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Sustainable development in manufacturing firms in Kenya: Assessing the influence of green practices

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Abstract:

Kenya is a member of the United Nations (UN) that ratified the sustainable development goals (SDGs) adopted in 2015 to protect the planet, end poverty, and ensure peace and prosperity. To this end, the country submitted her Nationally Determined contribution (NDC), intending to lessen greenhouse gas (GHG) emissions by 30 percent by 2030 relative to the business as usual (BAU) scenario. This percentage has since been updated to 32 percent. With the desire to protect the environment, most manufacturing firms have embraced green practices in their supply chains to realize zero carbon emissions. This study examines the influence of greening manufacturing on supply chain sustainability. A four-latent variable conceptual model is proposed to show the relationships. The model is empirically tested using data collected from Eldoret Town, Kenya, manufacturing firms. Data is collected using a closed-ended questionnaire comprising four latent measurement scales. Structural Equation Modeling (SEM) is used to test the postulations made. Results indicate that green practices have positive and significant influences on supply chain sustainability. These results underscore the emerging importance of green practices in responsible and sustainable supply chains. Future research should, however, seek to allow a diverse target population drawn across different counties

Key words:

sustainable development, green practices, green procurement, green manufacturing, green logistics

Introduction

Like other countries globally, Kenya is staring at the reality of the sixth mass extinction, with scientific knowledge showing a decline in biodiversity and ecosystem services. According to the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), close to one million animals and plant species face the threat of extinction, weakening livelihoods, health, food security, and reduction in the quality of life (IPBES, 2019). One sector that contributes significantly to the degradation and loss of biodiversity is manufacturing significantly impacts both employment and the global economy. According to Deloitte, the manufacturing industry accounts for about 23% of employment worldwide (Deloitte,2023). Additionally, manufacturing contributes close to 16% of the global Gross Domestic Product (GDP) (World Bank ,2023). This underscores the sector's critical role in driving economic activity and providing jobs globally.

Yet, research also points to manufacturing as one of the main sources of greenhouse gas emissions (Golasa et al., 2021).

The EU's innovative growth plan aspires to position Europe as the first continent to achieve climate neutrality by 2050, targeting net-zero greenhouse gas emissions. The Green Deal includes comprehensive actions across various economic sectors, such as energy, transport, agriculture, and industry, to promote the shift toward a competitive, resource-efficient, and circular economy (European Commission, 2024). The circular economy involves the methodical retrieval and recycling of products and natural resources to reduce the extraction, consumption, and disposal of natural resources. It aims to maximize resource efficiency (World Bank, 2022). Embracing a circular economy offers ecological advantages such as decreased reliance on primary raw materials and significant cuts in greenhouse gas emissions and external costs linked to manufacturing, transportation, and built environment systems.

It is argued that the prevention of the sixth extinction requires collaborative actions that leverage novelty and innovation to save the planet (Gianguzzi et al., 2022). Consequently, green manufacturing is a novel and innovative way of ensuring that the manufacturing industry stops the degradation and loss of biodiversity and enhances sustainable development. Sustainable development is the development that takes cognizance of future generations' needs while meeting present needs. In conformity with UNESCO, sustainable development is a concept first described by the Brundtland Commission report in 1987. It remains an overarching paradigm of the United Nations (UN).

Biodiversity and ecosystem feature significantly in the discourse on sustainable development (Khoury et al., 2019; Verma, 2021). These scholars identify biodiversity as central to agriculture-related economic activities, including livestock and crop production, fisheries, and forestry. Besides, biodiversity is the primary source of daily subsistence needs for the most vulnerable members of society (Vira and Kontoleon, 2010).

Another element that features prominently in sustainable development is disaster risk reduction (DRR). According to Navarrro (2020), DRR as a critical facet of social and economic growth is essential for future sustainable development. The manufacturing industry has experienced disasters caused either by incompetence or by accident. Some of the deadliest manufacturing disasters in the last two decades include: the collapse of the Rana Plaza, an eight-story building in Dhaka, Bangladesh that housed five garment factories in 2013; the Kunshan explosion that occurred in 2014 and affected an automotive factory; the Dhaka fire of 2012 that scorched the Tazreen fashion factory; the Pakistan factory fires that claimed 300 workers; the Glasgow factory explosion of 2004 that occurred in the Stockline plastics factory; and the Kader toy factory fire that occurred in 1993 in Thailand destroying the Kader Industrial Co. Ltd factory. Such disasters justify embedding DRR in sustainable development.

