 2019), and some companies employed different approaches to reuse waste from their production processes. The ISO 14001 EMS, therefore, encourages process innovation to reduce environmental impacts while also allowing companies to enjoy financial benefits. The quantities of waste volumes reused were different across the companies. Most companies reused less than 50% of their monthly waste, and the remaining reused more than 50%, and this indicates an improvement in EP because these industries extended the lifespan of materials and provided economic and environmental benefits. This finding confirmed the results reported by Fel-Baffoe *et al*. (2013) and Mungai *et al*. (2020) that ISO 14001 EMS assists companies in finding ways to reuse waste on-site.

5.5.1.3. Materials transfer

Some companies shipped waste materials to other organisations to be reused as raw materials, as ISO 14001 EMS encourages companies to find ways to ensure materials are circulated for a more extended period in the economy (ISO, 2015). Even though a few companies followed this approach, it still provides a financial benefit as waste shipped to other organisations is usually sold. Regardless of whether a few companies transferred waste to other organisations, it does not imply that those who did not partake in this process practiced poor waste management, since they participated in different operations along the waste management hierarchy and sustainable waste management. For instance, one company produced plastic products and re-melted all its plastic wastage on-site (internal recycling), so it did not transfer or recycle (external) its plastic wastage since it had an on-site technology. As a result, this company did not ship, externally recycle, or landfill any of its plastic waste, yet they were practising sustainable waste management. This illustration proves that companies must choose any or a combination of measures along the waste management hierarchy and sustainable waste management to reduce environmental impacts.

5.5.1.4. External recycling

The influence of the ISO 14001 standard on external recycling was measured by waste collection by recycling companies. Over 70% of the participating companies recycled waste such as steel, plastic, paper, aluminium, fibre, glass, old pallets, cans, cardboard, used oil, painted bumpers, coil stools, thermoplastic scrap, and tyres. Some of these waste materials have high recycling rates, as reported by the DEA (2018), and can easily be traded and recycled in South Africa. Furthermore, most companies recycled more than 60% of their monthly waste volumes, indicating an environmental benefit from the ISO 14001 standard. This finding agrees with reports by Marti-Ballester and Simon (2017), Johnson (2018) and Waxin *et al*. (2020) who found that ISO 14001 EMS helped companies to recycle their waste and improve their financial standing from the money they derived from selling scrap for recycling.

5.5.1.5. Waste disposal to landfill

Less than 50% of the companies were involved in waste disposal since not all waste materials can be reused, recovered, and recycled. As a result, companies must safely dispose of those types of waste (DEA, 2018). However, landfilling is not the preferred option along the waste management hierarchy (DFFE, 2020). It is the most prominent method in South Africa mainly because the price of landfilling waste and selling recyclables are often not appreciated and are low (Adeleke *et al*., 2021b). Most of the landfilled wastes were contaminated with hazardous substances. However, although the participating companies landfilled waste, they did not landfill 100% of the waste they produced monthly since some were reused, recycled, or transferred to other companies for reuse.

5.5.2. Wastewater recycling

Water is one of the raw materials used for manufacturing goods, as seen by more than 80% of the companies using it. Organisations need to reduce their consumption and consider water an essential aspect of their operations. It is also vital that companies prevent contaminating water resources or releasing effluent that is contaminated. Almost half of the companies recycled wastewater and had different ways of treating wastewater for recycling or before discharge. A few companies recycled more than

90% of their monthly wastewater, indicating an excellent environmental management practice. As with solid waste reuse, this approach requires technological innovation to be implemented, and the companies showed that the ISO 14001 standard provides flexibility to bring in technological innovation that is suitable for each company if, in the end, it provides environmental and economic benefits. The treated wastewater was reused for various reasons in the production line.

Analysis of the ISO 14001 EMS showed that it may have discrepancies as some participating companies were unsure how much wastewater they reclaimed. Since few companies discharged their effluents directly onto the environment, ISO 14001 EMS was not utilised effectively to conserve other receiving environments. This could be because ISO 14001 EMS allows organisations to select their environmental aspects and establish goals and targets to meet their objectives associated with those aspects (ISO, 2015). Therefore, the companies who stated that they were unsure about the amount of wastewater they recycled might not have perceived wastewater from an environmental perspective.

Since some companies took the initiative to recycle wastewater, ISO 14001 EMS was an effective tool that assisted almost half of the companies in considering wastewater as one of their organisational environmental aspects. This finding supports research published by Mungai *et al*. (2020), Gazoulit and Oubal (2021) and Bashir *et al*. (2022) as to the positive correlation between ISO 14001 EMS and wastewater recycling.

5.6. Section E: Barriers to implementing waste minimisation measures in the ISO 14001-certified manufacturing and service sectors

5.6.1. Internal technical knowledge, green procurement, environmental awareness programs, poor legislation enforcement, low value of recyclables and low cost of landfilling as well as absence of waste treatment options

A relative lack of internal expertise, green procurement, environmental awareness, waste treatment options, weak legislative enforcement, and low cost of recyclables and landfilling tax were the factors hindering effective waste management and pollution prevention. as with the ISO 14001 standard, pollution prevention, waste minimisation and management require internal technical knowledge to handle and shift the materials from being disposed of in landfills up the waste management hierarchy, i.e., reuse, recycle, and recover. This supports the results reported by Alnavis *et al*. (2021) in Indonesia and Polasi *et al*. (2020) in South Africa that internal expertise was vital to ensuring the efficacy of ISO 14001 EMS in managing environmental issues.

According to ISO 14001 EMS, effective waste minimisation depends on internal processes employed by companies, such as providing environmental education to employees to provide them with the essential skills or knowledge on waste handling matters. This agrees with the findings of Kitila (2015), who found that one of the problems associated with the South African waste crisis was a lack of environmental awareness in municipalities and private organisations.

