

Review Article

Overview of the opportunities and challenges towards the uptake of Sustainability practices among manufacturing firms in Uganda.

Abstract

The aim of this paper is to provide an in-depth exploration of the opportunities and barriers towards the uptake of sustainability practices (SPs) among manufacturing firms in Uganda. SPs are among the notable solutions in overcoming the challenges facing the global environment, society as well as prosperity for all. The study followed a review approach of relevant scientific, technical as well as government policy papers. From the review, enforcement of the available environmental laws and policies, customer's awareness, technological innovation, organisational culture and strict governance, emerge as key drivers towards the uptake of SPs in this country. However, weak legislations and enforcement in some instances, lack of sufficient resources to invest in new technologies, high costs of financing, organisational culture, and limited awareness emerged as the main challenges facing the uptake of SPs. Furthermore, our study provides policy implications that could mitigate the challenges identified especially in a least developed country, Uganda.

Keywords: Sustainability practices, Triple bottom line, opportunities, barriers, comprehensive review.

1. INTRODUCTION

The past decade has seen sustainability literature come to the forefront due to the growing importance that various companies continue attaching to the planet, people and prosperity concerns [1] [2]. Researchers [3] have emphasized the importance of sustainability practices (SPs) in the attainment of a balanced integration of the Triple Bottom Line (TBL) which collaborates the economic prosperity, social inclusiveness, and environmental resilience with its interdependencies to the benefit of present as well as the generations to come. Accordingly [4] added that, SPs are multifaceted and because of this multi-dimensionality, SPs have generated a lot of debate in various disciplines such as; production science, environmental and natural resource economics, mechanical engineering as well as, energy science [5].

Moreover, as concerns such as; rising population growth, resource depletion, environmental pollution, and waste management intensify, countries world over have begun to rethink on how to achieve Sustainable Development Goals (SDGs) [6][7][8]. In particular, SDG 12 focuses on sustainable consumption and production to which manufacturing firms should pay close attention [9]. Thus, in light of the global quest for the attainment of (SDG 12), the crucial role of SPs has placed most firms under close scrutiny from various industrial players observing the continued climate change, carbon footprints, resource and energy consumption [10] [11]. As such, [12] proposed the implementation of SPs among manufacturing firms in order to regulate the use of natural resources, especially when firms envisage a shortage in anyone of these resources.

To this end, the focus on manufacturing firms in this study is backed by the empirical support [13][14][15] which presents such firms as the prime route for investigating which changes are crucial for attaining sustainability goals, because of their ability to bring wealth and intelligent solutions to societies [16]. As such, world over, the role played by manufacturing firms towards economic growth and development cannot be overemphasized [17] [18].

Several researchers [19] [20] have demonstrated the potential contribution of SPs in the manufacturing domain. According to [21] SPs philosophy aims at creating products through economically sound processes that minimize the total negative impact on the environment while conserving energy and other resources. In addition, [22][23] noted that, SPs paves way for employment, leads to community and product safety, and security, creates a considerable financial and environmental benefits [24][25]; promotes the integration of technical feasibility, environmental responsibility and economic viability of manufacturing firms [26]. Additionally, SPs promote long-term business viability and success [27].

Table1: Summary of some benefits of implementing SPs in Uganda.

<i>Name of the companies</i>	<i>Conservation and energy efficient measures</i>	<i>Other benefits</i>
Aloesha Organic Natural Health products Ltd.	Installed efficient institution stove to reduce energy losses Constructed a firewood shade to ensure proper seasoning. Replacement of high energy consuming bulbs with LED bulbs	Reduced time for boiling, improved cost savings, occupational health and safety of workers. The company has so far earned a national drug

		authority certificate. Applied for UNBS certification.
Buzirasagama Tea Factory	The company serviced the capacitor bank leading to the power factor improvement from 0.85 to 0.98 Installed translucent sheets to take advantage of the day light. Replaced 25Hp motors that were rewound more than once.	This resulted into an annual saving of USD 6526.6 from 665.7 m ³ of wood saved. This consequently resulted into the reduction in greenhouse gas by 491286.6 Kg CO ₂ equivalent.
Mpanga Growers Tea Factory	Repaired the power back up system (diesel generator) to reduce waste generated during load shedding	The factory eliminated the tea that could be lost during load shedding. It was estimated that 3 tonnes of tea could be lost for a 24 hours load shedding.
GBK Dairy products Ltd.	Upgraded the steam system by repairing leaks and insulation of all un-lagged steam pipes to eliminate heat losses and steam leaks	Improved thermal efficiency, which reduced and improved fuel utilisation leading to cost savings.
Pearl Dairy Ltd.	The company is gradually switching from the use of fossil fuels to biomass by installing biomass fuel led boilers.	Reduction in emissions of greenhouse gas emissions from combustion of fossil fuels.

Source: [28]

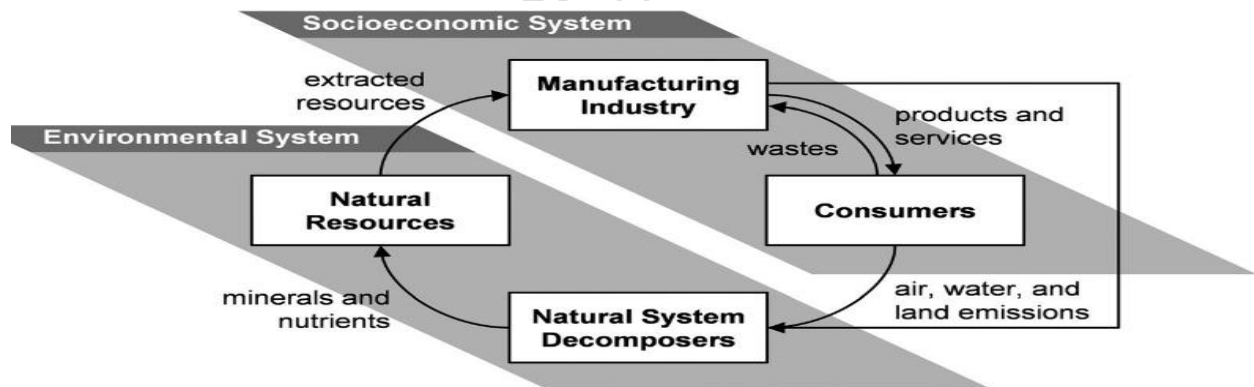
In spite of the benefits presented in Table 1, implementation of SPs remains a challenge in Uganda as evidenced in Fig. 4 and Fig. 5. These challenges forms the foci of our current study. We aim at exploring the opportunities and challenges to the uptake and implementation of SPs among manufacturing firms in Uganda.

Besides, [29] indicated that, manufacturing firms globally consume about one-third of energy and contribute approximately 38% of carbon emissions. Likewise, [30] reported an upward shift in consumption and production patterns in the Sub-Saharan Africa due to the underlying rapid demographic, socio-economic and environmental change, thus limiting the attainment of sustainability objectives. Moreover, [31] noted an upsurge in the total domestic material consumption from 3.6 to 4.2 billion metric tons between 2010 and 2017. This situation does not bode well as firms continue exerting much pressure on resources. In Uganda, [32] indicated environmentally unsustainable practices among manufacturing firms in form of pollution of air,

water and land. In sum, according to [33] air pollution kills an estimated seven million people a year, and air pollution-related mortality is escalating in most parts of the world.

