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Assessment of Enabling Factors of the Circular Economy Practices in Rwanda – Case of Food Manufacturing Industries of Kigali Special Economic Zone

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I. INTRODUCTION

Globally, as the human population expands and wage levels rise, more resources are being used by humans (Behrens *et al*., 2007; Dobbs *et al*., 2011). The global ecosystem is under alarming pressure from pollution and the natural resources scarcity to meet human needs. These elements simultaneously have a significant impact on the prices of energy and material goods as well as the volatility of their market prices (Benton and Hazell, 2013; Defra, 2012; Ecorys, 2012). According to the OECD (2019), by 2060, the usage of primary materials will have doubled, totaling 167 gigatons. By 2030, it is predicted that there will be 2.59 billion tons of waste generated annually, and by 2050, there will be 3.40 billion tons of waste produced globally (Ellen MacArthur Foundation, 2015). By balancing goals for economic development and environmental protection, the circular economy positions itself as the answer to all of these problems and also a variety of countermeasures have been suggested in order to seek more sustainable development (WCED, 1987). Given that the manufacturing sector is one of the most resource- and environment-intensive sectors of the economy (Halstenberg *et al*., 2017), this has an impact on not only consumer behavior but also on industrial players, including manufacturers.

On the other hand, in order to address the difficulties brought about by waste generation and accumulation in recent years, the alternative concept of a "circular economy" has been put forth as a remedy to the environmental problems created by inadequate waste management and resource management. A circular economy aims to promote the use of materials in manufacturing processes in a circular manner (Geissdoerfer *et al*., 2017). CE is "an industrial economy that is restorative and regenerative by intention and design," according to the Ellen MacArthur Foundation (2012). Its three guiding concepts are to maximize resource yields, protect and enhance natural capital, and promote system efficiency (Ellen MacArthur Foundation, 2015). By slowing, closing, and narrowing resource loops, CE aims to reduce resource usage (Geissdoerfer *et al*., 2017; Wang *et al*., 2018). The concept of the circular economy has gained increasing popularity over the years as an effective strategy to achieve sustainability at a global, national, and local level. According to Ghisellini *et al*. (2016), CE principles have been adopted at various scales, including the macro scale, which is representative of actions done by cities, regions, and countries, the meso scale, which is representative of a network of businesses, and the micro scale, which corresponds to the view of products and firms (Ghisellini *et a*l., 2016). Additionally, it has drawn more attention from policymakers in developed nations as well as from international organizations like the United Nations, etc. (Lacy *et al*. 2014; COM, 2015).

The possible advantages of adopting a circular economy strategy in low- and middle-income nations have largely been disregarded. In order for these nations to achieve the Sustainable Development Goals (SDGs) objectives, it is urgent that they implement this strategy (Anthony and Sandra, 2021). Circular economy practices in developing nations have, however, recently come to the attention of scholarly researchers (Chertow and Park, 2016) and professionals working in international development (Gower and Schröder, 2016). Many papers have been published citing circular economy case studies in developing nations like India, Brazil, Kenya, and Ghana, etc., which show how supporting circular economy business models can help to a three-way win: Productivity enhancement and increased economic growth, improvement of employment quantity and quality.

Most Rwandan businesses continue to operate using the traditional "take, make, dispose" model of consumption and production and are largely ignorant of the business opportunities related to CE. The idea of CE is not getting much attention in the research community in Rwanda (Whyte *et al*., 2020). The National Circular Economy Action Plan, which was released in December 2022 during the World Circular Economy Forum, is among the government's actions that represent the circular economy. The plan lays out specific guidelines for Rwanda's transition to a circular economy, which will eventually help the country realize its long-term goal of Vision 2050 (Ministry of Environment., 2022). Additionally, the Government of Rwanda recently released the Revised Green Growth and Climate Resilience Strategy (Revised GGCRS) (Goverment of Rwanda, 2023). The updated GGCRS aims to advance green industry and private sector investment to help better the business and industrial environment. In addition, the Cleaner Production and Climate Innovation Center, a

division of Rwanda's National Industrial Research and Development Agency (NIRDA), was established in 2017 and is in charge of all CE-related operations aside from research (Whyte *et al*., 2020). In order to address the growth of the industries, Rwanda created a national industries policy (MoIT, 2011). As a result, applying the principles of the circular economy is essential if the country is to reap their long-term benefits. However, over time, many low- and middle-income countries have paid relatively little attention to the circular economy idea (Anthony and Sandra, 2018). The circular economy concept is present in Rwanda's policies and behaviors, but little is known about it. There are no assessments about the circularity across all sectors to know the extent at which the circular economy is implemented and the gap between the Circular economy and traditional linear economy model. In order to maintain the global perspective of this idea, adequate circular economy research activities are needed to monitor the development and serve as the benchmark. In light of the circular economy principle, this study seeks to determine the degree of circularity within Rwandan industries by assessing the state of waste management strategies and the factors that support them.

This paper aims to fill the gap by identifying the enabling factors that facilitate the implementation of circular economy principles within the food manufacturing industries in Rwanda in the case of In Kigali Special Economic Zone (KSEZ) Located in Kigali city- Gasabo district. The practices that represent the circular economy were investigated to ascertain how much the circular economy enablers are influencing Rwanda's food manufacturing sectors.

II. METHODOLOGY

In this study, a survey research methodology was used to provide a quantitative description of trends, attitudes, or opinions about enablers of circular economy practices in food manufacturing industries (Creswell, 2017). By using Kigali Special Economic Zone as a case study, this research sought to evaluate circular economy enablers in Rwanda's food manufacturing sectors. Up to date of survey there was exist about 200 companies in Kigali Special Economic in different manufacturing process and services. 17 of them are food manufacturing industries, and thus constitute the research target population. all 17 food manufacturing industries were considered as sample size. Universal sampling technique was adopted which allowed the researcher to assess all 17 food manufacturing industries by asking one of the top managers on each industry as a representative respondent. In addition, as provided explained by the main reason to select this size of the population has the particular set of characteristics being food manufacturing industries and their number is typically very small.

The researcher had original set of questions to investigate. The questionnaire mainly was categorized into Company demography, Respondent CE awareness, the waste streams in industries and the strategies to manage them, and circular economy enablers/barriers (table and figure and appendix). The waste streams to be examined were predetermined and it includes Plastics, Organic solid wastes, Organic slurry, Paper and paper board, Air pollutants, Oil residues/grease, Wastewater, and Other. The company examined had to have at least one of them to allow to go further for examination based on waste management strategy (Rs: Reduce, Reuse, and Recycle; and Disposal). The assessed set of potential enablers were pre-determined from the literatures and the waste streams together with waste management strategy within the industry was pre-identified according to the nature and type of the industry.