Sustainable consumption and production (SCP) is a component of sustainable development that delinks economic growth from environmental degradation leading to a sustainable lifestyle and increased resource efficiency. According to the United Nations Environment Programme (UNEP), the rate of resource consumption exceeds the planet's capacity to generate. Moreover, there is a growing disparity between the rich and the poor, as is the growth in waste and pollution (Alder et al., 2012). The need for stakeholder cooperation across sectors to leverage SCP to alleviate poverty and to transit towards green and low-carbon economies has never been any higher (Green Deal Europa, 2023). The Green Deal emphasizes the importance of coordinated efforts among various sectors to achieve sustainable economic growth while addressing social inequalities and environmental challenges.Meanwhile, climate change is perceived as another indicator of sustainable development that can lead to social, economic, and natural system shocks. Therefore, sustainable development was conceptualized as the endogenous construct in the study and measured using the four indicators.

Exploring and stopping the threat of the sixth extinction requires eco-innovations upon which to prototype collective green creativity. One such eco-innovation is green manufacturing. Green manufacturing targets operations that recycle and reuse materials, reduce waste and pollution, moderate emissions, and use fewer resources. Therefore, green manufacturing is the establishment of environmentally friendly and renewable product processes in manufacturing (Dornfeld et al., 2013). Such a process brings positive change and limits the negative impact of manufacturing.

Three practices through which green manufacturing is conducted are delineated from existing research. The first practice outlined is energy decarbonization (Faria et al., 2019). Through this practice, manufacturing is supposed to rely more on electricity use, increase reliance on biomass, expand carbon capture, and increase the use of hydrogen in processes. The second green manufacturing practice often considered is greening the scrap pile (Dini et al., 2018). Through this practice, manufacturers are expected to extend production responsibility, trim waste in packaging and transportation, and manufacture durable and reusable products. The third prominent green manufacturing practice is workers' protection and enablement (Menon et al., 2018). This practice aims to have manufacturers align operational safety with efficient material and energy use, employ worker robots, and enhance automation based on artificial intelligence (AI). Therefore, these three practices were conceptualized as exogenous variables.

In this study, we examine the influence of green practices on sustainable development in manufacturing firms in Kenya. Throughout the study, references are made to specific sectors such as the 'scrap pile' and the 'maritime sector' to illustrate the diverse applications of green practices. The mention of these sectors serves to highlight key areas where green manufacturing initiatives can have a significant impact on sustainable development outcomes. For instance, greening the scrap pile emphasizes the importance of waste reduction and resource efficiency, while discussions on the maritime sector underscore the broader implications of energy decarbonization efforts. These references are intended to provide context and illustrate practical applications of green practices within the manufacturing sector.

Research conducted in Kenya has endeavored to explore the impacts of green manufacturing on, among other functions, the operational performance of the cement manufacturing firm (Eshikumo and Odock, 2017), food processing in Mombasa County (Nyakundi, 2013), operational performance of manufacturing firms (Musau, 2019), and performance of Kibos sugar and allied industries (Juma, 2016). However, little or no research has explained the influence of greening manufacturing on sustainable development from a Kenyan perspective. This research analyzed the effect of green practices on sustainable development in Kenyan manufacturing firms.