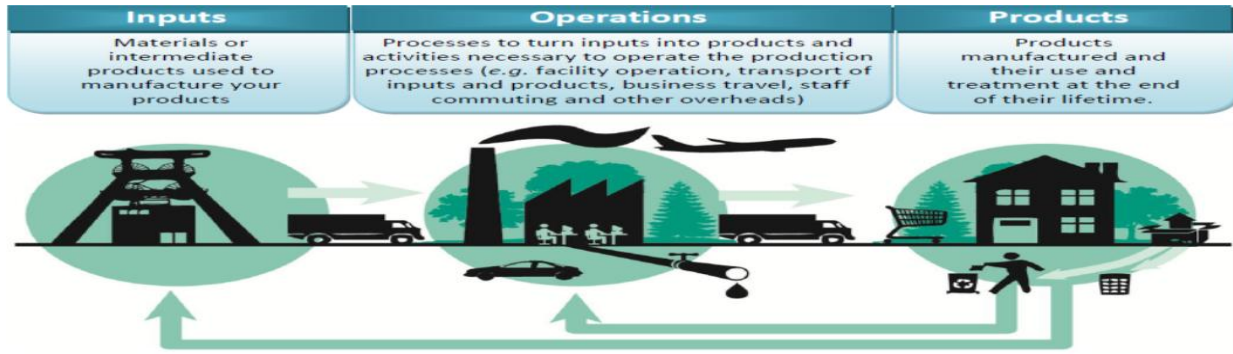
To this end, [34] highlighted that, a system which is unsustainable, occurs when the rate of consumption of resources and generation of waste by the society overshoots the nature's capacity to convert industrial and society wastes into environmental nutrients and resources. Accordingly, [34] added that, companies should observe sustainability discourse from a closed system perspective such as in **Fig. 1** because manufacturing subsystems coexist alongside human, ecological, and natural subsystems. [34] Argued further that, we cannot detach SPs from the broader environmental and socioeconomic systems and those sustainability-related impacts are a result of operations and activities that manufacturing processes and systems employ to convert raw materials and energy into finished products. Additionally [34] indicated that, materials and energy drive manufacturing processes and systems while wastes and emissions may serve as inputs to some firms through a closed loop model (circular model) and as such posing serious impacts on the triple bottom-line as highlighted by [34].

Fig. 1 The role of the manufacturing industry in a sustainable system.



Source: [34]

Fig. 2: shows the basic relationship between manufacturing and the environment.



Source: [35]

Largely, absolute decoupling which describes an economy that is growing while reducing its absolute impacts on natural resources has yet to become a reality. Notably, environmental damage may have economic consequences, given that they affect human health, ecosystem services, and labour productivity, capital and crop yields [36]. In Uganda for example, as the number of industries increase in Kampala industrial business park so is the amount of waste generated [37]

1.1 SUSTAINABILITY PRACTICES AMONG MANUFACTURING FIRMS IN UGANDA

The environment, economic and social well-being, coined under the umbrella concept of sustainability are closely intertwined [38]. From the environment, society draws resources that drive economic processes on which society directly or indirectly depends and the environment acts as a sink for emissions and waste [38][39] (see; Fig. 3).

Fig. 3: The linkages between the environment, society and the economy.



Source: [35]

However, [38] noted that, environmental pollution in Uganda continue to affect air, water, and land adversely. For example, Air quality monitoring undertaken by [38] revealed that for a number of facilities, emissions of particulate matter (PM2.5 and PM10) is the biggest contributor to air pollution. These emissions resulted from burning of waste and from industrial boilers, furnaces and incinerators [38].

Fig. 4: wastes from the factory dumped in the swamps



Source: [40]

Fig. 5: Waste from the factories emitted in River Rwizi in the western part of Uganda



Source: [41]

Fig. 4 and 5 presents cases of unsustainable practices in Uganda. From Fig. 4, Busia Sugar and Allied Factory Limited was disposing off (effluent) waste into river Malaba while in Fig. 5. Factories producing beverages in Mbarara city were reported dumping plastic bottles into River Rwizi. The pollution in River Rwizi negatively affected residents of Ankole sub-region who depended on this water source for agriculture, domestic, and commercial. Against this backdrop, the environment is increasingly under threat from both natural and manmade drivers of change like manufacturing activities [42]. Moreover, unsustainable consumption and production is

responsible for land degradation, air and water pollution, resource depletion and the associated ecological and social challenges that characterize Uganda today.

1.2 PURPOSE OF THE STUDY

Researchers note two compelling gaps in explaining the decision to implement SPs in Uganda. First, available evidence show that manufacturing firms in Uganda are slow to adopt SPs (see; Fig.4 and Fig. 5). Second, the increasing demand for goods and services calls for increased consumption and production by manufacturing firms to meet this demand, which in turn increases the amount of waste, generated. Introducing SPs within the manufacturing domain will help to close the two gaps. The foregoing gaps drives us to the following research question, “what are the opportunities and challenges to the uptake of SPs among manufacturing firms in Uganda?” We focus on this thematic issue for four reasons. First, the study is timely because of the outbreak of Covid-19 pandemic, the president of Uganda called for manufacturing firms to increase the production of locally made products. In this study, we intended to create awareness within the manufacturing domain on the best practices that will help these firms to attain a balanced integration of environmental conservation, social as well as economic well-being. Second, there is sparse evidence of studies addressing this topic in Uganda. Third, for policy formulation, our study will guide regulatory bodies like NEMA in strengthening the environmental regulations geared towards driving the uptake of SPs in Uganda which is consistent with the third National Development Plan of 2020/21-2024/25, National Vision 2040 as well as the UN SDGs especially goal 12 (i.e. sustainable consumption and production). Lastly, to the management of the manufacturing firms. Management will be guided on the relevant decision criteria for selecting which practices are critical for their operations while at the same time introduce cleaner production mechanisms in the country.

The paper is structured as follows: section one “Introduction” presents the justification for adopting sustainability practices among manufacturing firms in Uganda. Our approach to the study is presented in section two “Approach”. In this section, we present the research methodology utilized in our study and section three “review of related studies”. This section summarises and synthesizes the relevant empirical studies. Section four addresses the drivers

towards adoption of SPs while section five dwells on the barriers/inhibitors for adoption of SPs and lastly we present the conclusion and recommendations in section six.

2. APPROACH

We adopted a comprehensive review approach. The study identified, evaluated, and summarized existing studies regarding opportunities and challenges to implementation of SPs. To answer our research question, we reviewed government environmental reports, energy policy documents, water management reports, Kampala city council reports especially on waste generated by manufacturing firms, Green growth strategy reports, reports from Uganda Manufacturers Association and the existing empirical studies. Our recommendations are informed by; (a) the benefits that come with adopting and implementing SPs, (b) the limited research effort to address sustainability issues in Uganda, and (c) identified gaps in the adoption and implementation of SPs in Uganda. We adopted a comprehensive review approach and in Table 2, we present a summary of the relevant articles utilised in this study.

3. REVIEW OF RELATED STUDIES

Empirical studies have demonstrated the opportunities and challenges to SPs in various jurisdictions. [43] studied the drivers and barriers for adoption of eco-design practices in pulp and paper industry in Finland; [44] studied the drivers to sustainable manufacturing practices and circular economy: a perspective of leather industries in Bangladesh; [45] looked at the drivers of SMPs in Egyptian SMEs and their impact on competitive capabilities: A PLS-SEM model. [46] focused on the analysis of drivers and barriers for green manufacturing practices in Malaysian SMEs: A preliminary findings; and [47] studied an integrated approach to modeling the barriers in implementing green manufacturing practices in SMEs with focus on India.

Globally, extensive opportunities exist for the uptake and implementation of SPs. In literature, institutional pressures [48] [49] [50]; green culture [51] [52], technological infrastructure [53] [45]; technological innovation [54] [55] [45], environmental commitment [56]; regulatory compliance [57]; Top Management support [53], energy consumption [58], Firm resources [59], organisational capabilities [60] are among the crosscutting drivers for SPs. We note that, the main challenges towards the implementation of SPs relate to; finance and cost of implementation

[61]; technological infrastructure [45]; lack of awareness [61]; lack of management commitment [43]; organisational culture [62].

Table 2: Summary of the studies on drivers and barriers towards the implementation of Sustainability Practices

References	Title	Aim, Approach and Key findings
[43]	Drivers and Barriers for the Adoption of Eco-design Practices in Pulp and Paper Industry: a Case Study of Finland.	<ul style="list-style-type: none"> • The paper aimed at defining, analyzing and evaluating barriers and drivers for eco-design implementation to the Finnish pulp and paper industry by using multi-criteria decision-making methods and consolidated ranking methodology. • Results showed that barriers more commonly present and interconnected in companies originate from internal management, while drivers often originate from external stakeholders.
[63]	Do human critical success factors matter in adoption of sustainable manufacturing practices? An influential mapping analysis of multi-company perspective.	<ul style="list-style-type: none"> • Human Critical Success Factors (HCSFs) may play an important role in adoption of SM. • Results suggested that ‘Green motivation’, ‘Customer relationship management’, ‘Management leadership’, ‘Communication’ and ‘Strategic alignment’ are the highly significant causal HCSFs in efficient adoption of SM practices.
[44]	Drivers to sustainable manufacturing practices and circular economy: A perspective of leather industries in Bangladesh	<ul style="list-style-type: none"> • The main contribution of the study was to assess, prioritize and rank the drivers of sustainable manufacturing practices in the leather industries of Bangladesh. • The study used graph theory and a matrix approach to examine the drivers.