The enablers were the management willingness, technology and skills, finance and investment and Government Policies (legislations and incentives). The questionnaire was designed to maximize the accuracy of the target information. During the data analysis the set of the responses from the interviewee was analyzed based on interpretative classification. The researcher gathered all the field information toward the coherence between the circular economy enablers and the circular economy practices found in the food manufacturing industries.

Both the descriptive statistical technique and interpretive measures were used to watch and analyze the ideas and viewpoints expressed by the companies. By using statistical percentages and averages were used to summarize and depict the circularity in the study area. MS Excel 2016 computer program was used for statistical data processing. Specifically, the statements made while filling the form linked to enablers previously noted in the study literature. By categorizing the enablers to CE practices according to the companies' point of view and using benchmarking enablers derived from the literature, these approaches met our study objective.

Table 1 Summary of the Structure and Themes in the Questionnaire Survey

SN	Category	Questions
1	Demography	• Company name and size • Respondent position in the company • Company email and telephone
2	CE awareness	• If respondent Heard CE • How respondent think CE • What respondent see in the company as practice of CE
3	waste streams and waste management strategies	• Selection of waste streams generated in company (Plastics, Organic solid wastes, Organic slurry, Paper and paper board, Air pollutants, Oil

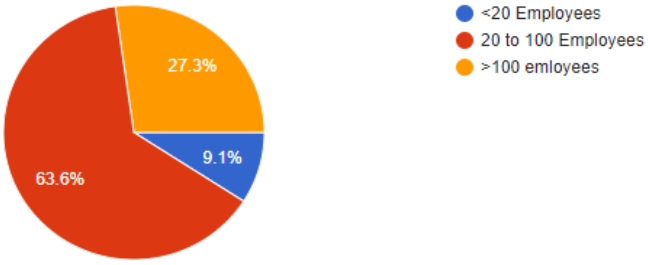
		residues/grease, Wastewater, and Other) • Waste management strategy (Reduce, Reuse, Recycle and Disposal) per each waste stream. • Selection of process follow to those wastes which are not disposes (Reusing, Recycling, Animal feeding Composting, Burning or used for fire Incineration Bioenergy/Biofuel conversion/Biogas and Others).
4	Enablers/Barriers of CE	• Likert scale (No Affect, Minor Affect, Moderate Affect, Major affect) how each of 3Rs (Reduce, Reuse and Recycle) is affected by CE enablers (Management willingness, technology and skills, finance and investment, and Government legislations and incentives) • Likert scale how each of 3Rs is affected by CE barriers of Lack of management willingness, No skills and technology, Lack of investment and finance, and no government incentives and legislation.

III. RESULTS AND DISCUSSION

➢ *Results*

- *Demography of Respondents*

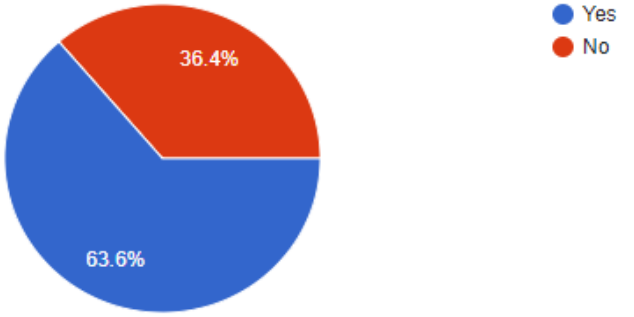
Out of the 17 representative of industries which was eligible to participate in this research as respondents, 11 corresponding to 64.7% of them was able to respond survey questionnaire which adequate response rate to assess the finding of the study according to Nulty (2008). 9.1% of company has less than 20 employees, 63.6% has between 20 to 100 employees and the rest 27.3% has more than 100 employees (Fig 1).



Source: Researcher Compilations, 2023
Fig 1 The Company Size

- *Circular Economy Awareness in Food Manufacturing Industries*

The CE awareness among the industries representative asked in the survey of this study, 36.4% has shown they did not hear Circular Economy yet at time of survey while 63.6% of respondent stated they heard circular economy (Fig 4.2). They were asked how they understand Circular economy and their responses fall in different range of concept of Waste reduction, Reusing waste, waste as raw materials, Efficient Economy and no wastage, minimizing raw materials for product manufacturing by using/recycling the already used to a usable healthy product and by that reducing the risks of affecting environment by continuous disposals with no plan for disposal materials, A Business Model which design out the waste and pollution, making sure that the product/service is used as long as possible and regenerate the environment, suggesting businesses to recycle.



Source: Researcher Compilations, 2023
Fig 2 Companies' Awareness about CE

- *Waste Streams and Waste Management in Food Manufacturing Industries*

The waste stream in manufacturing industries was examined it was found to account 72.7% of campaniles responded they generate Plastics, Organic solid by 45.5% of companies, wastes Organic slurry including organic liquid/viscous waste generated by 36.4%, Paper and paper board by 90.9%, Air pollutants including dust, fumes, odors by 36.4%, Oil residues/grease by 27.3%, Wastewater by 90.9% and other wastes 18.2% (Fig 3). With the regard to the waste management strategy in practice the strategies were identified by respondent to each waste streams (Fig. 4). The strategies were reduced, reuse recycle and Disposal. as found on (Fig 4.4). Disposal is the major waste management practice application compare to the other practices on each waste stream (see table 4.1 and fig 4.4). And also, the representatives of industries were asked to demonstrate the activities follow after generation of their wastes and found to be: Reused either by you or another industry as raw materials, recycled either by you or another company, used for Animal feeding, composting for use in Agriculture, Burning or used for fire, Incineration (destruction by fire), Bioenergy/Biofuel conversion/Biogas, while the others found to recycle only their wastewater. The conversion of the organics into the agricultural composting was the main where 36.4% of the industries practice it, reuse and recycle by 27.3%, burning and incineration by 18.2%, and 9.1% for animal feeding and Bioenergy/biofuel conversion.