1 Literature review

1.1 Sustainable development

The concept of sustainable development can be traced to the concerns about the impact of civilization evolution on resources and the environment. For instance, Robert Malthus (1766-1834), in an essay on the principle of the population, predicted starvation or minimal subsistence among the world's population due to the inability of food production to keep pace with population growth (Rogers et al., 2008). Consequently, the link between the environment and development was first articulated in a conference held in Stockholm, Sweden, in 1972 and attended by 113 states and representatives of 19 international organizations (Volger, 2007). The conference focused on the human environment and was devoted exclusively to environmental issues. The conference catalyzed the adoption of agreements on ship pollution, ocean dumping, and trade in endangered species. Building on the achievement of the Stockholm conference, the UN Assembly created a world commission on environment and development, later named the Brundtland Commission after its chair in 1983. In 1987, the commission gave the most concise definition of sustainable development as development that meets the present generation's needs without compromising the ability of future generations to meet their own needs (Vogler, 2007). The concept of sustainable development was thus born, albeit with some criticisms.

Interest in sustainable development has continued with scholars examining diverse themes, including the social pillar of sustainable development (Murphy, 2012), innovations for sustainable development (Silvestre and Tirca, 2019), rationalities for sustainable development (Bolis et al., 2017), bioaromas perspectives for sustainable development (de Oliveira et al., 2017) among others. Moreover, the UN member states committed to 17 global sustainable development goals to act as a blueprint for a better future (Stafford–Smith et al., 2017). However, not many studies have explored sustainable development from a green manufacturing perspective.

1.2 Green manufacturing

Green manufacturing (GM), also known as clean manufacturing, benign manufacturing, environmentally conscious manufacturing, or sustainable manufacturing, focuses on the design and manufacture of products with minimal negative impacts on the environment (Rehman and Shrivastava, 2013). Consequently, GM advocates for waste management, conservation, recycling, pollution control, regulatory compliance, and environmental protection, among other eco-friendly practices.

Green manufacturing has its genesis in Germany in the late 1980s and early 1990s (Bylinsky, 1995). Bylinsky (1995) posits that Germany had established a manufacturing standard requiring that to compete globally, companies should comply with the green regulations of the European market. At the onset, sustainable manufacturing dwelt more on reducing waste in production. However, the paradigm soon changed to resource reduction, reduction of toxic materials and energy consumption, and use of renewable materials (Selinger et al., 2008). Companies started to restrict carbon emissions and earned green credits, pushing them to recycle CO_2.

Green manufacturing has since been critical to a low-carbon future. According to Munirathinam (2020), green manufacturing subsumes the fourth industrial revolution. This revolution is popularly referred to as industry 4.0 and Industrial Internet of Things (IIoT). It offers innovation opportunities to decarbonize energy, develop sustainable and environmentally friendly materials, maximize production through minimum resource use, and extend the life cycle of goods. In essence, green manufacturing drives decarbonization, greens the scrap pile, and protects and empowers workers.

1.3 Energy decarbonization and sustainable development

Ezinna et al. (2021) used the maritime sector to reflect energy decarbonization as a sustainable goal number 13, intended to reduce global warming to 2o C by 2030. They determined that achieving the desired 2030 green shipping was not feasible given that the worldwide community does not read the same urgency regarding the decarbonization of the shipping sector. This difference in urgency has resulted in some nations failing to align with the Paris agreements' 1.5o C goal.

Sachs et al. (2019) examined the six transformations required to achieve sustainable development. Key transformations among their findings included education, gender and inequality, energy decarbonization, demography, health and wellbeing, sustainable water, oceans, land, and food; digital revolution; and sustainable communities and cities. Yet, there was no mention of sustainable manufacturing despite its role in environmental pollution.

Sezen and Cankaya (2013) took cognizance of the pressure for firms to become greener to explore the effects of green manufacturing and eco-innovation on sustainable performance. Using a survey of 53 firms drawn from the electronics, chemistry, and automotive sectors in Turkey, they established that green manufacturing practices significantly and positively impacted their social and environmental performance. Moreover, eco-process innovation impacted corporate sustainability significantly and positively. However, they did not specify the direct effect of decarbonization on sustainable development. With the looming sixth extinction, the role of energy decarbonization in manufacturing remains unexplored. Therefore, this research postulated that energy decarbonization in manufacturing significantly affected sustainable development.