- [64] Examining barriers to organizational change for sustainability and drivers of sustainable performance in the metal manufacturing industry
- The study employed ISM technique and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) to examine the barriers to organizational change for sustainability and drivers, which support sustainable performance.
 - Results indicate that, inefficient legal framework, inadequate proactive plans, lack of sustainable waste management and preferences of institutional buyers are the key barriers.
 - Furthermore, enforcing government regulations, integrating sustainability in proactive plans, promoting sustainable products and developing infrastructure support and facility for sustainability were found to be the most influential drivers.
- [45] The drivers of sustainable manufacturing practices in Egyptian SMEs and their impact on competitive capabilities: A PLS-SEM model
- The paper examined the impact of technological, organisational and environmental (TOE) drivers on sustainable manufacturing practices (SMP), and the influence of these practices on competitive capabilities (i.e., quality, cost, delivery and flexibility).
 - Environmental pressures from stakeholders, management support and the engagement of employees positively influences SMP.
 - Technology infrastructure, technology competence, and environmental regulations do not significantly affect SMP.
- [65] The adoption of operational environmental sustainability approaches in the Thai manufacturing sector.
- A survey-based exploratory research utilised. Data analysed by combining descriptive and inferential statistics. The study revealed that a large amount of investment capacity, and proper training & knowledge needed to fully implement the studied operational approaches.
 - Environmental awareness, and cost saving, from conservation of energy as the main reasons for adopting the studied operational approaches.
 - Thai manufacturing firms implement them because of internal factors and that they lack of motivation

from external factors and involvement from other stakeholders.

- [66] Stakeholders' influences on the adoption of cleaner production practices: A survey of the textile industry
- The study aimed at exploring the influence of stakeholders on the adoption of CPP in the textile industry.
 - The study builds on data from survey data and expert perspectives, whereas data analysis resorted to structured equation modelling and Spearman's correlation test.
 - Shareholders were found to have a positive influence on the adoption of CPP driven by the expected impacts that CPP may have for reducing costs and improving company's brand. On the contrary, the study finds no support for business partners, society and the government influencing the adoption of CPP.
- [67] Industrial sustainability: Modelling drivers and mechanisms with barriers
- The paper reviewed literature on drivers to sustainability and to the areas of occupational health and safety, eco efficiency, and energy efficiency, and contributes to industrial sustainability research presenting a novel framework of drivers.
 - Regarding model of drivers, capacity to represent, usefulness and ease of use were evaluated; concerning model of mechanisms usefulness and ease of use were evaluated.
- [47] An integrated approach to modeling the barriers in implementing green manufacturing practices in SMEs
- Based on a comprehensive literature review and experts' opinion (Delphi method), the study revealed 25 barriers, in three broad categories, of GM implementation in Indian SMEs. The identified barriers are ranked, and their interrelationships are explored using a novel integrated multi-criteria decision making (MCDM) framework, with a combination of Decision-Making Trial and Evaluation Laboratory Model (DEMATEL), Analytical Network Process (ANP), and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) in a fuzzy context.
 - Several barriers related to lack of internal abilities and strategies, In particular, most critical barriers are

- lack of research and development (R&D), failure in eco-design and lack of accreditation respectively.
- [46] Drivers and barriers analysis for green manufacturing practices in Malaysian SMEs: A Preliminary Findings. • Reported preliminary findings on the drivers and barriers faced by SMEs in implementing green manufacturing practices, in Malaysia.
• SMEs lack the data, resources, technical expertise and experience required to implement green initiatives.
• The study used the Delphi survey method to explore, identify and verify the drivers and barriers of green manufacturing practices by obtaining consensus from a panel of experts.
- [61] Enablers and Barriers of Sustainable Manufacturing: Results from a Survey of Researchers and Industry Professionals. • This paper presents the opinions of various researchers around the globe and industry professionals on the enablers and barriers.
• It was observed that 'lowering manufacturing cost'; 'investment in innovation & technology' and 'pressure from market' emerge as top 3 priority enablers along with 'lack of awareness of sustainability concepts' and 'cost too high' as top 2 barriers in both groups.
- [68] Evaluating the enablers and barriers for successful implementation of sustainable business practice in 'lean' SMEs. • The study explored the co-evolution of 'lean and green thinking' and the potential for lean and green practices to enable successful transitions to sustainable business practice.
• Four key enablers and six key barriers to sustainable business practice, derived from a series of in-depth interviews with CEOs and senior managers involved in sustainability and lean manufacturing were identified.
• The study offered an institutional theory perspective, concluding the potential for normative, coercive and mimetic drivers to influence SMEs to shape environmental, social and economic decision making and legitimize the transition to sustainable business practice.
- [69] Critical success factors of • A holistic view of the critical success factors (CSFs) impacting the SSCM process as well as the performance outcome was presented.

- sustainable supply chain management and organization performance: An exploratory study.
- [70] Drivers and Barriers in sustainable manufacturing implementation in Malaysian Manufacturing firms.
- [71] Drivers for the adoption of sustainable manufacturing practices, A Malaysian perspective.
- [72] Drivers and Barriers to sustainability manufacturing practices by small and medium enterprises in South Africa.
- Using (SEM) technique, the study found that organisations' internal environment was very positively associated with SSCM practices.
 - The paper aimed at investigating the drivers and barriers of sustainable manufacturing implementation in Malaysia. Data were collected by use of self-administered questionnaires.
 - Increment in the overall cost of implementation is regarded as the main barrier to implementing SMPs while environmental regulation and top management commitment are regarded as the main drivers.
 - This research aim was to provide an insight into drivers to the adoption of sustainable practices in developing nations, specifically in Malaysia. A cross sectional survey conducted among various manufacturing company in Malaysia and the data collected was analysed using SEM.
 - Results showed that competitiveness, company culture and public awareness has positive impact on SMPs Supply chain management was identified as the most important practice in the implementation of SPs.
 - The study investigated the drivers and barriers to the implementation of SMP by SMEs in the manufacturing sector. Utilised the quantitative research approach.
 - The cross-sectional survey method used for data collection.
 - The study identified four major drivers of SMP namely environmental, economic, management support and social.
 - The major barriers included financial, management and social factors.

- [73] Implementation of sustainable manufacturing practices in Indian manufacturing companies
- The study aimed at finding the relationship between sustainable and smart manufacturing practices in the emerging economies using hypothesis modelling approach to link the manufacturing competitiveness and top management commitment with the sustainable and smart manufacturing practices.
 - Data collected with the help of questionnaire. SEM approached was used. The adoption level of Smart manufacturing practices in India is limited due to technological, economical and other challenges.
- [74] Environmental Sustainability Practices of Albanian Micro Enterprises and SMEs Enterprise
- The paper discussed environmental SPs of microenterprises and SMEs in Albania. Nine Albanian SMEs were interviewed about their SPs.
 - Results indicated that, Albania lacks detailed sustainability requirements, many SMEs are aware of environmental sustainability.
 - For some Albanian SMEs and microenterprises, the implementation of SPs is a requirement for accessing lucrative international markets, like the EU.
- [75] An analysis of enablers and barriers of sustainable manufacturing in South Africa
- The study highlights the key enablers and barriers behind implementation of sustainable manufacturing in the region.
 - Views and opinions from expert researchers and practitioners were collated and analyzed to draw useful strategies for implementing sustainable manufacturing.
- [76] Drivers and Barriers to circular economy implementation.
- The paper aimed at identifying the drivers and barriers to implementing a CE in Pakistan's automobile manufacturing industry. Adopted an explorative approach. Study applied both qualitative and quantitative methods.
 - "profitability/market share/benefit" (30 percent), "cost reduction" (22 percent) and "business principle/concern for environment/appreciation" (19 percent) are the top three drivers.
 - "Unawareness" (22 percent), "cost and financial constraint" (20 percent) and "lack of expertise" (17 percent) are the top three barriers.
- [77] Drivers and
- The research investigated the current status of

Barriers to energy efficiency management for sustainable development.