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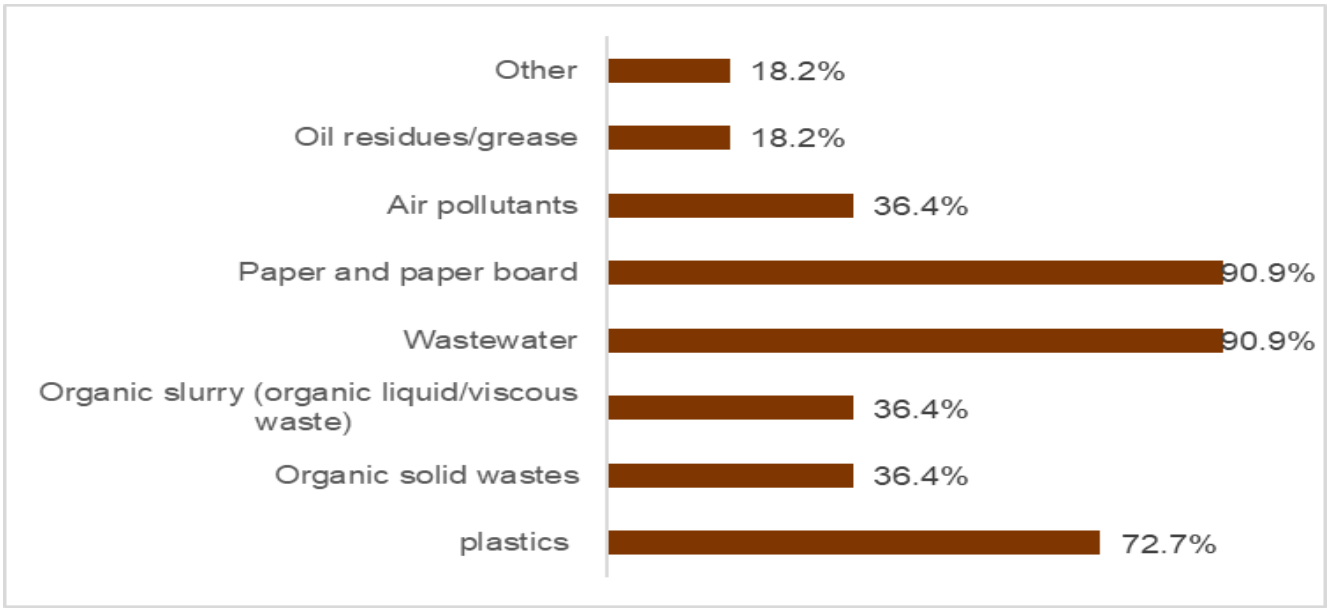


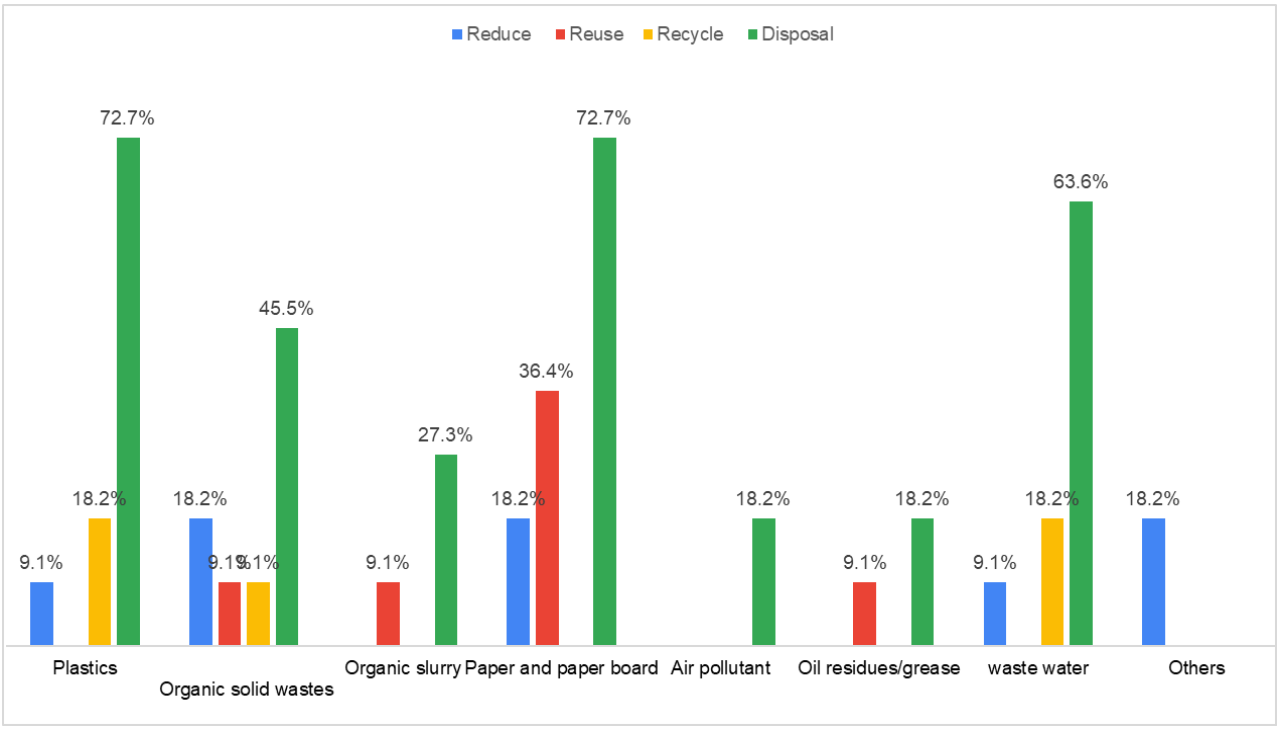
Source: Researcher Compilations, 2023

Fig 3 The Waste Streams and their Respective Percentage from Respondent Companies

Table 2 Waste Management Practice/Strategy Per Each Waste Stream

	Reduce	**Reuse**	**Recycle**	**Disposal**
Plastics	9.1%		18.2%	72.7%
Organic solid wastes	18.2%	9.1%	9.1%	45.5%
Organic slurry		9.1%		27.3%
Paper and paper board	18.2%	36.4%		72.7%
Air pollutant				18.2%
Oil residues/grease		9.1%		18.2%
waste water	9.1%		18.2%	63.6%
Others	18.2%			