Regarding legislation enforcement, this study supports the results reported by Kitila (2015) and Polasi *et al*. (2020) that poor legislation enforcement was one of the causes of the South African waste problem. This is because a collection of legislation binds all countries and South Africa is no exception and has laws to protect the environment by reducing waste disposal, air emissions, and raw materials consumption (DEA, 2018).

The low cost of recyclables produces fewer waste recycling markets. In addition, as the cost of landfilling waste is low, companies will not invest as much in technologies that will ensure that they move up the waste management hierarchy. Companies will see waste disposal as an affordable approach to managing waste. This finding agrees with those reported by Adeleke *et al.* (2021b), who found that the low landfill tax may contribute to the South African waste crisis. Lastly, not all waste materials can undergo waste minimisation, and certain waste materials are contaminated to a point where there is no technology to make them valuable again. Therefore, companies have one option, to dispose of them.

5.7. Impact of ISO 14001 on organisations and their waste minimisation

Benefits such as improved waste minimisation, environmental awareness, and financial performance were achieved by the companies. On waste minimisation, this agrees with the findings of Fel-Baffoe *et al. (*2013), Pinto *et al. (*2017), Johnson (2018) and Waxin *et al*. (2020), on environmental awareness, (Johnstone, 2020; Waxin *et al*., 2020; Fahmi *et al*., 2021; Szoke, 2021; Muktiono & Soediantono, 2022), and lastly, on economic benefits (Marti-Ballester & Simon, 2017; Pinto *et al*., 2017; Johnson, 2018). Although Wang and Zhao (2020) found that ISO 14001 EMS hurt financial performance, and Zobel (2013, 2015, 2016) found inconclusive outcomes, no companies endured a financial performance decline.

Most of the companies were satisfied with their waste and pollution prevention efforts. However, a few were not, which means there is still a need to be innovative by investing in technologies and green supply chain management methods to reduce waste disposal volumes and pollution since the waste management hierarchy requires industries to reach a point where zero waste is taken to landfills by circulating it in the economy for a longer period.

5.8. Statistical correlations

Although there was no significant association between the company size versus internal processes to reduce pollution (i.e., materials substitution, process modification, and wastewater recycling) and the number of management systems, it implies that small companies can implement pollution prevention measures and management systems to reduce pollution. However, measures such as adopting advanced technologies and management systems require funds that might not be available to small and medium-sized enterprises (Boiral & Sala, 2012; Alsulamy *et al.,* 2022). These funds are needed to purchase equipment, fund human resources, and audit, among other things (Alsulamy *et al.,* 2022). Therefore, small and medium-sized enterprises should carefully choose safety, health, environment and quality aspects and objectives they can afford (Boiral & Sala, 2012; Alsulamy *et al.,* 2022).

A significant number of the participating companies were trading outside South Africa, and no significant relationship was found between international exposure versus company size and the number of management systems. This means that companies without the ISO 14001 standard can take their business outside South Africa and adopt other management systems. However, establishing a fruitful business might take much effort since some international companies require the ISO 14001 EMS certificate before launching a business deal (Wang & Zhao, 2020).

The number of management systems versus the age of ISO 14001 EMS certification, process modifications, waste disposal, wastewater recycling, and effluent discharge, as well as the age of ISO 14001 EMS certification versus process modifications, materials substitution, materials separation, waste disposal, and wastewater recycling, were insignificant. This means that implementation of green operations is independent of the number of management systems and the period they are used. This is because management systems are written processes, and the practical part relies on companies' creativity and innovation to implement them successfully (ISO, 2015). This implies that any organisation can plan and execute green operations, regardless of their formal EMS, QMS, OHSMS, or FSMS.

Thus, management systems do not automatically make organisations environmentally responsible, but their actions play a role in performance (Boiral & Henri, 2012; Boiral *et al*., 2017). Companies without ISO 14001 EMS certification can be creative and innovative in modifying their operations to limit waste or pollution. Zobel (2016) stated that having ISO 14001 EMS certification does not automatically make companies green, their actions do, and this confirmed the report by Zobel (2015), who did not find a statistical significance linking ISO 14001-certified and uncertified companies. Therefore, companies do not need to wait for years before supplementing ISO 14001 EMS with other management systems since there was no significant link between the age of ISO 14001 EMS certification and the number of management systems. Ideally, a company can implement both ISO 9001 QMS and ISO 14001 EMS simultaneously, or another can opt only to adopt ISO 9001 QMS over ISO 14001 EMS.

Although this study found no association between the number of management systems and the age of ISO 14001 EMS certification on internal processes (i.e., process modification, materials separation, wastewater recycling, and waste disposal), there was an association between the number of management systems versus materials substitution and the age of ISO 14001 EMS certification versus effluent discharge. These findings imply that companies taking initiatives to reduce process pollution and waste will eventually not need more management systems or changes to perfect their operations since they will emit less pollution or waste. The longer companies have the ISO 14001 standard, the more they will eventually plan and execute measures to improve their operations, i.e., wastewater reuse. However, these relations were represented by a very weak correlation, which means even companies that still need the standard or those that have newly adopted the standard, they can implement measures to recycle and reuse their wastewater internally.

There was an association between process modification and materials substitution, as well as on-site materials separation and waste disposal. The former implies that companies who perceive a need to shy away from materials with high pollution and bring in those with a lower impact will further perceive a need to modify their processes, products, or services to emit fewer pollutants. The latter implies that the more companies that use eco-friendly raw materials in their production line, the lower will be their waste output. The steps in the waste management hierarchy are linked, but effective waste minimisation aims to avoid waste handling and disposal. There was no association between wastewater recycling and effluent discharge because the two processes are independent. Thus, companies can treat wastewater internally and discharge it at a later stage.

5.9. Conclusion

Most of the participating companies in the four South African provinces were certified to ISO 14001 EMS for internal reasons, which include environmental concerns (the most important), management decisions and pressure from stakeholders and external reasons, such as government regulations, customer requirements and access to international markets. In addition, the companies had a green procurement policy embedded in their operations, and they hosted environmental awareness education to equip employees with the necessary knowledge on ecological matters.