- energy management practices in the Korean steel industry in order to examine how drivers and barriers to energy efficiency operate, the circumstances in which these practices arise and the extent to which public policy or organizational change may overcome them.
- Market-based factors, and organizational/individual behavioural factors, play important roles in energy efficiency investment towards sustainable development.
- Economic factors (cost savings, energy tax, capital budget, cost of identifying and analysing business opportunities, beneficial loans for energy efficiency investments) and organizational factors (technical risk, lack of manager's influence, owner's demand, top management commitment, and corporate reputation) affect energy efficiency.

[78]

Pressure or Premium: what works best where? Antecedents and outcomes of sustainable manufacturing practices.

- The study empirically tested the antecedents and consequences of SMPs across India, China and OECD.
- PLS-SEM applied to test the conjectures. Customer willingness to pay has a significant impact on SMPs; stakeholder pressure is able to influence their adoption in OECD and India, but not in China.
- Firms that are high on SMPs not only reap sustainability benefits, but also derive cost reduction and quality improvement in many contexts.

[62]

Prioritization of sustainable manufacturing barriers using Best Worst Method.

- The study prioritized barriers by calculating their weights through the application of Best Worst Method in one of the manufacturing organizations of India.
- The barriers identified through a review of the peer-reviewed articles and expert's opinion.
- Barriers categorized into six major criteria.
- Economical & managerial barriers as the most obstructive barriers among the major criteria of sustainable manufacturing barriers followed by organizational barriers, social & environmental barriers, technological barriers, knowledge & learning barriers, and independent barriers.

The next section presents a discussion on the drivers and barriers to implementation of SPs in Ugandan manufacturing firms.

4.1 DRIVERS OF SUSTAINABILITY PRACTICES AMONG MANUFACTURING FIRMS IN UGANDA.

4.1.1 Environmental regulation

Sustainability practices form an integral part of national planning and development frameworks in Uganda [42]. Several policies, legal, and institutional frameworks are in place to facilitate sustainable development through economic growth, social inclusion, and environmental protection. Key among these are; the constitution of the republic of Uganda (1995), the Uganda Vision 2040 and National Development Plans (I, II & III), the National Environment Management policy (1994), the Poverty Eradication Plan (2000), the Energy Policy (2002) and the Renewable Energy Policy (2007). Various researchers [70] [45] indicated that the uptake of SPs is hinged on environmental regulations. This assertion was supported by [51] in a study on regulatory compliance and environmental SPs of manufacturing entrepreneurial ventures in Uganda. [51] Found out that, controls, legitimacy and deterrence as antecedents of regulatory compliance are crucial in environmental SPs unlike social norms and values. These results are consistent with the findings of [79] who argued that, environmental regulations positively influence the company's sustainability actions. [80] added that, high fines and penalties, in case of noncompliance with regulations drives SMEs to adopt SPs. Moreover, [81] reiterated that, along with the legislation and regulation, incentives in the form of loans, grants, tax concessions and other economic benefits facilitate easy adoption and behavioral change in SMEs towards sustainable practices. Thus, environmental regulations are crucial for the implementation of SPs within manufacturing firms of Uganda. Accordingly, [38] has made several calls to control waste generation to the greatest extent possible through the circular economy.

4.1.2 Customers' awareness

[82] Noted that, consumers have started to show more concerns on the development and use of products, stemming from the increasing awareness of environmental and social issues associated with these products. More so, [83] argued that, customer awareness is at the forefront towards the attainment of SPs. [44] stressed the importance of environmental collaboration with

customers in this regard. According to [44] customers choose environmentally friendly products because they are getting information about this from the government or via increased public awareness. [83] emphasised that, training and education are at the forefront in creating awareness about SPs. [83] reiterated further that, education by formal or informal means can play a vital role in gaining knowledge about SPs. In Uganda, various institutions have been applauded for the role they play in promoting awareness about SPs. These institutions include; National Planning Authority, Ministry of Finance Planning and Economic Development, Climate Change Department, Ministry of water and Environment, Ministry of Energy and Mineral Development, National Environment Management Authority, Uganda Cleaner Production Centre, The Climate Action Network Uganda, United Nations Development Programme, Uganda Manufacturers Association, Environmental Management for Livelihoods improvement-Bwaise facility, Economic policy research center [84] . The named institutions aim at creating awareness in order to drive the uptake of SPs.

4.1.3 Cost reduction

The desire to reduce costs through efficient use of resources such as materials and energy may drive companies to implement SPs [85]. [86] Indicated that, pollution occurring during manufacturing leads to hidden costs in form of waste. These costs can be averted by embracing SPs. [87] indicated that, the desire to pursue SPs by SME managers may be anchored on the need to satisfy their economic self-interest. More so, researchers [88][89] indicated that, adoption of sustainability actions promotes competitive advantage resulting from benefits such as; cost reduction, waste reduction, recycling and differentiation among others. Additionally, [90] argued that, medium-sized firms undertook environmental engagements in order to attain incentives such as long run financial and market position payoffs. In Uganda, Table 1 depicts evidence of cost reduction through implementation of SPs among notable manufacturing firms.

4.1.4 Establishment of the green growth development strategy

The government of Uganda demonstrated a commitment towards the principles of green growth and sustainable development as highlighted in the various legal, policy and planning and institutional frameworks. The 1995 Uganda constitution provides for sustainable development and public awareness about effective management of natural resources. The Uganda vision 2040

aspires to transform the country from a peasant to modern and prosperous country by 2040. The country established the UGGDS as a tool to reconcile the existing economic, social and environmental conflicts and facilitate the achievement of economic, social and environment targets simultaneously. The aim of UGGDS is to optimize the potential, maximize the benefits, and minimize the costs of the country's economic growth pathway. Uganda is implementing the Switch Africa Green project, coordinated by the National Environment Management Authority and financially supported by various development partners. The project seeks to ensure resource use efficiency in SMEs by adopting sustainable consumption and production principles [84].

4.1.5 Technological innovations

The 2030 Agenda recognises new technologies as an important means for implementing the sustainable development goals across 3BL dimensions, and as a critical instrument to address existing and emerging challenges. Technologies can bring many benefits to communities in both developed and developing countries. Accordingly, [45] found technological infrastructure and technological competence as key drivers of SPs. [91] added that, an important step towards a low-carbon economy is the implementation of low carbon technologies. More so, following the increasing global awareness of the dangers posed by the present climate change, countries such as Uganda have adapted to long-term plans for a transition to decarbonised economies and a major strategy for decarbonisation is to intensify the use of renewable energy technologies as the fundamental source of energy [92]. Moreover, In Uganda, Table 1 provides benefits associated with technological innovations among the selected manufacturing firms.

4.1.6 Establishment of the Uganda cleaner production centre.

The primary government initiative in the area of cleaner production is the Uganda Cleaner Production Centre (UCPC). The Government of Uganda jointly with the United Nations Industrial Development Organisation (UNIDO) established UCPC in 2001. The main objective of UCPC is to introduce cleaner production practices at the enterprise level. UCPC provides advice, technical assistance and professional training in cleaner production and good environmental management practices. It also focuses on eco-design as a strategy in product development. The eco-design strategy is based on the premise that sustainable product development helps companies to improve the environmental performance of their products whilst

reducing the financial, health and safety costs of production. UCPC also creates awareness about cleaner production in various institutions and to the public by presenting case studies (for example companies successfully implementing cleaner production and the resultant benefits).