Source: Researcher compilations, 2023



Source: Researcher compilations, 2023

Fig 4 Waste Management Practice/Strategy per each Waste Stream

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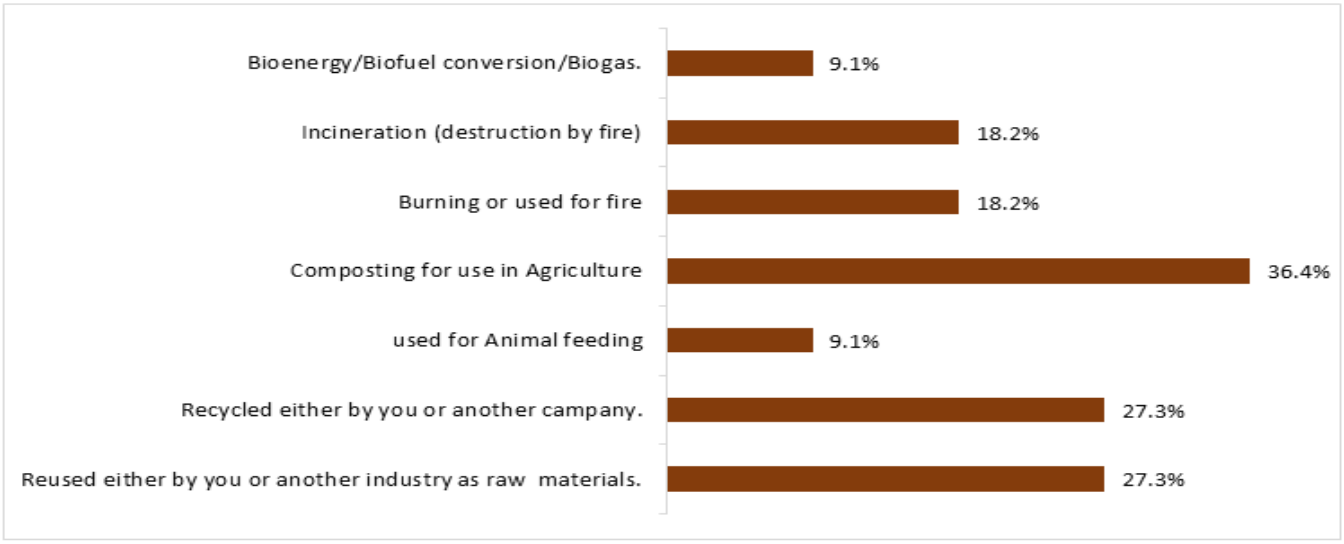
Table 3 Processes follows after the Generated Wastes but not Disposed to Landfill

Process	Fi	%
Reused either by you or another industry as raw materials.	3	27.3%
Recycled either by you or another company.	3	27.3%
used for Animal feeding	1	9.1%
Composting for use in Agriculture	4	36.4%
Burning or used for fire	2	18.2%
Incineration (destruction by fire)	2	18.2%
Bioenergy/Biofuel conversion/Biogas.	1	9.1%

Source: Researcher Compilations, 2023



Source: Researcher Compilations, 2023

Fig 5 Processes follow Generated Wastes but not Disposed to Landfill

- *Circular Economy Enablers in Food Manufacturing Industries*

The enablers and barriers of CE was evaluated on each of the circular economy strategies i.e., 3Rs (Reduce, Reuse and Recycle) (Manickam and Duraisamy, 2019) with in this study. In order to examine well each strategy/R was examined to reveal the circular economy enabling factor and barriers. By referring to study conducted by (Keulen and Kirchherr 2021) potential enablers examined are: Management willingness/ company culture (Top management commitment and/or consistent awareness of staff and culture inside the organization about CE and/or Inter-organizational partnership to implement CE), Skills and Technology (There is know-how on CE and/or reverse supply chain is available and applicable and/or Efficient technology for the CE processes), Finance and investment (CE products compete well with linear/normal products and/or increase your finance while cutting expenses and/or there is strong public demand for CE products, and Government incentives and legislations (Fig 4.8, 4.10 and 4.12). At the same time we examined the barriers which hinder the implementation of these circular economy practices and found are: Company is in favor of a linear economy/the Company does not have/awareness and culture about CE and/or Company only thinks within its own company realms and own industry, There is no know-how to develop CE solutions/ No reverse logistics and material traceability/ No efficient and effective technology for the CE processes, CE products do not compete with linear ones and or No public demand about CE products and/or It increases the expenses while the profit is considerably low and Government policies about CE are unclear and/or no tax incentives and/or regulation is not in favor of CE products (Keulen, and Kirchherr 2021). In addition to this the Likert scale (No Affect-Minor Affect-Moderate Affect-Major affect) used to each of examined enabler/barrier (Fig 4.9, 4.11 and 4.13). Generally, in all top three 3Rs enablers and barriers the Management willingness enabler has found to be high impactful with 15% as per respondents representing the industries (Fig 6 and table 4). While the barrier of skills and technology was the main barriers as per survey (fig 7 and Table 5).

Table 4 How Enabler Affect 3Rs in General

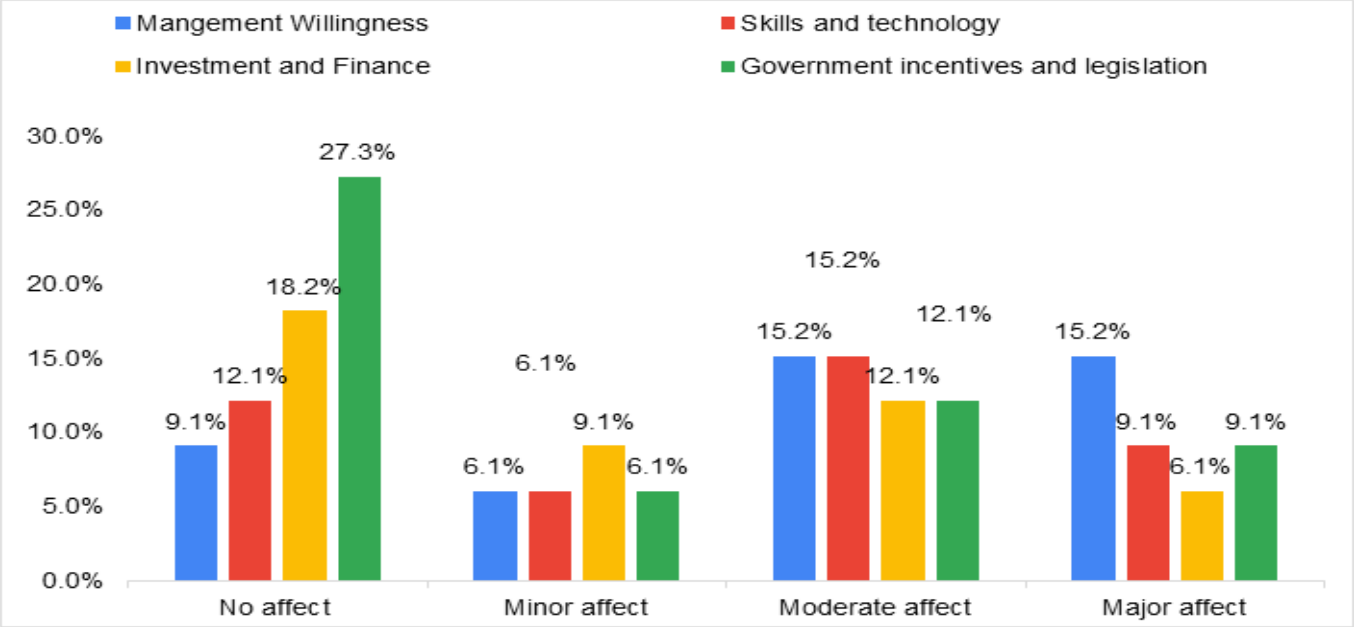
	No Affect	Minor Affect	Moderate Affect	Major Affect
Management Willingness	9.1%	6.1%	15.2%	15.2%
Skills and technology	12.1%	6.1%	15.2%	9.1%
Investment and Finance	18.2%	9.1%	12.1%	6.1%
Government incentives and legislation	27.3%	6.1%	12.1%	9.1%