The companies had objectives for waste minimisation, so that few substituted materials with ones that had a lower environmental impact, and about half modified production processes to reduce pollution and waste. In addition, most companies separated materials for distinct reasons, such as reuse, recycling, shipping to other organisations, and disposal.

Over 80% of the companies used water as one of the inputs for production lines, i.e., cooling equipment, diluting, washing, and transportation. Most used more than 1000 M^3 of water monthly, over 50% internally recycled wastewater, and over 80% discharged effluents via municipal wastewater systems and less than 20% directly onto the environment. The discharged effluents were either organic or inorganic.

Lack of environment education campaigns, green procurement policy, internal expertise, poor legislative enforcement, unavailability of waste treatment options, low cost of recyclables and landfilling were the barriers that negatively influenced pollution prevention, waste minimisation and management.

The ISO 14001 EMS has impacted most companies in realising improvement in pollution prevention and waste minimisation and management. Most companies were satisfied with their pollution and waste prevention.

6. Chapter 6: Conclusions and Recommendations

6.1. Introduction

Studies have investigated the impact of the International Organisation of Standards (ISO) 14001 standard or Environmental Management System (EMS) and reported that it positively affects the environmental and financial performance of companies. In addition, the ISO 14001 standard is compatible with ISO 9001 Quality Management System (QMS), ISO 45001 Occupational, Health and Safety Management Systems (OHSMS), and ISO 2200 Food Safety Management System (FSMS) (Marti-Ballester & Simon, 2017; Purwanto *et al*., 2020).

South African companies have realised the economic and social benefits of certifying to the ISO 14001 standard. However, a review of the literature indicated that there was a need for research to investigate the impact of the ISO 14001 standard on the environment, especially regarding waste. Hence, the present research prepared a questionnaire for distribution to South African representatives of business to study the impact of ISO 14001 EMS on waste minimisation in their businesses.

This chapter presents study conclusions aligned with the study objectives. These are followed by recommendations that can be implemented from the study.

Study objective 1: To determine the reasons for ISO 14001 certification in manufacturing and service sectors

One of the essential conditions of the ISO 14001 standard is that companies must develop and maintain a protocol to pinpoint and provide access to the legal and other regulations to which they subscribe and that are appropriate to the environmental aspects of their operations, goods, or services (ISO, 2015). Published reports indicate that the efficacy of ISO 14001 EMS is often associated with international trading, the maturity of environmental management systems, company size, resources, and other management systems (Marti-Ballester & Simon, 2017; Mungai *et al*., 2020; Wang & Zhao, 2020).

Motivation behind the participating companies certifying to the ISO 14001 standard can be thematically classified as internal or external (Johnson & Hallberg, 2020). In the present study, reasons for ISO 14001 EMS certification were determined from analysing relevant published literature. These included customer requirement, boardroom decision, environmental concern, access to the global market, pressure from stakeholders, government regulations, pressure or demand from employees, pressure/demand from guests. The survey results regarding the motives behind companies' certifying to ISO 14001 EMS were counted independently from each other, that is, some companies certified to the standard for more than one reason.

Reasons for the 32 participating companies certifying to the ISO 14001 standard were as follows:

The most common reason (78%; n=25) for certification to the ISO 14001 standard was environmental concerns. This result supports those published by Johnstone and Hallberg (2020).

Another common reason (50%; n=16) for certification was in response to customer requirements. Published results report that trading customers require their suppliers to have ISO 14001 EMS certification as a pre-requisite in their trading deals (Gazoulit & Oubal, 2021). In addition, Johnson (2018) and Gazoulit and Oubal (2021) found that international customers required companies to be certified to ISO 14001 EMS and to comply with necessary regulations.

Over a third (38%; n=12) of the participants indicated that their companies were certified on the grounds of boardroom decisions, or to gain access to global markets. These results contrast slightly with those published by Zobel (2016) and Boiral *et al*. (2017) who stated that companies decided to certify to the standard to open doors for international trading.

Less common reasons for ISO 14001 EMS certification were pressure from stakeholders (19%; n=6), government regulation (16%; n=5), and as a duty of care (3%; n=1). Szoke (2021) suggested that South African companies certified to the standard for financial gain and so environmental issues were secondary motivators.

Thus, there appeared to be no pressure from employees or guests for companies to certify. This may not reflect apathy towards the environment as shown by staff and guests but rather may reflect the need to provide training to sensitise staff and guests regarding the environment and the part that the company can play in sustaining it.

This discussion of study results supports the assertion that study objective 1 was suitable addressed.

Study objective 2: To identify measures for pollution prevention as a waste minimisation approach in the ISO 14001-certified manufacturing and service sectors

The ISO 14001 standard is a process-based management system that encourages the participating companies to implement measures to reduce waste and pollution from manufacturing goods and services. Therefore, certifying ISO 14001 EMS influenced companies to adopt cleaner technologies or innovations to reduce their ecological footprint.

A significant number of companies had embedded green procurement in their operations to source sustainable materials to realise sustainable waste management, pollution prevention, the circular economy (CE), and cleaner production. They used environmental awareness campaigns to think green, to avoid or reduce waste generation and disposal and other environmental pollution such as emissions. This agrees with the results of published research (Matela, 2006; Johnstone, 2020; Waxin *et al*., 2020; Fahmi *et al*., 2021; Szoke, 2021; Muktiono & Soediantono, 2022).

Initiatives such as substitution of materials that had a detrimental impact on the environment with those that are non-hazardous, and modification of manufacturing processes, technologies or products were used by companies to reduce their ecological footprint (reduction of waste and emissions), speeding up their production process, or a combination of both. Regarding the environment, however, most companies substituted raw materials to reduce process waste in contrast to emissions.