4.2. BARRIERS TOWARDS THE UPTAKE OF SUSTAINABILITY PRACTICES AMONG UGANDAN MANUFACTURING FIRMS.

4.2.1 Legislation

Researchers [93] indicated that, among the hurdles to the implementation of SPs are the limited support from the regulatory authorities. [81] Further noted that, strong policies and legislation serves as the cornerstone for implementing green strategies. As such, [94] suggested the creation of a suitable framework, which fosters the establishment of a system for retaining effective laws in order to overcome the lack of government support for rules pertaining to environmental conservation. In Uganda, [95] highlights a number of laws which were enacted to safeguard the environment amongst which are; the national environmental Act, No. 5 of 2019, National environment (Audit) Regulation, 2020, National environment (Management of Ozone Depleting substances and products) Regulations S.I. No. 48 of 2020, National environment (Waste Management) regulation S.I. No. 49 of 2020, 153-2, national environment (standards of discharge of effluent into water and land) regulation 2020, national environment (wetlands, riverbanks and lake shores management) regulation 153-5. This withstanding, the enumerated laws are limited when it comes to enforcement and this in part explains why manufacturing firms still exhibit unsustainable behaviours (*see; fig. 4 and 5*).

4.2.2 Economics and finance

In order to realize the universal 2030 Agenda, drawing on all sources of finance-public and private, domestic and international-in all countries will be essential. [96] indicated that, the implementation of sustainability initiatives are mainly limited by resources and high initial cost of capital. Additionally, [68] argued that, most firms would not wish to invest money in a venture where the outcome in form of returns are uncertain. Considerably, investing in SPs such as pollution control measures require huge finances, which most firms may not be having. More so, the cost of financing in countries like Uganda is so high for an ordinary small and medium

manufacturing firm which forms the biggest percentage, this in turn limits these firms from securing adequate funds which could be used to implement SPs. Additionally, researchers such as [62] [46] indicated that, the complications that most firms have in accessing credit also discourages them from implementing SPs. According to [97] the real interest rate for Uganda stood at 14.6%. The real interest rate is the lending interest rate adjusted for inflation as measured by the GDP deflator. This rate of interest may not favour manufacturing firms in Uganda in its current form and this in turn limits the implementation effort of SPs.

4.2.3 Organizations culture

Various researchers [68][62] have argued that, for some manufacturing firms, existing culture is considered to be a frequent barrier to the incorporation of SPs. Accordingly, the lack of human creativity and innovation and the lack of responsibility are the underlying reasons for the existing organizational culture. In this regard, the lack of expertise in sustainability issues is another widely discussed barrier in literature [96]. Researchers [98][99][62] have indicated that managers may resist change for fear of the outcomes associated with these changes which may be unfavorable. Again, [100] [62] highlights the lack of support from the top management of the companies among key hindrances in implementing SPs. The commitment of management during the initial implementation of sustainable product service systems was identified as a main enabler by [99]. The main findings in [68] consider lack of time as one of the major barriers that SMEs face. To achieve sustainable infusion in the organizations and raise awareness, the time dedicated to these issues is key [99].

4.2.4 Limited employee skills and competences

Researchers [99] [46] indicated the relevance of knowledge, skills and competences in the implementation effort of sustainability practices. Additionally, [98] noted that, without adequate resources such as knowledge, skills, and technologies within developing countries, moving toward a more sustainable economy will be a daunting task. More so, According to [99] limited skills, knowledge and other sustainability competences impede various firms' endeavors in establishing a clear roadmap of sustainability hinged on the 3BL perspective. In a study by [101] on "the challenge of implementing sustainable development goals in Africa: The way forward" highlighted a dearth of knowledge and skilled workforce in the areas of sustainability. [61] In a

study on the enablers and barriers of Sustainable Manufacturing: Results from the survey noted limited awareness as one of the impediments towards implementation of SPs.

4.2.5 Desire to increase economic growth

According to [102] some notable factors behind environmental degradation include population growth and overexploitation of the ecosystems driven by unsustainable consumption and production patterns. The growing global middle class with higher consumption levels as well as urbanisation dynamics, put pressure on agriculture and industry needs. Moreover, given the current resource and energy intensity of production, these activities result in resource depletion along with environmental degradation and climate change [102]. In Uganda, [103] notes that, while the Uganda Vision 2040 aspires to pursue economic development and socioeconomic transformations premised on the principles of a green economy such as equity, environmental sustainability, resource efficiency, climate change adaptation and mitigation and inclusiveness, the available evidence indicates continued unsustainable practices being exhibited by manufacturing firms (see Fig. 4 and Fig 5).

5. SUGGESTED MEASURES AND POLICY IMPLICATIONS.

This section presents the various policy interventions that need implementing in order to overcome the challenges identified in section 4.

- i. Uganda established several policies in order to drive sustainability practices. These include; industrial Policy, 2008; trade policy, 2008; Cooperative Development Policy; renewable energy policy, 2007 for renewable energy generation and promotion of energy efficiency projects. This withstanding, there is need for the government to strengthen these policies for the betterment of the environment, society and prosperity for all.
- ii. Currently, manufacturing firms in Uganda continue to use biomass in their production processes for instance, in baking of bread and tea processing factories. Promote generation and integration of all energy sources to reduce on the cost and sustain the sufficient supply of power to industries. Use of cleaner and renewable energy sources is consistent with SDG 7 target 7.1 that focuses on ensuring universal access to affordable, reliable and modern energy services.

- iii. There is need for strengthening awareness creation and trainings in the areas of waste management like the application of circular models where waste is used as an input as opposed to the current traditional linear model of take make and waste which being applied in most manufacturing firms of Uganda. Knowledge generation through research should go hand in hand with strategies to create the capacity to apply and roll out new knowledge to promote the implementation of sustainability practices.
- iv. Improve financing mechanisms to promote technology transfer and innovation. The current financing modes in Uganda are not favourable. The interest rates charged by commercial banks in Uganda are exorbitant and as a result, this has made it very difficult for manufacturing firms to invest in new and up-to-date manufacturing technologies.
- v. As a catalyst to capacity building, there is need to strengthen academic institutions in Uganda. These institutions occupy important position and play central role in contributing to the uptake of sustainability practices. Research carried out in these institutions will help in building capacity in the area of sustainability practices. The newly established programmes (Masters and PhD) in energy economics and governance at Makerere University Business School Kampala and Bachelors of Resource and environmental economics at Makerere University Kampala are making insurmountable efforts in promoting sustainability practices among manufacturing firms.
- vi. Manufacturing firms should upgrade employees' skills and competences. Concerns such as; switching off lights when they are not in use, wastewater management require building employees skills and competences through trainings. Literature suggest that implementation of SPs is partially hinged on the employee's skills and competences in areas of production science, energy management, environmental economics and natural science management.
- vii. In addition to the numerous laws and policies in place, effective regulation and implementation of SPs efforts calls for reinforcement of institutional measures and capacity to implement the existing legal and policy frameworks, taking into account the use of innovation and positive incentives.
- viii. Management should Carry out Cleaner Production Assessments and prepare industry specific Environmental Management Plans; develop a code of conduct that could be abided by the industry and promote labelling and recognition mechanisms that recognises continuous improvements by the manufacturing industry; promote lifecycle assessments in the sector.

This in turn may enhance efficiency of resource consumption in the manufacturing sub-sector while minimizing adverse environmental impacts and thus increase productivity.

6. CONCLUSION

The paper examines the current state of sustainability practices among manufacturing firms in Uganda as well as the opportunities, barriers and suggest policy interventions that aim at mitigating the challenges and barriers identified. Considering that Uganda is a least developed country, the desire to increase economic growth calls for an increase in resource consumption and as a result, implementation of SPs becomes inevitable. In Uganda, researchers envisaged that, plenteous impediments in implementing SPs still exist. The notable challenges identified in this study related to weak government policies, limited technological infrastructure and competence, organisational culture, financial resources, and the high cost of financing among others. Nonetheless, some manufacturing firms have started to embrace SPs as a result of awareness creation, trainings and technical assistance provided by the Uganda cleaner production centre, environmental regulations, advances in technological innovations, establishment of the Uganda green growth strategy and as a result, many firms have attained numerous benefits as observed in Table 1.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

REFERENCES

1. Kraus, S., Burtscher, J., Niemand, T., Roig-Tierno, N., & Syrj a, P. (2017). Configurational paths to social performance in SMEs: The interplay of innovation, sustainability, resources and achievement motivation. *Sustainability*. 2017. <https://doi.org/10.3390/su9101828>.
2. Yu, Y., Choi, Y., & Zhang, N. (2015). Strategic corporate sustainability performance of Chinese state-owned listed firms: A meta-frontier generalized directional distance function approach. *The Social Science Journal*, 2015; 52(3), 300–310.

3. Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The circular economy—A new sustainability paradigm? *Journal of Cleaner Production*, 2017; 143, 757–768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
4. Malek, J., & Desai, T.N. (2021). A framework for prioritizing the solutions to overcome sustainable manufacturing barriers. 2021.
5. Lee, Hyun-Taek; Song, Ji-Hyeon; Min, Soo-Hong; Lee, Hye-Sung; Song, Ki Young; Chu, Chong Nam; Ahn, Sung-Hoon (2019). *Research Trends in Sustainable Manufacturing: A Review and Future Perspective based on Research Databases. International Journal of Precision Engineering and Manufacturing-Green Technology*, 2019–. Doi: 10.1007/s40684-019-00113-5
6. Furstenau *et al.*, (2020) "Link between Sustainability and Industry 4.0: Trends, Challenges and New Perspectives," in *IEEE Access*, 2020; vol. 8, pp. 140079-140096, doi:10.1109/ACCESS.2020.3012812
7. Bag, S., Gupta, S., Kumar, S., Sivarajah, U., (2020a). Role of technological dimensions of green supply chain management practices on firm performance. *J. Enterp. Inf. Manag.* 2020a. <https://doi.org/10.1108/JEIM-10-2019-0324>.
8. Bag, S., Wood, L.C., Mangla, S.K., Luthra, S., (2020b). Procurement 4.0 and its implications on business process performance in a circular economy. *Resour. Conserv. Recycl.* 2020b; <https://doi.org/10.1016/j.resconrec.2019.104502>.
9. Can, U., & Alatas, B. (2017). Big social network data and sustainable economic development. *Sustainability*, 2017; 9 (11), 2027.
10. Agyabeng-Mensah, Y., Afum, E., Acquah, I.S.K., Dacosta, E., Baah, C. and Ahenkorah, E., “The role of green logistics management practices, supply chain traceability and logistics ecocentricity in sustainability performance”, *The International Journal of Logistics Management*, 2021; Vol. 32 No. 2, pp. 538-566, doi: 10.1108/IJLM-05-2020-0187.
11. Baah, C., Amponsah, K.T., Issau, K., Ofori, D., Acquah, I.S.K. and Agyeman, D.O. “Examining the interconnections between sustainable logistics practices, environmental reputation and financial performance: a mediation approach”, *Vision*, 2021a; Vol. 25 No. 1, pp. 47-64, doi: 10.1177/ 0972262920988805.
12. Nave, A., Laurett, R., & do Paço, A.. Relation between antecedents, barriers and consequences of sustainable practices in the wine tourism sector. *Journal of Destination Marketing & Management*, 2021; 20, 100584. doi:10.1016/j.jdmm.2021.100584
13. Baah, C., Jin, Z. and Tang, L., “Organizational and regulatory stakeholder pressures friends or foes to green logistics practices and financial performance: investigating corporate reputation as a missing link”, *Journal of Cleaner Production*, 2020a; Vol. 247, 119125
14. Baah, C., Opoku-Agyeman, D., Acquah, I.S.K., Agyabeng-Mensah, Y., Afum, E., Faibil, D. and Abdoulaye, F.A.M., “Examining the correlations between stakeholder pressures, green production practices, firm reputation, environmental and financial performance: evidence from manufacturing SMEs”, *Sustainable Production and Consumption*, 2020b; Vol. 27, pp. 100-114.
15. Baah, C., Opoku-Agyeman, D., Acquah, I.S.K., Issau, K. and Abdoulaye, F.A.M. “Understanding the influence of environmental production practices on firm performance: a proactive versus reactive approach”, *Journal of Manufacturing Technology Management*. 2020c; Doi: 10.1108/jmtm-05-2020-0195.

16. Stark, R., Seliger, G., Bonvoisin, J. Sustainable Manufacturing, challenges, solutions and implementation perspectives. 2017. ISSN 2194-0541, ISBN 978-3-319-48513-3. <https://doi.org/10.1007/978-3-319-48514-0>.
17. Abdul Rashid, S., Sakundarini, N., Ghazillah, R., & Ramayah, T. Impact of sustainable manufacturing practices on sustainable performance: Empirical evidence from Malaysia. *International Journal of Operations and Production Management*, 2017; 37(2), 182-204.
18. Singh, R.K., Modgil, S., Tiwari, A.A. "Identification and evaluation of determinants of sustainable manufacturing: a case of Indian cement manufacturing", *Measuring Business Excellence*, 2018; <https://doi.org/10.1108/MBE-08-2018-0056>
19. Alayón, C., Säfssten, K., & Johansson, G. Conceptual sustainable production principles in practice: Do they reflect what companies do? *Journal of Cleaner Production*, 2017; 141, 693-701
20. Shankar, K.M., Kannan, D., & Kumar, P.U. Analyzing sustainable manufacturing practices—A case study in Indian context. *Journal of Cleaner Production*, 2017; 164, 1332-1343.
21. Govindan, K., Khodaverdi, R., Vafadarnikjoo, A. Intuitionistic fuzzy based DEMATEL method for developing green practices and performances in a green supply chain, *Expert Systems with Applications*, 2015; Volume 42, Issue 20, Pages 7207-7220, ISSN 0957-4174, <https://doi.org/10.1016/j.eswa.2015.04.030>.
22. Gupta, K., Laubscher, R.F., Davim, J.P., Jain, N.K., Recent developments in sustainable manufacturing of gears: A review. *J. Clean. Prod.* 2016; 112, 3320–3330. doi:10.1016/j.jclepro.2015.09.133
23. Bellantuono N., Carbonara P. Pontrandolfo. The organization of eco-industrial parks and their sustainable practices. *Journal of Cleaner Production* 2017; 161, 362-375. DOI: 10.1016/j.jclepro.2017.05.082
24. Sheldon, R.A., Green and sustainable manufacture of chemicals from biomass: state of the art. *Green Chem.* 2014; 16, 950–963. doi:10.1039/C3GC41935E
25. Álvarez, M.E.P., Bárcena, M.M., González, F.A. On the sustainability of machining processes. Proposal for a unified framework through the triple bottom-line from an understanding review. *J. Clean. Prod.* 2017; 142, 3890–3904. doi:10.1016/j.jclepro.2016.10.071
26. Sáez-Martínez, F.J., Lefebvre, G., Hernández, J.J., Clark, J.H., Drivers of sustainable cleaner production and sustainable energy options. *J. Clean. Prod.* 2016; 138, 1–7. doi:10.1016/j.jclepro.2016.08.094
27. Wang, Z., Subramanian, N., Gunasekaran, A., Abdulrahman, M.D., Liu, C. Composite sustainable manufacturing practice and performance framework: Chinese auto-parts suppliers' perspective. *Int. J. Prod. Econ.* 2015; 170, 219–233. doi:10.1016/j.ijpe.2015.09.035
28. <http://www.switachfricagreen.org/UG/index.php/resources/national-networking-forum-2017/7-promoting-sustainable-manufacturing-sag-mtic-project/file> (accessed 25/January/2022).
29. IEA, O. Energy and Climate Change, IEA, Paris, 2015; available at: <https://www.iea.org/reports/energy-and-climate-change>.
30. UNDP. Africa sustainable development report: towards a transformed and resilient continent. United Nations Development Programme (UNDP), 2018a; New York.
31. UN. The sustainable development goals report 2019. United Nations New York.