Source: Researcher Compilations, 2023

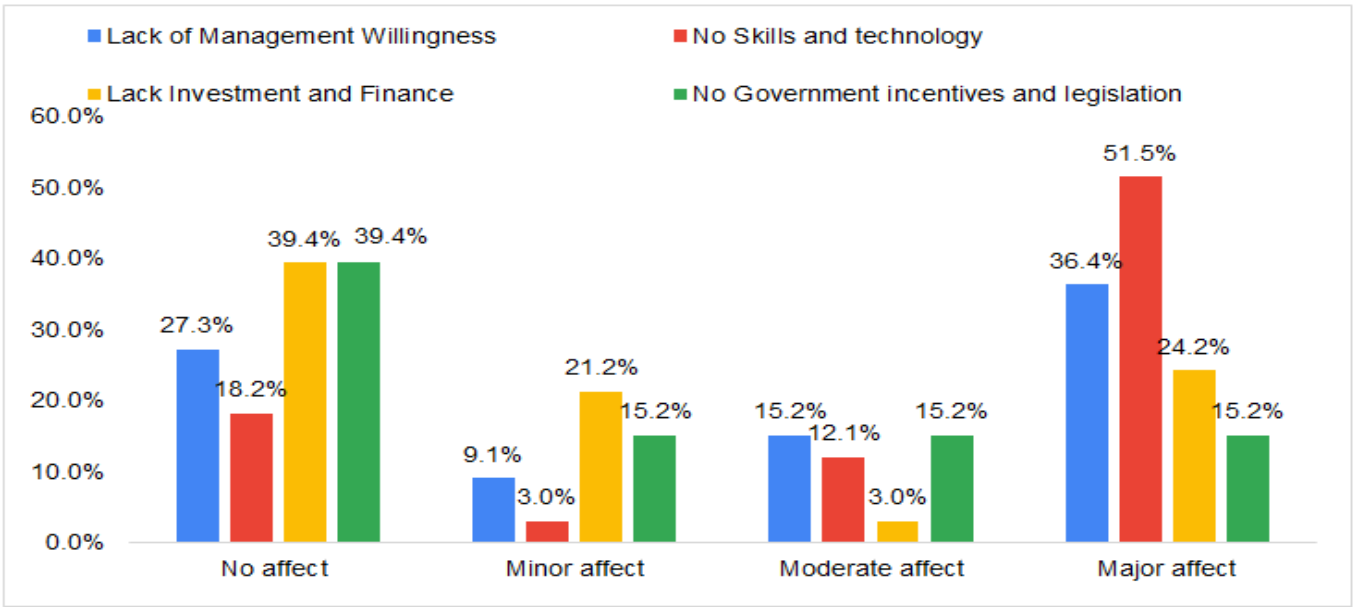
Table 5 How Barriers Affect 3Rs in General

Barriers	No Affect	Minor Affect	Moderate Affect	Major Affect
Lack of Management Willingness	27.3%	9.1%	15.2%	36.4%
No Skills and technology	18.2%	3.0%	12.1%	51.5%
Lack Investment and Finance	39.4%	21.2%	3.0%	24.2%
No Government incentives and legislation	39.4%	15.2%	15.2%	15.2%

Source: Researcher Compilations, 2023



Source: Researcher Compilations, 2023
Fig 6 How Enabler Affect 3Rs in General



Source: Researcher Compilations, 2023
Fig 7 How Barriers Affect 3Rs in General

- *Extent which Circular Economy Enabler Affect Circular Economy of Reduce*

A survey demonstrated the enablers of like Management willingness was found to be majorly affect the implementation of circular economy at rate of 36.4% while Government incentives and legislation was found greatly have no influence to circular economy (fig. 8) (table). on the other hand, the skills and technology were the majorly affectual barrier (54.5%) to implement circular economy (Fig 9) and many time this was found to be the major barrier for full implementation of CE followed by 36.4% of lack of management willingness.

Table 6 The Extent at which Enablers Affect Reduce as Practice of Circular Economy

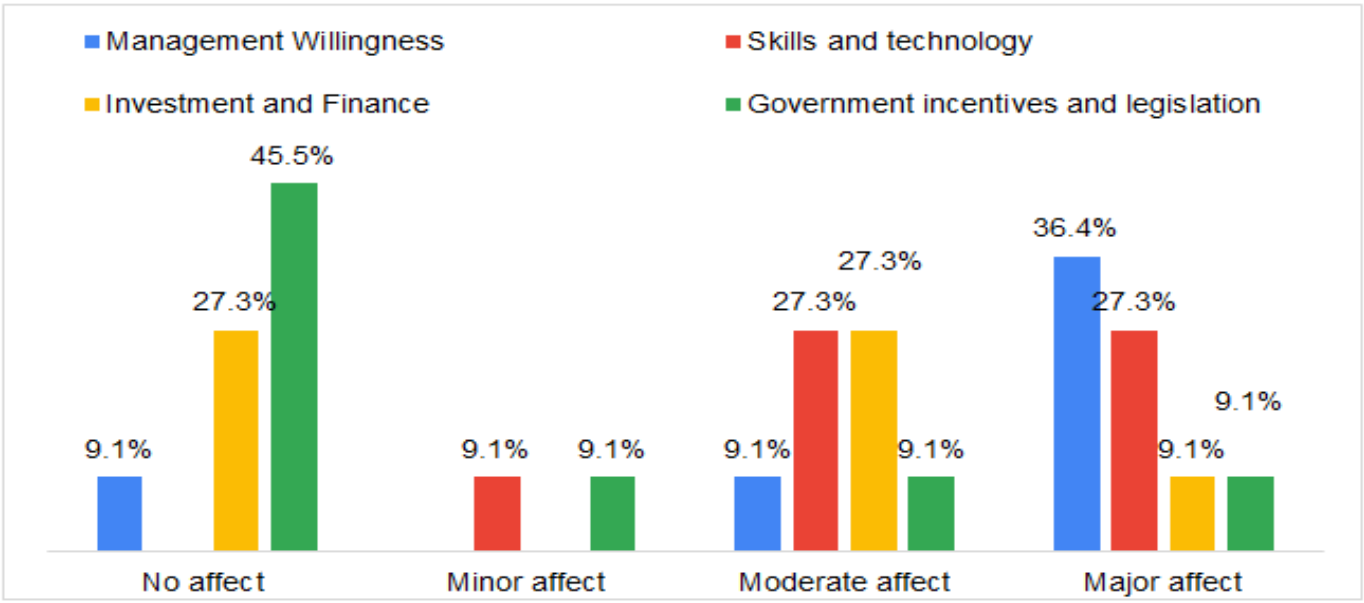
	No Affect		Minor Affect		Moderate Affect		Major Affect	
Management Willingness	1	9.1%		0.0%	1	9.1%	4	36.4%
Skills and technology		0.0%	1	9.1%	3	27.3%	3	27.3%
Investment and Finance	3	27.3%		0.0%	3	27.3%	1	9.1%
Government incentives and legislation	5	45.5%	1	9.1%	1	9.1%	1	9.1%