Firm size (number of employees and annual turnover) had no significant association with international exposure, the number of management systems, process modification, materials substitution, and wastewater recycling. The age of ISO 14001 EMS had no significant relationship with materials substitution, process modification, materials separation, waste disposal, and wastewater recycling. The number of management systems had no association with international exposure, the age of ISO 14001 EMS, process modification, waste disposal, wastewater recycling, and effluent discharge. No significant relationship was found between wastewater recycling and effluent discharge. A weak positive significant correlation was found between the age of ISO 14001 EMS and effluent discharge. A weak negative significant association was found between the number of management systems and materials substitution.

A significant moderate positive relationship was found between materials substitution and process modification. This indicates that ISO 14001 EMS is a process-based management system. It relies on innovations companies put in place to reduce waste and pollution since no strong relationship ties, e.g., the age of EMS, number of management systems, and size of companies with waste and pollution reduction measures. These results tie in with Johnson (2018), who found no existing association between firm size and ISO 14001 EMS effectiveness; Melnyk *et al*., (2003), who found a neglectable association between the age of EMS and corporate performance; and Singh *et al*., (2015) and Mungai *et al*., (2020) who found no influence of international exposure and firm on environmental performance (EP).

Overall, different technologies and materials were used to enhance production processes and reduce environmental impacts. These findings agree with published results (Fel-Baffoe *et al*., 2013; Pinto *et al*., 2017; Johnson, 2018; Waxin *et al*., 2020; Bashir *et al*., 2022).

This discussion of study results supports the assertion that study objective 2 was suitable addressed.

Study objective 3: To determine waste management measures towards waste minimisation to the final disposal of waste in the ISO 14001-certified manufacturing and service sectors

Most companies generated general solid waste (plastic, metals, glass, and paper). All the companies were found to be separating waste at a source. This finding supports results of research conducted by Fel-Baffoe *et al*., (2013). Waste materials that were separated onsite had different destinations, and some were reused onsite (internal recycling), or transferred to other organisations to be reused for other production processes, taken by a recycling company for further processing, and transported for landfilling. These findings were also reported by Fel-Baffoe *et al*. (2013), Johnson (2018) and Mungai *et al*. (2020).

Technological innovations such as closed loop, melting, crushing, and re-entering waste were used to reuse waste material in some companies as their internal recycling processes to reuse materials. Aluminium cans and plastics were the most waste materials that were reused. Metal scraps, batteries, e-waste, coal ash, fluorescent tubes, and polyethene terephthalate plastics were the waste materials that were transferred by companies to other companies to be reused as raw materials for different production processes. Steel, plastic, paper, aluminium, fibre, glass, old pallets, cans, cardboard, used oil, painted bumper, coil stools, thermoplastic scrap, and tyres were collected in companies for recycling. Waste materials such as metals with grease, non-recyclable content, e-waste, empty chemical containers, chip waste, oily rags, and aluminium metals were the waste materials that were disposed of in landfills by companies.

Most companies used water for production processes and consumed more than 1 000 M^3 per month in production lines, such as manufacturing and transporting goods, cooling equipment, washing machines, and diluting. Less than half of the companies recycled wastewater onsite that was later reused as grey water for flushing toilets and reused back into the production process. Technologies such as reverse osmosis, closed-loop systems, clarifiers, and a built-in wastewater treatment plant to treat wastewater were by companies to treat wastewater effluents. Similar results, 'wastewater recycling', were found by Mungai *et al*. (2020), Gazoulit and Oubal (2021), and Bashir *et al*. (2022).

Therefore, ISO 14001 EMS certification supports the contents of sustainable waste management, i.e., avoiding, reducing, reusing, and recycling waste to keep it circulating for a prolonged period in the economic cycle. It also supports wastewater treatment and recycling. In addition, ISO 14001 EMS supports innovations to reduce waste generation and disposal and improve wastewater effluent quality before discharge. For these reasons, the certification of ISO 14001 EMS positively influenced companies' waste minimisation efforts and, to a lesser extent, wastewater recycling and improving effluent quality.

This discussion of study results supports the assertion that study objective 3 was suitable addressed.

Study objective 4: To investigate barriers to implementing waste minimisation measures in the ISO 14001-certified manufacturing and service sectors

Lack of internal expertise, green procurement, environmental awareness, other waste management options or technologies, poor legislative enforcement, and low cost of recyclables and landfilling waste were the contributing factors to not realising effective pollution prevention, waste minimisation or effective management. This is in line with the finding of Kitila (2015), Polasi *et al*. (2020), and Adeleke *et al*. (2021b).

This brief discussion of study results supports the assertion that study objective 4 was suitable addressed.

Limitations of the study

Firstly, the study was geographically restricted and only covered four provinces in South Africa, viz., Mpumalanga Province, Limpopo Province, North West Province, and Gauteng Province. Therefore, the results of this study do not represent all companies that have ISO 14001 EMS in South Africa.

Secondly, most companies participated in international trading and so their international business partners might have affected or influenced their responses.

Thirdly, in Africa, ISO 14001 EMS adoption or certification is relatively small compared to other parts of the world. Thus, a small number of organisations in South Africa are ISO 14001-certified and this contributed to the small sample size.

Fourthly, the selection of participating companies and respondents was not random; they were purposively selected. The companies were selected because they were ISO 14001-certified, and the respondents were based on their occupations, i.e., they worked closely with environmental issues or production processes. Therefore, the finding does not include all industries in the selected provinces but only those with ISO 14001 EMS certification.

6.2. Recommendations

This section will provide recommendations from the conclusions reached in this study.

6.2.1. Financial provision for skills development and career advancement

Although no significant relationship was found between company size and internal processes, the adoption of cleaner production, such as sourcing sustainable raw materials, advanced technologies, and skilled people, requires money, and small and medium-sized enterprises might not have the necessary finances. The South African government should consider subsidising small and medium-sized enterprises with funds directed towards cleaner production. Such provision of finances will assist these enterprises in purchasing and upgrading machinery for cleaner production to have a long-term benefit on the environment and economy of South Africa.