32. National Environment Management Authority (NEMA) Annual Corporate Report For 2018/19 (Accessed on 27th January, 2022)
33. World Health Organization “How Air Pollution Is Destroying Our Health,” October 29, 2018, <https://www.who.int/air-pollution/news-and-events/howair-pollution-is-destroying-our-health> (accessed August 9, 2019).
34. David A Dornfeld, Jawahir I S, Andres F Clarens, Dechant K and Altman B, “Environmental Leadership: From Compliance to Competitive Advantage”, Academy of Management Executive, 1994; Vol. 8, No. 2, pp. 7-20.
35. <https://www.oecd.org/innovation/green/toolkit/48704993.pdf> (Retrieved on 21st December, 2021).
36. OECD, The economic consequences of climate change, OECD Publishing, Paris 2015.
37. Omara, T., Othieno, N., Obonge, J., Ssebulime, S. and Kansime, M. Characterization and Prognostication of Wastes Generated by Industries in Kampala Industrial and Business Park Namanve. Open Access Library Journal, 2019; 6: e5189. <https://doi.org/10.4236/oalib.1105189>
38. National State of the Environment Report 2018-2019 “Managing the Environment for Climate Resilient Livelihoods and Sustainable Economic Development” Accessed on <https://www.nema.go.ug/sites/default/files/NSOER%202018-2019.pdf>.
39. OECD, The economic consequences of outdoor air pollution, OECD Publishing, Paris. 2016
40. <https://Ugandaradionetwork.net/story/Busia-Tororo-districts-want-sugar-factory-closed-for-polluting-river-malaba>. (accessed on 25/January/2022)
41. <https://kaarokarungi.com/2021/09/06/three-districts-grappling-with-restoration-of-river-Rwizi/>(accessed on 25th /January/2022).
42. Third National Development Plan (NDP III) 2020/21 – 2024/25
43. Buzuku, S., Kässi, T. Drivers and Barriers for the Adoption of Eco-design Practices in Pulp and Paper Industry: a Case Study of Finland, *Procedia Manufacturing*, 2019; Volume 33, Pages 717-724, ISSN 2351-9789.
44. Abdul Moktadir, Towfique Rahman, Hafizur Rahman, Syed Mithun Ali, Sanjoy Kumar Paul, Drivers to sustainable manufacturing practices and circular economy: a perspective of leather industries in Bangladesh, *Journal of Cleaner Production*. 2017.
45. Aboelmaged, M. (2018). The drivers of sustainable manufacturing practices in Egyptian SMEs and their impact on competitive capabilities: A PLS-SEM model. *Journal of Cleaner Production*, 2018; 175, 207–221.
46. Ghazilla, R.A.R., Sakundarini, N., Abdul-Rashid, S.H., Ayub, N.S., Olugu, E.U., & Musa, S.N. Drivers and Barriers Analysis for Green Manufacturing Practices in Malaysian SMEs: A Preliminary Finding. *Procedia CIRP*, 2015; 26, 658-663.
47. Karuppiah, K., Sankaranarayanan, B., Ali, S. M., Chowdhury, P., & Paul, S. K. An integrated approach to modeling the barriers in implementing green manufacturing practices in SMEs. *Journal of Cleaner Production*, 2020.
48. Masocha, R and Fatoki, O, The Role of Mimicry Isomorphism in Sustainable Development Operationalization by SMEs in South Africa. 2018
49. Masocha, R. “Normative environmental configuration of SMEs within the sustainable development discourse in South Africa: an empirical study”, *Sustainability*, 2019; Vol. 11 No. 23, p. 6537.

50. , S., Charan, P. and Murty, L.S., "Institutional pressure and the implementation of corporate environment practices: examining the mediating role of absorptive capacity", *Journal of Knowledge Management*, 2018; Vol. 22 No. 7, pp. 1591-1613. <https://doi.org/10.1108/JKM-12-2016-0531>
51. García-Machado, J.J.; Martínez-Ávila, M. Environmental Performance and Green Culture: The Mediating Effect of Green Innovation. An Application to the Automotive Industry. *Sustainability* **2019**, *11*, 4874. <https://doi.org/10.3390/su11184874>
52. Yang, Z., Sun, J., Zhang, Y., Wang, Y., Green, Green, It's Green: A Triad Model of Technology, Culture, and Innovation for Corporate Sustainability. *Sustainability Journal*. MDPI, 2017.
53. Islam, M.F., Zhang, J. and Hasan, N., "Assessing the adoption of sustainability practices in tourism industry: Insights from a developing country", *The Bottom Line*, 2020; Vol. 33 No. 1, pp. 94-115. <https://doi.org/10.1108/BL-09-2019-0113>
54. Sreenivasan Jayashree, Mohammad Nurul Hassan Reza, Chinnasamy Agamudai Nambi Malarvizhi, Muhammad Mohiuddin, Industry 4.0 implementation and Triple Bottom Line sustainability: An empirical study on small and medium manufacturing firms, *Heliyon*, 2021; Volume 7, Issue 8, 2021, e07753, ISSN 2405-8440, <https://doi.org/10.1016/j.heliyon.2021.e07753>.
55. Chege, S. M., & Wang, D. (2020). The influence of technology innovation on SME performance through environmental sustainability practices in Kenya. *Technology in Society*, 2020; 60, 101210. doi:10.1016/j.techsoc.2019.101
56. Sendawula, K., Bagire, V., Mbidde, C.I. and Turyakira, P. (2021), "Environmental commitment and environmental sustainability practices of manufacturing small and medium enterprises in Uganda", *Journal of Enterprising Communities: People and Places in the Global Economy*, Vol. 15 No. 4, pp. 588-607. <https://doi.org/10.1108/JEC-07-2020-0132>
57. Sendawula, K., Turyakira, P., Ikiror, C.M. and Bagire, V. (2021), "Regulatory compliance and environmental sustainability practices of manufacturing entrepreneurial ventures in Uganda", *Asia Pacific Journal of Innovation and Entrepreneurship*, Vol. 15 No. 1, pp. 62-74. <https://doi.org/10.1108/APJIE-08-2020-0122>
58. Kaawaase, T.K., Bananuka, J., Tumwebaze, Z. and Musimenta, D. (2021), "Do energy and firm characteristics matter for sustainable development practices? An empirical evidence", *International Journal of Energy Sector Management*, Vol. ahead-of-print No. ahead-of-print. <https://doi.org/10.1108/IJESM-03-2021-0007>
59. Knight, H., Megicks, P., Agarwal, S., & Leenders, M. A. A. M. Firm resources and the development of environmental sustainability among small and medium-sized enterprises: Evidence from the Australian wine industry. *Business Strategy and the Environment*, 2019; 28(1), 25–39. <https://doi.org/10.1002/bse.2178>
60. Annunziata, E., Pucci, T., Frey, M. and Zanni, L., "The role of organizational capabilities in attaining corporate sustainability practices and economic performance: evidence from Italian wine industry", *Journal of Cleaner Production*, 2018; Vol. 171, pp. 1300-1311.
61. Bhanota, N., Rao, P., & Deshmukh, S. Enablers and barriers of sustainable manufacturing: Results from a survey of researchers and industry professionals. *Procedia CIRP* 2015; 29, 562–567.

62. Malek, J., & Desai, T.N. Prioritization of sustainable manufacturing barriers using Best Worst Method. *Journal of Cleaner Production*. 2019.
63. Ahuja, J., Panda, T. K., Luthra, S., Kumar, A., Choudhary, S., & Garza-Reyes, J. A. Do human critical success factors matter in adoption of sustainable manufacturing practices? An influential mapping analysis of multi-company perspective. *Journal of Cleaner Production*, 2019; 117981.
64. Orji, I. J. Examining barriers to organizational change for sustainability and drivers of sustainable performance in the metal manufacturing industry. *Resources, Conservation and Recycling*, 2019; 140, 102–114.
65. Piyathanavong, V., Garza-Reyes, J. A., Kumar, V., Maldonado-Guzmán, G., & Mangla, S. K. The adoption of operational environmental sustainability approaches in the Thai manufacturing sector. *Journal of Cleaner Production*. 2019; doi:10.1016/j.jclepro.2019.02.093
66. Neto, G. C. de O., Tucci, H. N. P., Correia, J. M. F., da Silva, P. C., da Silva, D., & Amorim, M. Stakeholders' Influences on the Adoption of Cleaner Production Practices: A Survey of Textile Industry. *Sustainable Production and Consumption*. 2020
67. Neri, A., Cagno, E., Di Sebastiano, G., & Trianni, A. Industrial sustainability: Modelling drivers and mechanisms with barriers. *Journal of Cleaner Production*, 2018; 194, 452–472.
68. H.T.S. Caldera, C. Desha, L. Dawes, (2019) Evaluating the enablers and barriers for successful implementation of sustainable business practice in 'lean' SMEs, *Journal of Cleaner Production*, 2019; Volume 218, Pages 575-590, ISSN 0959-6526
69. Prasad D. S, Pradhan, R. P, Guarav, K. Sabat, A. K. Critical success factors of sustainable supply chain management and organisation performance: An exploratory study. World conference on Transport Research-WCTR 2019, Mumbai, 26-30 May 2019. 2020.
70. Nordin N., Ashari H., Hassan M.G., Drivers and barriers in sustainable manufacturing implementation in Malaysian Manufacturing firms. 2014.
71. Abdul-Rashid, S.H., Sakundarini, N., Ariffin, R. et al. Drivers for the adoption of sustainable manufacturing practices: A Malaysia perspective. *Int. J. Precis. Eng. Manuf.* 2017; 18, 1619–1631.
72. Fatoki. Drivers and Barriers to sustainability manufacturing practices by small and medium enterprises in South Africa. 2019.
73. Gupta, S., Dangayach, G.S., Singh, A.K., Meena, M.L. and Rao, P.N. "Implementation of sustainable manufacturing practices in Indian manufacturing companies", *Benchmarking: An International Journal*, 2018; Vol. 25 No. 7, pp. 2441-2459.
74. Icka, Engjellushe; Adams, Jeffery; and Kauffman, Ralph G. "Environmental Sustainability Practices of Albanian Micro Enterprises and SMEs," *Midwest Social Sciences Journal*: 2021; Vol. 24: Iss. 1, Article 5. DOI: 10.22543/0796.241.1041.
75. Mutingi, M., Musiyarira, H.K., & Mbohwa, C. An Analysis of Enablers and Barriers of Sustainable Manufacturing in Southern Africa. 2017.
76. Agyemang, M., Kusi-Sarpong, S., Khan, S. A., Mani, V., Rehman, S. T., & Kusi-Sarpong, H. Drivers and barriers to circular economy implementation: an explorative study in Pakistan's automobile industry. *Management Decision*, 2019; 57(4), 971-994. <https://doi.org/10.1108/MD-11-2018-1178>