Source: Researcher Compilations, 2023

Table 7 Extent at which Identified Barriers Affect Circular Economy Practice of Reduce

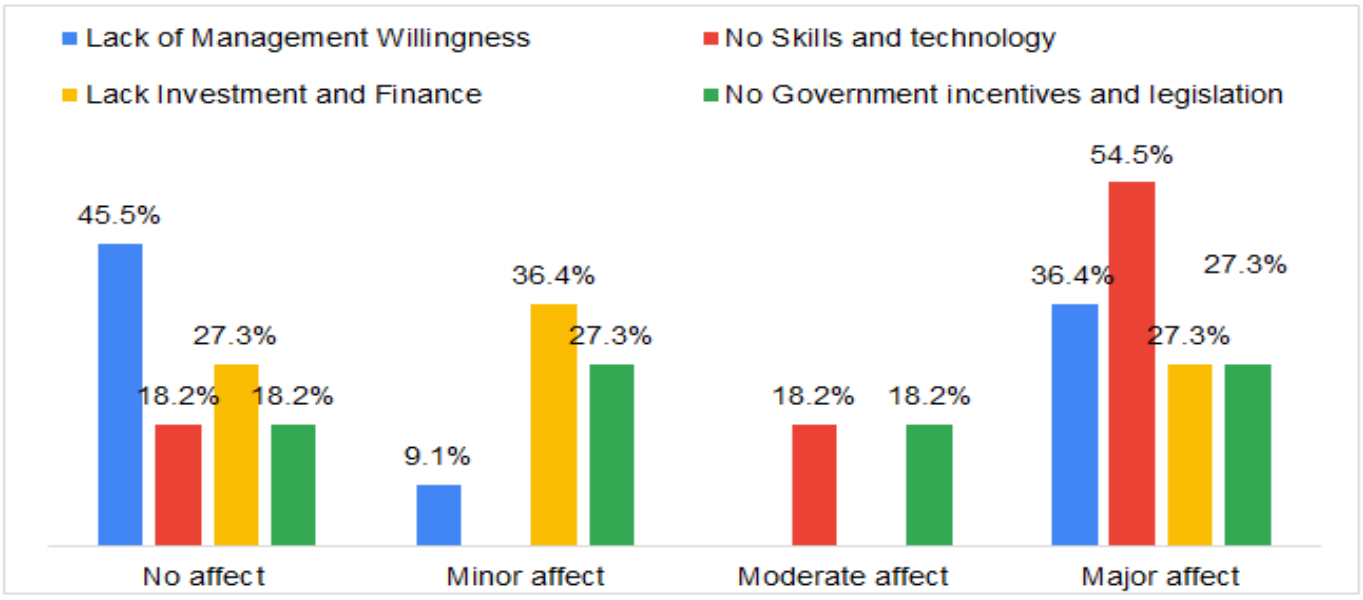
	No affect		Minor affect		Moderate affect		Major affect	
Lack of Management Willingness	5	45.5%	1	9.1%	0	0.0%	4	36.4%
No Skills and technology	2	18.2%	0	0.0%	2	18.2%	6	54.5%
Lack Investment and Finance	3	27.3%	4	36.4%	0	0.0%	3	27.3%
No Government incentives and legislation	2	18.2%	3	27.3%	2	18.2%	3	27.3%

Source: Researcher Compilations, 2023



Source: Researcher Compilations, 2023

Fig 8 The Extent at which Enablers Affect Reduce as Practice of Circular Economy



Source: Researcher Compilations, 2023

Fig 9 Extent at which Identified Barriers Affect Circular Economy Practice of Reduce

- *Extent which Circular Economy Enabler Affect Circular Economy of Reuse*

The enablers of Management willingness and Government incentives and legislation was found to be moderately affect the implementation of circular economy at rate at 18.2 % (Fig 10) and the same to Reduce, skills and technology was the majorly affectual barrier (36.4%) to implement Reuse in circular economy (Fig 11) (table 8).

Table 8 The Extent at which Enablers Affect Reuse as Practice of Circular Economy

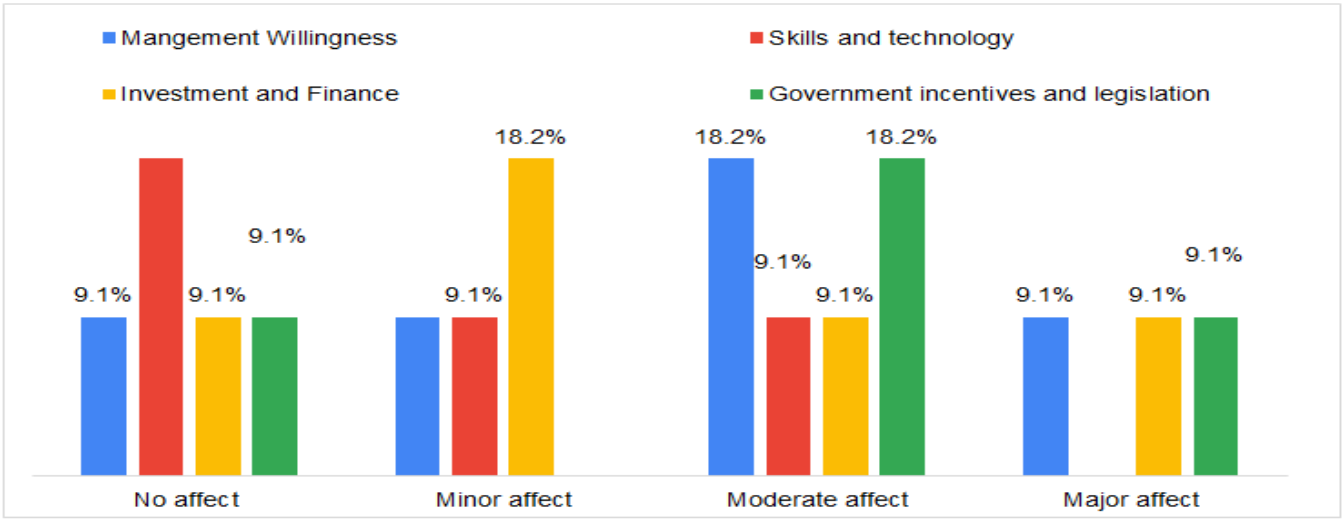
	No Affect		Minor Affect		Moderate Affect		Major Affect	
Management Willingness	1	9.1%	1	9.1%	2	18.2%	1	9.1%
Skills and technology	2	18.2%	1	9.1%	1	9.1%		0.0%
Investment and Finance	1	9.1%	2	18.2%	1	9.1%	1	9.1%
Government incentives and legislation	1	9.1%	0	0.0%	2	18.2%	1	9.1%