6.2.2. Sharing of information

Individual businesses acting alone find it more difficult to achieve EP. Companies should be able to compare their EP to similar companies' performance, to enhance their environmental operations by evaluating operations against companies doing better environmentally. Thus, companies should be encouraged to form alliances and collaborations to pool their resources and share knowledge on environmental challenges, especially those in the same location. This would also facilitate ISO 14001-certified companies more accurately reporting information regarding their performance, both on the environment and economy.

Companies should also share information regarding the raw material they use and the type of waste materials they generate at the end of a production line. This will allow companies, especially those close to each other, to check if the waste materials of neighbouring companies are compatible with their raw material requirements. This will influence waste exchange and the CE.

6.2.3. Consideration of environmental aspects

Companies should consider all the environmental mediums as their aspects since some companies needed clarification about their performance on wastewater; this will encourage companies to evaluate their impact on receiving water bodies and implement measures to reduce water pollution.

6.2.4. Increasing the value of recyclables

Only a small proportion of the annual waste generated is recovered and recycled in South Africa, leaving enormous volumes of waste in landfills and in illegal dumps. Therefore, the South African government should close unregistered recycling facilities that accept waste materials and pay out a small amount to informal waste pickers who play a pivotal part in recovering waste. In addition, the South African government should increase the monetary value of waste retrieved per mass.

6.2.5. Enforcing stricter environmental measures and legislation

South African companies must ensure their operations do not detrimentally affect the receiving environment. However, there needs to be more and effective enforcement from government officials to check if companies comply with environmental legislation. The South African government should employ more environmental experts who will pay surveillance visits to companies for auditing. Companies with ISO 14001 EMS should be given special treatment by reducing surveillance visits and environmental liabilities, encouraging others to adopt the standard.

6.2.6. Investing in other waste management options

Currently, South Africa has one large waste-to-energy plant in the Western Cape Province. However, South Africa needs more such plants to manage garbage. Therefore, more investment should be negotiated and directed to build more Waste-to-Energy plants across the country to reduce waste disposed of in landfills and illegally dumped across the country.

6.3. Recommendation for further research

Although ISO 14001 EMS has been observed to have a positive connection with EP globally, and this study also found a positive effect of the standard on pollution prevention, waste minimisation and management in South Africa, it is not known how companies without a formal environmental management system would perform regarding the environment compared to ISO 14001-certified companies in South Africa. For this reason, future research could compare companies with ISO 14001 EMS to those without a formal EMS as to green supply chain management practices such as eco-design, green procurement, and reverse logistics on different environmental aspects such as waste, wastewater, emissions, and social factors such as environmental awareness and relation to communities.

6.4. Conclusion

Most companies certified to ISO 14001 EMS due to internal factors, i.e., environmental concerns. The research found no strong association between the age of ISO 14001 EMS certification, company size, and the number of management systems on internal pollution prevention measures. The study found that ISO 14001 EMS positively impacted pollution prevention, waste minimisation and management measures (avoid, reuse, recycling). Furthermore, the study found that a lack of internal expertise, green procurement, environmental awareness, other waste management options or technologies, poor legislative enforcement, and low cost of recyclables and landfilling waste were factors impeding effective pollution prevention, waste minimisation and management measures. Lastly, most companies were satisfied with their environmental actions and have realised improved EP.

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8. List of Appendices

8.1. Survey questionnaire

Instruction to Fill a Questionnaire

Method 1

- Open a PDF document in Acrobat DC.
- Click the Fill & Sign tool in the right pane.
- Fill out the form: complete form filling by clicking a text field and typing or adding a text box.
- Sign the form by clicking Sign in the toolbar at the top of the page.
- Save the form by clicking File at the top-left and proceed clicking Save.

Method 2

- You can print out the form and manually fill in your responses and scan the form.

Method 3

- You can contact the researcher using contact details given in the Consent Form to have an interview where he will fill the responses for you as you state them.

Method 4

- You can fill the form by accessing this link:

https://forms.office.com/Pages/ResponsePage.aspx?id=DQSIkWdsW0yxEjajBLZtrQAAAAAAAAAAAAN gdPqzRUNU9KOFU4MjVDSUZZS0xBU1hNMTFETDhINi4u

Survey form

Research Title: Investigating the Impact of ISO 14001 on Waste Minimisation within South Africa

A. Background

1. In which province is your organisation located?

Gauteng ☐ Limpopo ☐ Northwest ☐ Mpumalanga ☐

1.1. Where is your industrial area located? (State the exact location of your industry or the nearest town)

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2. What is your position in the organisation?

Production Supervisor ☐ Project Manager ☐ Environmental Officer ☐ Health and Safety Manager ☐ General Manager ☐

Other (please specify)

____

____

____

3. As per South African Standard Industrial Classification, under which industry does your organisation fall?
(*Please tick one option from column 2 and 3 in line with your organisation sector or subsector*)

Sector or subsector	**Total full-time of equivalent employees**	**Total annual turnover**
Agriculture, Forestry, and Fishing	0 – 10 11 – 50 51– 250 >250	≤ 35 million ≤ 17 million ≤ 7 million Not sure
Mining and Quarrying	0 – 10 11 – 50 51– 250 >250	≤ 210 million ≤ 50 million ≤ 15 million Not sure
Manufacturing	0 – 10 11 – 50 51– 250 >250	≤ 170 million ≤ 50 million ≤ 10 million Not sure
Electricity, Gas, Steam and Air Conditioning Supply	0 – 10 11 – 50 51– 250 >250	≤ 180 million ≤ 60 million ≤ 10 million Not sure
Water Supply; Sewerage, Waste Management and Remediation Activities	0 – 10 11 – 50 51– 250 >250	≤ 70 million ≤ 22 million ≤ 5 million Not sure
Construction	0 – 10 11 – 50 51– 250 >250	≤ 170 million ≤ 75 million ≤ 10 million Not sure
Wholesale and Retail Trade	0 – 10 11 – 50 51– 250 >250	≤ 220 million ≤ 80 million ≤ 20 million Not sure
Repair of Motor Vehicles and Motorcycles	0 – 10 11 – 50 51– 250 >250	≤ 80 million ≤ 25 million ≤ 7,5 million Not sure
Transportation and Storage	0 – 10 11 – 50 51– 250 >250	≤ 140 million ≤ 45 million ≤ 7,5 million Not sure
Accommodation and Food Service Activities	0 – 10 11 – 50 51– 250 >250	≤ 40 million ≤ 15 million ≤ 5 million Not sure