77. Lee. Drivers and Barriers to energy efficiency management for sustainable development. 2015.
78. Gouda, S. K and Saranga, H. Pressure or premium: what works best where? Antecedents and outcomes of sustainable manufacturing practices, *International Journal of Production Research*, 2020; volume 58, pages 7201 - 7217
79. Wang, S., & Song, M. Influences of reverse outsourcing on green technological progress from the perspective of a global supply chain. *Science of the Total Environment*, 2017; 595, 201-208. <https://doi.org/10.1016/j.scitotenv.2017.03.243>
80. Sáez-Martínez, F.J., Díaz-García, C., & González-Moreno, Á. Factors promoting environmental responsibility in European SMEs: The effect on performance. *Sustainability (Switzerland)*, 2016 8(9), 1-10.
81. Gandhi, N. S., Thanki, S. J., & Thakkar, J. J. Ranking of drivers for integrated lean-green manufacturing for Indian manufacturing SMEs. *Journal of Cleaner Production* 2018; (Vol.171). Elsevier B.V. <https://doi.org/10.1016/j.jclepro.2017.10.041>.
82. Saeed, M. A., Kersten, W. Drivers of sustainable supply chain management: identification and clarification, sustainability review, MDPI. 2019
83. Siemieniuch, C.E., Sinclair, M.A., Henshaw, M.J.C., Global drivers, sustainable manufacturing and systems ergonomics. *Appl. Ergon.* 2015; 51, 104–119. doi:10.1016/j.apergo.2015.04.018
84. [www.http//Npa.go.ug/about-mpa/Uganda-green-growth-development-strategy/](http://Npa.go.ug/about-mpa/Uganda-green-growth-development-strategy/) (accessed on 6th January, 2022)
85. Yusuf, Y. Y., Gunasekaran, A., Musa, A., El-Berishy, N. M., Abubakar, T., and Ambursa, H. M., “The UK Oil and Gas Supply Chains: An Empirical Analysis of Adoption of Sustainable Measures and Performance Outcomes,” *International Journal of Production Economics*, 2013; Vol. 146, No. 2, pp. 501-514.
86. Porter, M. E. and Van der Linde, C., “Toward a New Conception of the Environment-Competitiveness Relationship,” *The Journal of Economic Perspectives*, 1995; Vol. 9, No. 4, pp. 97- 118.
87. Gadenne, D. L., Kennedy, J., & McKeiver, C. An empirical study of environmental awareness and practices in SMEs. *Journal of Business Ethics*, 2009 84(1), 45 63. <https://doi.org/10.1007/s10551008-9672-9>
88. Battisti, M., & Perry, M. Walking the talk? Environmental responsibility from the perspective of small-business owners. *Corporate Social Responsibility and Environmental Management*, 2011; 18(3), 172–185. <https://doi.org/10.1002/csr.266>
89. Font, X., Garay, L., & Jones, S. Sustainability motivations and practices in small tourism enterprises in European protected areas. *Journal of Cleaner Production*, 2016; 137, 1439–1448. <https://doi.org/10.1016/j.jclepro.2014.01.071>
90. Jansson, J., Nilsson, J., Modig, F., & Hed Vall, G. Commitment to Sustainability in Small and Medium-Sized Enterprises: The Influence of Strategic Orientations and Management Values. *Business Strategy and the Environment*, 2017; 26 (1), 69–83. <https://doi.org/10.1002/bse.1901>
91. Ansuategi, A., Greno, P., Houlden, V., Markandya, A., Onofri, L., Picot, H., et al. *The Impact of Climate Change on the Achievement of the Post-2015 Sustainable Development Goals*. 2015; Available online at: https://assets.publishing.service.gov.uk/media/57a0897bed915d622c000233/Impact-of-climate-on-SDGs_Technical-Report-CDKN.pdf (accessed July 26, 2021).

92. Fashina, A., Mundu, M., Akiyode, O., Abdullah, L., Sanni, D and Ounyesiga, L. (2018). *The Drivers and Barriers of Renewable Energy Applications, and Development in Uganda: A review*, clean technologies. 2018.
93. Majumdar, A., & Sinha, S. modeling the barriers of green supply chain management in small and medium enterprises. *Management of Environmental Quality: An International Journal*. 2018; Doi: 10.1108/meq-12-2017-0176
94. Bhanot, N., Rao, P.V., Deshmukh, S.G., An integrated approach for analysing the enablers and barriers of sustainable manufacturing. *J. Clean. Prod.* 2017; 142, 4412–4439
95. Nema.go.ug/projects/environmental-laws (accessed on 13 December 2021).
96. Álvarez Jaramillo, Juanita; Zartha Sossa, Jhon Wilder; Orozco Mendoza, Gina Lía *Barriers to sustainability for small and medium enterprises in the framework of sustainable development— <scp>L</scp> iterature review. Business Strategy and the Environment*, 2018; (), bse.2261–. doi:10.1002/bse.2261
97. <https://data.worldbank.org/indicator/FR.INR.RINR?locations=UG> (Retrieved on 28th January 2022)
98. United Nations Industrial Development Organisation (2020). Making industrialisation in Africa sustainable. Retrieved April 21, 2021, from the United Nations Industrial Development Organisation website: <https://www.un.org/en/un-chronicle/making-industrialisation-africa-sustainable>.
99. De Jesus Pacheco, D.A., ten Caten, C.S., Jung, C.F., Sassanelli, C., and Terzi, S. Overcoming barriers towards sustainable product-service systems in small and medium-sized enterprises: state of the art and a novel decision matrix. *J. Clean. Prod.* 2019b; 222, 903e921. <https://doi.org/10.1016/j.jclepro.2019.01.152>.
100. Mitchell, G. J. L., Cagno, E., Mustillo, G., & Trianni, A. Green supply chain management drivers, practices and performance: A comprehensive study on the moderators. *Journal of Cleaner Production*, 2020; 121024.
101. Jaiyesimi R. The challenge of implementing sustainable development goals in Africa: the way forward. *Afr J Reprod Health (special edition on SDGs)*. 2016; 20(3):13–8.
102. United Nations Environment Programme (2017). The Emissions Gap Report 2017: A UN Environment Synthesis Report. Nairobi. 2017; https://wedocs.unep.org/bitstream/handle/20.500.11822/22070/EGR_2017.pdf?isAllowed=y&sequence=1
103. Uganda Green Growth Strategy Development (2018/2031) retrieved from <http://www.npa.go.ug/about-npa/uganda-green-growth-development-strategy/> on 28th January 2022.