Source: Researcher Compilations, 2023

Table 9 The Extent at which Enablers Affect Reuse as Practice of Circular

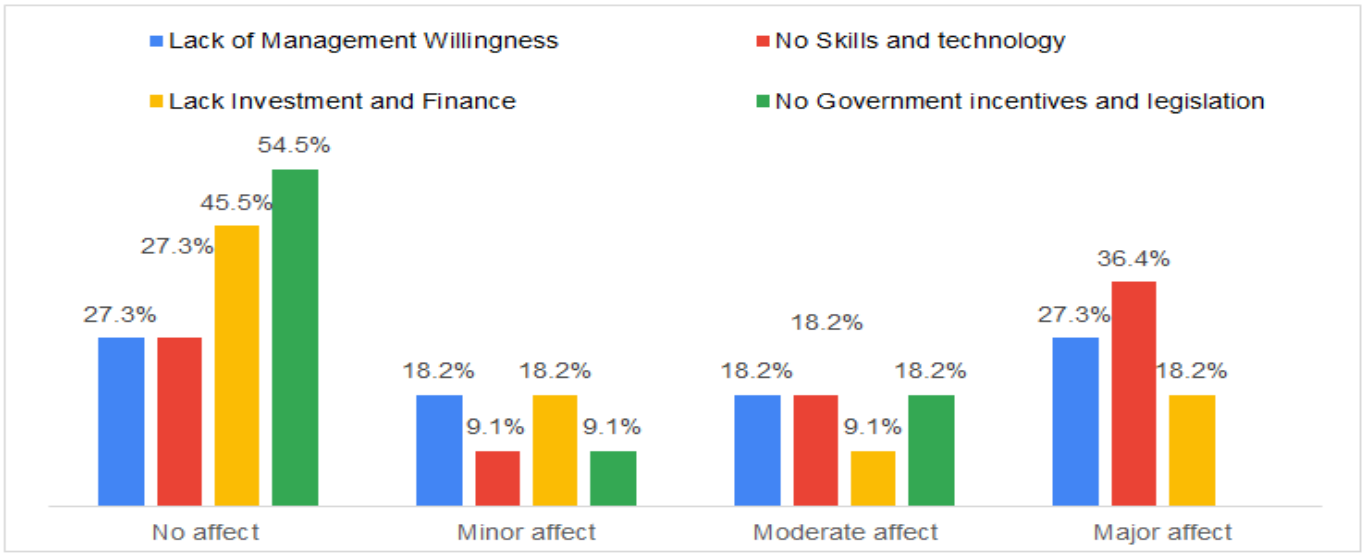
	No Affect		Minor Affect		Moderate Affect		Major Affect	
Lack of Management Willingness	3	27.3%	2	18.2%	2	18.2%	3	27.3%
No Skills and technology	3	27.3%	1	9.1%	2	18.2%	4	36.4%
Lack Investment and Finance	5	45.5%	2	18.2%	1	9.1%	2	18.2%
No Government incentives and legislation	6	54.5%	1	9.1%	2	18.2%	0	0.0%

Source: Researcher Compilations, 2023



Source: Researcher Compilations, 2023

Fig 10 The Extent at which Enablers Affect Reuse as Practice of Circular Economy



Source: Researcher Compilations, 2023

Fig 11 Extent at which Identified Barriers Affect Circular Economy Practice of Reuse

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- *Extent which Circular Economy Enabler Affect Circular Economy of Recycle*

By refereibg to figure 13 and table 10 the lack of skills and management willingness at rate of 63.6% and 45.5% found to be the main factor hinder the implementation of circular economy while there is no most occuring enabler to this practice of circular economy (fig. 12 and table 11).

Table 10 The Extent At Which Enablers Affect Recycle As Practice Of Circular Economy.

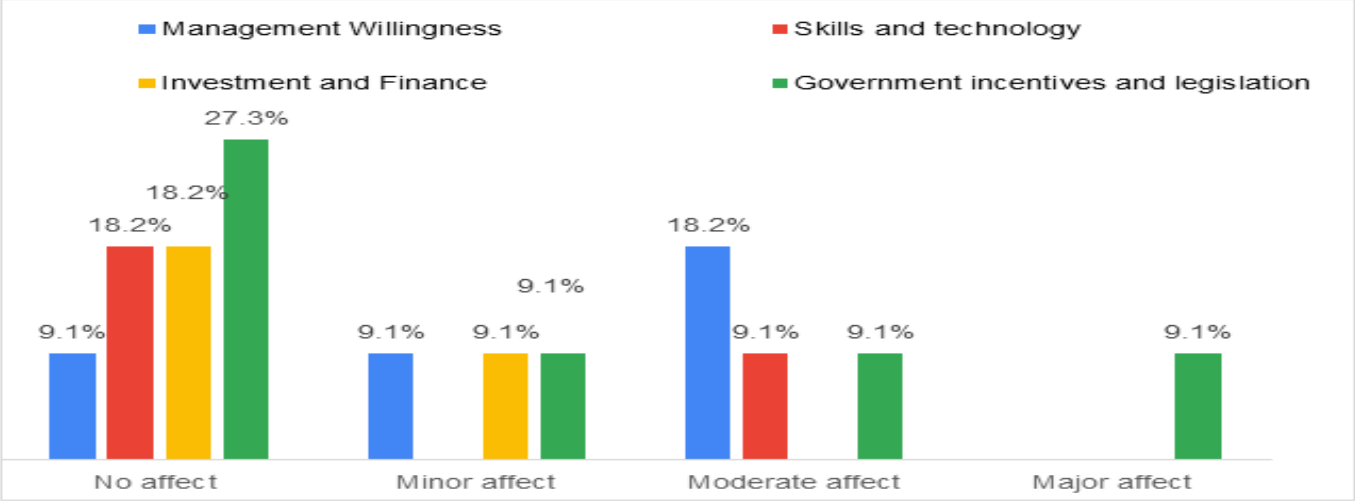
	No Affect		Minor Affect		Moderate Affect		Major Affect	
Management Willingness	1	9.1%	1	9.1%	2	18.2%	0	0.0%
Skills and technology	2	18.2%	0	0.0%	1	9.1%	0	0.0%
Investment and Finance	2	18.2%	1	9.1%	0	0.0%	0	0.0%
Government incentives and legislation	3	27.3%	1	9.1%	1	9.1%	1	9.1%