Information and Communication	0 – 10 11 – 50 51– 250 >250	≤ 140 million ≤ 45 million ≤ 7,5 million Not sure

3.1. What product or services does your organisation offer? (Please specify)
Example: Manufacturing of plastic/ packaging/ civil and construction

___

___

___

3.2. Do you conduct your business internationally?
Yes ☐ No ☐

Waste

4. Do you have objectives or targets set for waste minimisation?
Yes ☐ No ☐

5. How will you classify waste emanating from your manufacturing or operation process? (Tick all the applicable)
General solid waste ☐ Hazardous solid waste ☐ General liquid waste ☐

Hazardous Liquid Waste ☐

5.1. Which type of waste/s emanate from your manufacturing or operation process? (Tick all the applicable)
Commercial and Industrial Waste ☐ Slag ☐ Organic Waste ☐ Construction and Demolition Waste ☐ Paper ☐ Plastic ☐ Glass ☐ Metals ☐ Tyres ☐ Bottom Ash ☐ Fly Ash and Dust ☐ E-Waste ☐ Biomedical Waste ☐ Radioactive Waste ☐ Mineral Waste ☐

other/s (please specify)

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ISO 14001 EMS

6. How long have you been certified to ISO 14001 EMS?

___

___

7. Other than ISO 14001 EMS certification, what another ISO certification/s do you have? (Tick all the applicable)
ISO 45001/ OHSAS 18001 ☐ ISO 9001 ☐ ISO 2200 ☐ None ☐

other/s (please specify)

____

____

____

B. Ascertain the Reason/s for ISO 14001 Certification in both Manufacturing and Service Sectors.

8. What was the drive to get ISO 14001 certification? (Tick all the applicable)

Customer Requirement ☐ Boardroom Decision ☐ Environmental Concern ☐ To Access Global Market ☐ Pressure from Stakeholders ☐ Government Regulations ☐ Pressure or Demand from Employees ☐ Pressure/Demand from Guests ☐

If other/s, please specify:

____

____

____

C. Ascertaining Measures for Pollution Prevention in Manufacturing and Service Sectors

Question 9-12 seeks to establish a baseline regarding measures that organisations have in practice to prevent pollution.

9. Do you have green a procurement policy in your organisation?

Yes ☐ No ☐

10. Do you host environmental awareness programmes in your organisation?

Yes ☐ No ☐

11. Has your organisation substituted raw material for eco-friendly raw material since you were certified to ISO 14001 EMS?

Yes ☐ No ☐

11.1. If yes, please provide details of the previous raw material and current raw material in term of environment, cost, or both.

(*For example: we replaced XX with YY because it had more impacts in the environment/ we replaced XX with YY because XX is reusable and provide cost benefits***)**

____

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____

11.2. If yes, please tick below why you substituted your process raw material (tick all the applicable)

To reduce process/operation emissions ☐ To reduce process/operation waste ☐ To speed up the manufacturing/operation process ☐

Other/s. please specify.

____

____

____

12. Has your organisation modified technology/equipment since you were certified to ISO 14001 EMS?

Yes ☐ No ☐

12.1. If yes, please provide details on what you did to modify process technology or equipment. **(***For example: we installed sensors on our machinery to combat workplace incidents/ we bought this machinery or equipment because it gives us XXX benefits***)**

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12.2. What drove your organisation to implement such a change? (Please tick all the applicable)
To reduce process/operation emissions ☐ To reduce process/operation waste ☐ To avoid/reduce environmental incidents ☐ To reduce spills ☐ To speed up the manufacturing/operation process ☐

Other/s. please specify.

-

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D. Ascertaining Waste Management Measures to the Final Disposal of Waste in Manufacturing and Service Sectors.

Solid Waste

13. Do you have separation at source initiatives in your organisation?

Yes ☐ No ☐

If yes, please answer questions 13.1.

13.1. What is it that you do with waste that you separate? (Tick all the applicable)
Reuse it onsite ☐ transferred it to other organisation to be reused as raw material ☐ collected by recycling company ☐ transported to Waste-to-Energy/ cement Kilns ☐

13.1.1. If yes you are reusing your process waste onsite, from the total amount of solid waste you generate, what is the percentage of process solid waste do you reuse monthly?

0%-9% ☐ 10%-19% ☐ 20%-29% ☐ 30%-39% ☐ 40%-49% ☐
50%-59% ☐ 60%-69% ☐ 70%-79% ☐ 80%-89% ☐ 90%-100% ☐ Not Sure ☐

Please provide details on the type of waste you reuse.

____

____

____

____

____

13.1.2. If yes you are transferring your process waste to another organisation to reuse it as raw material, from the total amount of process solid waste you generate, what percentage of your process waste do you transfer monthly?

0%-9% ☐ 10%-19% ☐ 20%-29% ☐ 30%-39% ☐ 40%-49% ☐
50%-59% ☐ 60%-69% ☐ 70%-79% ☐ 80%-89% ☐ 90%-100% ☐ Not Sure ☐

Please provide details on the type of waste you transfer.

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13.1.3. If yes, your process/operation waste is collected by a recycling company or transported by your company to a recycling facility, from the total amount of process/operation solid waste you generate, what is the percentage of your process/operation waste that is collected by a recycling company or transported by your company to a recycling facility?

0%-9% ☐ 10%-19% ☐ 20%-29% ☐ 30%-39% ☐ 40%-49% ☐
50%-59% ☐ 60%-69% ☐ 70%-79% ☐ 80%-89% ☐ 90%-100% ☐ Not Sure ☐

Please provide details on the type of waste that is taken for recycling.

____

____

____

____

____

13.1.4. If yes you are transporting your process/operation waste to Waste-to-Energy/ cement Kilns, from the total amount of process/operation solid waste you generate, what is the percentage of process/operation solid waste do you transport monthly?

0%-9% ☐ 10%-19% ☐ 20%-29% ☐ 30%-39% ☐ 40%-49% ☐
50%-59% ☐ 60%-69% ☐ 70%-79% ☐ 80%-89% ☐ 90%-100% ☐ Not Sure ☐

Please provide details on specificity of the type of waste you transport to Waste-to-Energy/ cement Kilns.

____

____

____

____

14. Do you dispose waste to landfill?

Yes ☐ No ☐

14.1. If yes, from 100% of solid waste you generate per month, what is the percentage of waste do you dispose to landfill monthly?

0%-9% ☐ 10%-19% ☐ 20%-29% ☐ 30%-39% ☐ 40%-49% ☐
50%-59% ☐ 60%-69% ☐ 70%-79% ☐ 80%-89% ☐ 90%-100% ☐ Not Sure ☐

14.2. If yes, please describe the type of waste you dispose to landfill?

____

____

____

____

____

Wastewater

15. Does your manufacturing or operation process use water?

Yes ☐ No ☐

15.1. If yes, how much water do you use per month?

____

____

15.2. If yes, please select the purpose of using water in your manufacturing/operation process? (Please tick all the applicable)

For production process ☐ For cooling equipment ☐ Washing machinery ☐
Diluting ☐ Transporting a product ☐

Other/s, please specify.

____

____

____

16. Do you participate in an onsite wastewater recycling/ treatment process?

Yes ☐ No ☐

If yes, please comment on the process you use to recycling your wastewater?

____

____

____

____

16.1. If yes, what is the percentage of wastewater do you recycle from the total amount of wastewater you generate monthly?

0%-9% ☐ 10%-19% ☐ 20%-29% ☐ 30%-39% ☐ 40%-49% ☐ 50%-59% ☐ 60%-69% ☐ 70%-79% ☐ 80%-89% ☐ 90%-100% ☐ Not Sure ☐

17. Do you discharge wastewater from your operation or manufacturing process out of your organisation?

Yes ☐ No ☐

17.1. If yes, what kind of wastewater do you discharge?

Inorganic Wastewater ☐ Organic Wastewater ☐ Not Sure ☐

17.2. If yes, from the total amount of wastewater you generate, what is the percentage of wastewater do you discharge monthly?

0%-9% ☐ 10%-19% ☐ 20%-29% ☐ 30%-39% ☐ 40%-49% ☐ 50%-59% ☐ 60%-69% ☐ 70%-79% ☐ 80%-89% ☐ 90%-100% ☐ Not Sure ☐

17.3. If yes, where to do you discharge it?

Via authorised Conveyance System to Wastewater Treatment Plant ☐ Directly to the Environment ☐

other (specify)

____

____

____

E. Ascertaining Barriers in Implementing Pollution Prevention and Waste Management Measures in both Manufacturing and Service Sectors.

18. Indicate the extent to which you agree with the following factors that would act as barriers to an organisation's implementation of pollution prevention and waste minimisation practices.

18.1. Lack of internal technical knowledge is limiting effective pollution prevention and waste management.

Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

18.2. Lack of green procurement practices promotes higher generation of waste:

Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

18.3. Lack of environmental awareness programmes impede effective pollution prevention and waste management:

Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

18.4. Lack of financial support to initiate programmes to prevent pollution and waste generation:
Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

18.5. Poor enforcement of legislation impedes effective pollution prevention and waste management:
Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

18.6. Low value of recyclables impedes effective recycling of materials:
Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

18.7. Low cost of landfilling and absence of other waste treatment options are the drivers to landfilling as a practical approach to dispose of waste:
Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐

18.8. Which of the following do you think ISO 14001 has brought an impact to your organisation? (Tick all the applicable)
Improved waste minimisation and management ☐ worsened waste management ☐
Increased environmental awareness ☐ Decreased workplace incidents ☐ Increased financial performance ☐ Reduced financial performance ☐

18.9. How will you rate your organisation pollution prevention and waste minimisation practices?
Very satisfying ☐ Satisfying ☐ Need improvement ☐ Not satisfied at all ☐

____________________THANK YOU FOR YOUR PARTICIPATION______________________________

8.2. Participants information sheet

Investigating the Impact of ISO 14001 on Waste Minimisation within South Africa.

Dear Prospective Participant

My name is Rabalao Kokesto Johannes, and I am doing research with Dr. Roelien Du Plessis a lecturer in the Department of Environmental Sciences towards MSc. in Environmental Management at the University of South Africa. We are inviting you to participate in a study titled Investigating the Impact of ISO 14001 on Waste Minimisation within South Africa.

WHAT IS THE PURPOSE OF THE STUDY?

The main aim of this study is to investigate if the certification to ISO 14001 resulted in waste Minimisation and sound waste management.

WHY AM I INVITED TO PARTICIPATE?