Source: Researcher Compilations, 2023

Table 11 Extent at which Identified Barriers Affect Circular Economy Practice of Reuse

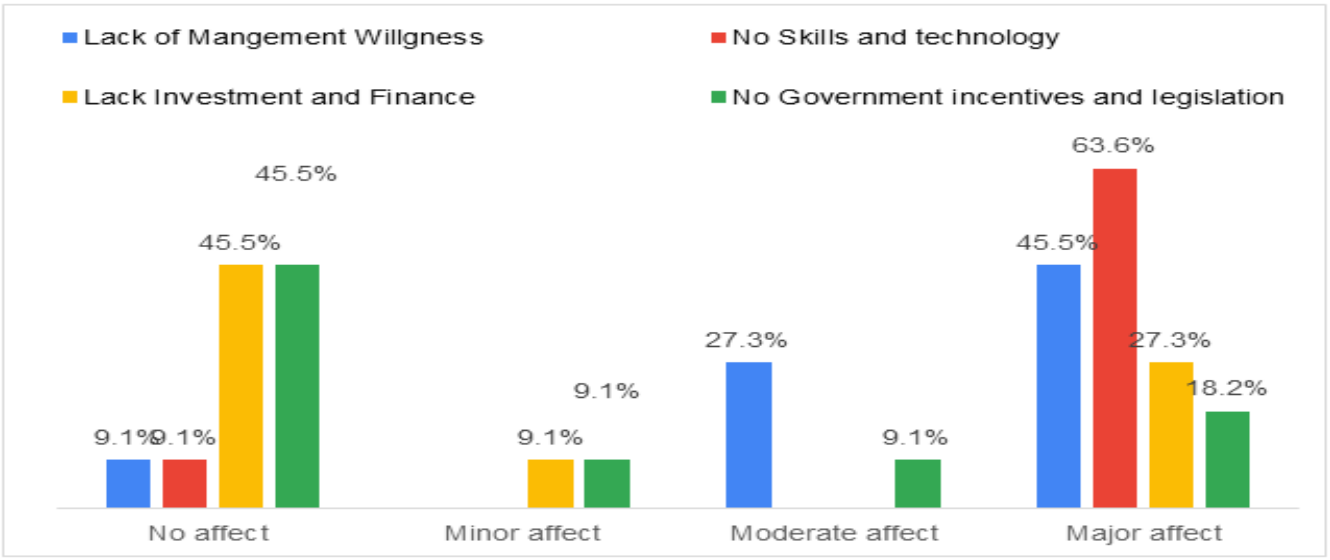
	No Affect		Minor Affect		Moderate Affect		Major Affect	
Lack of Management Willingness	1	9.1%	0	0.0%	3	27.3%	5	45.5%
No Skills and technology	1	9.1%	0	0.0%	0	0.0%	7	63.6%
Lack Investment and Finance	5	45.5%	1	9.1%	0	0.0%	3	27.3%
No Government incentives and legislation	5	45.5%	1	9.1%	1	9.1%	2	18.2%

Source: Researcher compilations, 2023



Source: Researcher Compilations, 2023

Fig 12 The Extent at Which Enablers Affect Recycle As Practice Of Circular Economy.



Source: Researcher Compilations, 2023

Fig 13 Extent at which Identified Barriers Affect Circular Economy Practice of Reuse

IV. DATA ANALYSIS AND DISCUSSION

Among them 36.4% has shown they did not hear Circular Economy yet at time of survey and it reflect the gap to shift to circularity (Murray *et al.*, 2017). Mainly in developing nations there is a lack of awareness of the benefits of CE in manufacturing. And there is lack of information based on consumer patterns missing, the model for the CE leads to derailing CE efforts in manufacturing sector of developing nations (Rathi *et al*., 2022). Lack of expertise. A major perceived bottleneck of CE is the lack of relevant expertise or detail technical knowledge in place for the transition from linear to CE (Shahbazi *et al*., 2016). The waste stream in manufacturing industries was examined and as it common worldwide plastic wastes generation (Lebreton and Andrady, 2019) it was found to account 72.7% of campaniles responded they generate Plastics. Or most of waste streams which is an indicator that there is need long and many steps to be taken to implement circularity (Pires and Martinho, 2019). The strategies were reduced, reuse recycle and Disposal. as found on (Fig 4.4) disposal is the major practice/strategy in application for most of waste streams which is an indicator that there is need long and many steps to be taken to implement circularity (Pires and Martinho, 2019). A survey demonstrated the enablers of like Management willingness was found to be majorly affect the implementation of circular economy at rate of 36.4% (Millar *et al*., 2012) that reflect the influence of leadership willingness to implement CE and the Government incentives and legislation was found to have no great influence to circular economy (fig. 4.5). over the time Top management commitment has shown to be vital for the adoption of circular practices to shift towards a CE (Shahbazi *et al.* (2016), Govindan and Hasanagic (2018) from. The management willingness has found to provide constant training and development programmes on CE practices for the skill development of workers and bringing new ideas and changes for transform the way enterprises operate or design their supply chains.

On the other hand, the skills and technology were the majorly affectual barrier (54.5%) to implement circular economy (Fig 4.6) and many time this was found to be the major barrier for full implementation of CE (Lobo *et al*., 2021). This main barrier is in line with finding Sharma *et al*. (2019) further highlighted that lack of technology, innovation, lack of government policies, law, standard system, and lack of knowledge, awareness among consumer and supplier are the most critical barriers for effective adoption of CE in the food industries. Krishnan *et al*., 2020 also highlighted that technology aspects hinder the adoption of CE in FSC. Lack of consumer awareness, lack of emerging technologies and innovation, policies and law, lack of financial capability/funds to drive capital investments and R&D, lack of firm's awareness, and cross-sectoral collaboration among different stakeholders are few barriers obstructing the adoption of CE practices in India (Ellen Macarthur Foundation, 2016).

V. CONCLUSION AND RECOMMENDATIONS

In this paper aimed to fill the gap of lack of literature related to CE in Rwanda by assessing the enabling factors that facilitate the implementation of circular economy principles within the food manufacturing industries in Rwanda in the case of In Kigali Special Economic Zone (KSEZ) Located in Kigali city- Gasabo district. Based on the findings their huge gap in application of circular economy in Rwanda, based on the fact that most of representatives of the industries replied they apply Disposal as their main waste management. The most of waste of plastics was noted as the most occurring challenging wastes and there is no established circularity for it. The findings show that there is no enabler that is common for all, the enablers which occur om major affect are applied to few companies and this also is reflected through most occurring of disposal as the strategy for waste management. While many companies have reported that the skills & technology and management willingness are the major barriers for circularity. Which warn all the stakeholders that the awareness project and the establishment of technological and skills enhancement facilities that lead to CE development.

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