You are being selected as a participant since your company is ISO 14001 certified. Your company's contact details were extracted from third-party certification bodies.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

You are required to participate to fill a questionnaire survey that will not take more than 40 minutes to complete.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participation in this research is voluntary and declining to participate will not result in any penalty. Moreover, the participant may discontinue at any time without any penalty. However, it will not be possible to withdraw from the study once you have submitted the questionnaire.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

There are no direct benefits for the participants; besides the knowledge that you are contributing towards this research will benefit the industry. The data will provide some insight regarding waste minimisation and management practices in ISO 14001 certified companies.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

Participant may feel uncomfortable in disclosing some answers. This is mitigated by designing ordinal scale questions.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

You will not be required to state your name and company name. Instead, the researcher will use pseudonym to denote your response. Your response will be used for the purpose of this study and nowhere in the study your identifiable information will be stated.

HOW WILL THE RESEARCHER PROTECT THE SECURITY OF DATA?

Paper based copies of your response will be stored in a locked cabinet for a period of five years, and further use of such data will be subjected to further Research Ethics Review and approval if applicable. Electronic copies of your response will be stored in a password protected computer. Paper based copies of your response will be shredded and electronic copies will be permanently deleted from the computer through use of a relevant software.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There are no incentives associated with participating in this research, participation is voluntary.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There are no incentives associated with participating in this research, participation is voluntary.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the Health Research Ethics Committee of the College of Agriculture and Environmental Sciences, Unisa.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed about the results of the research or inquire, please contact Mr. Rabalao Kokesto Johannes on 0833765033/0766326244/ 66366089@mylife.unisa.ac.za

If you encounter concerns regarding the manner this study is conducted, you can reach out to my supervisor, Mrs. Roelien Du Plessis on 0845844707 or dplesr@unisa.ac.za. Moreover, if you encounter ethical issues, you can contact Research Ethics chairperson, Prof MA Antwi of the UNISA-CAES Health Research Ethics Committee on 011-670-9391 or antwima@unisa.ac.za.

Thank you for taking time to read this information sheet and for participating in this study.

Rabalao Kokesto Johannes

____

8.3. Consent form

Investigating the Impact of ISO 14001 on Waste Minimisation within South Africa

I acknowledge:

1. that I have been informed about the above study by Rabalao Kokesto Johannes.
2. that the aim, anticipated benefits, and the possible hazards of the research study have been explained to me.
3. that I have read and understood the study as explained in the information sheet.
4. that I voluntarily and freely give my consent to my participation in the research study.
5. I understand that the results will be used for the research purposes.
6. that I am free to withdraw my consent at any stage along the study, in which my participation will immediately cease.
7. that all personal details will be kept strictly confidential.

Name: ________________________________

Signature: ____________________________

Date: ________________________________

8.4. Ethical certificate

UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 21/02/2022

NHREC Registration # : REC-170616-051
REC Reference # : 2022/CAES_HREC/009
Name : Mr KJ Rabalao
Student #: 66366089

Dear Mr Rabalao

Decision: Ethics Approval from 18/02/2022 to 31/01/2025

Researcher(s): Mr KJ Rabalao
kjrabalao@gmail.com; 083-376-5033

Supervisor (s): Mrs R Du Plessis
dplesr@unisa.ac.za; 084-584-4707

Working title of research:

Investigating the impact of ISO 14001 on waste minimisation within South Africa

Qualification: MSc Environmental Management

Thank you for the application for research ethics clearance by the Unisa-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is granted for three years, **subject to submission of the relevant permission letters and yearly progress reports. Failure to submit the progress report will lead to withdrawal of the ethics clearance until the report has been submitted.**

The researcher is cautioned to adhere to the Unisa protocols for research during Covid-19.

Due date for progress report: 31 January 2023
The progress report is available on the college ethics webpage: https://w2.unisa.ac.za/www.unisa.ac.za/sites/corporate/default/Colleges/Agriculture-%26-Environmental-Sciences/Research/Research-Ethics.html

Please note the points below for further action:

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

1. The committee notes that permission will be obtained from the targeted companies before data collection will commence at a particular company. Please submit these permission letters to the committee once obtained.

*The **low risk application** was **reviewed** by the UNISA-CAES Health Research Ethics Committee on 18 February 2022 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
8. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

URERC 25.04.17 - Decision template (V2) - Approve

University of South Africa
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PO Box 392 UNISA 0003 South Africa
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www.unisa.ac.za

*The reference number **2022/CAES_HREC/009** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof MA Antwi
Chair of UNISA-CAES Health REC
E-mail: antwima@unisa.ac.za
Tel: (011) 670-9391

Prof SR Magano pp
Executive Dean : CAES
E-mail: magansr@unisa.ac.za
Tel: (011) 471-3649

8.5. Editor declaration

John Dewar Tel: +27833210844
PhD, DAHM Email: johndewar65@gmail.com

Dear Dr du Plessis,

This letter is to confirm that I completed a language and content edit of a dissertation entitled: **Investigating the Impact of ISO 14001 on Waste Minimisation within South Africa.**

This dissertation describes a research study under your supervision and will be presented to the Department of Environmental Sciences, College of Agriculture and Environmental Sciences, University of South Africa in fulfilment for the requirements for the degree Master of Science in Environmental Management. The dissertation was prepared by Mr Johannes K Rabalao.

My edit included the following:

- Spelling and grammar
- Vocabulary and punctuation
- Sentence structure and word usage
- Checking of in text references

Text formatting included:

- Reformatting frontis page and correcting the order of initial pages of dissertation
- Requesting the use of fewer abbreviations and replacing these with corresponding words
- Transferring description of figures and tables to above same
- Adjusting the format and text for the study conclusions
- Suggesting the inclusion of qualitative research themes

Yours sincerely,

John Dewar

8.6. Turnitin digital receipt

turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	KOKESTO JOHANNES RABALAO
Assignment title:	Complete dissertation/thesis Final
Submission title:	Final Dissertation
File name:	66366089_Dissertation_Rabalao_Kokesto_084555.docx
File size:	3.05M
Page count:	147
Word count:	35,123
Character count:	212,268
Submission date:	19-Dec-2023 09:01PM (UTC+0200)
Submission ID:	2262725933