1.4 Greening the scrap pile and sustainable development

Empirical research on greening the scrap pile has mainly centered on extended producer responsibility (EPR). For instance, Woolridge and Hoboy (2019) focused on medical waste when extolling the utility of EPR schemes in addressing scrap piles in the form of medical waste and old unused medicines. According to Woolridge and Hoboy (2019), EPR schemes ensure that household waste streams are not polluted by pharmaceutical and sharps waste. Such waste is denatured or incinerated to deter reuse. They, however, failed to relate such gains to sustainable development.

Kosior and Crescenzi (2020) argued that EPR as a producer-focused mechanism is gaining worldwide recognition due to its efficiency in waste management. They concluded that effective implementation of EPR programmes greens the scrap pile by increasing recycling and collecting rates, reducing waste expenditure, and increasing product durability and reusability. However, the study did not enumerate the direct effect of EPR on sustainable development. With the earth on the edge of a sixth extinction, the question then is the role greening the scrap pile can play in alleviating this extinction. Consequently, this research presupposed that greening the scrap pile can play a role in cleaning the environment and leading to sustainable development.

Worker Protection and Enablement and Sustainable Development

Worker safety and involvement feature prominently in green manufacturing and sustainability discourse. Camuffo et al. (2017) explored safety and sustainability from a high involvement and lean operations work practice perceptive. Buoyed by the quest to understand the human role in sustainability, they determined that highly involving work practices, lean production systems, workers' capacity development, and empowerment impacted occupational safety positively. However, this result fell short of confirming their effects on sustainable development.

Nawaz et al. (2019) examined the nexus between safety and sustainability. Using a systematic literature review, they determined that safety was closely linked to sustainability. Ignoring such a link would likely result in dangerous consequences to society, the economy, and the environment. Despite these positive contributions, they failed to connect workers' protection and enablement to sustainable development.

Meanwhile, Awan (2019) analyzed the effect of social practices on sustainable development from a supply chain perspective. Focusing on green practices such as environmental cooperation and safety practices, Awan (2019) empirically demonstrated that safety practices, alongside other green manufacturing practices in the social supply chain, impacted sustainable performance positively. Although the study contributed positive insights on safety and sustainability issues, it did not show the direct effects of workers' protection and enablement on sustainable development. This research argued that workers' protection and empowerment, including automation and use of work robots, have the potential to address the imminent extinction and postulated that protecting and enabling workers would positively impact sustainable development.

It is necessary to deal with Worker Protection and Enablement in the context of Sustainable Development because the well-being and empowerment of workers are fundamental to achieving long-term sustainability goals. Workers who are protected and empowered are more likely to contribute to sustainable practices and innovation within their organizations. This, in turn, leads to enhanced productivity, reduced environmental impact, and stronger economic performance. Ensuring worker protection and enablement fosters a safe and supportive work environment, which is crucial for maintaining the social pillar of sustainable development. Moreover, it aligns with the principles of corporate social responsibility, enhancing the overall sustainability profile of an organization. This research argued that workers' protection and empowerment, including automation and use of work robots, have the potential to address the imminent extinction and postulated that protecting and enabling workers would positively impact sustainable development.

2 Methods and methodology

2.1 Study design

The study was conducted in manufacturing firms drawn from Eldoret town. The town is a manufacturing hub that hosts nationally recognized manufacturing firms, including Rupa Textiles, Raiply Woods, Pyrethrum, Corn, and wheat factories, Kenya Cooperative Creameries, and Kenya Pipeline Company. This array of manufacturing firms in diverse sectors made the town ideal for enhancing external validity. However, it is acknowledged that the unique characteristics of Eldoret may not fully capture the conditions of other towns or regions. Future research should consider replicating this study in different locations to verify the robustness of the findings across various contexts. The research was anchored in the positivist research paradigm that supports cause-effect relations. Consequently, the study employed the ex-post-facto explanatory research design.

2.2 Study sample

The study targeted supply chain-related employees, including employees from production/operations management, logistics, transport management, and customer service management. These sections play supply chain functions and contribute significantly to environmental degradation, making them suitable for green manufacturing studies. A reconnaissance study of the town identified twenty-six major manufacturing firms with 1182 employees in the targeted sections. The research used a sample of 290 employees determined using a sample size formula suggested by Getu and Tegbar (2016). The stratified and simple random sampling techniques were used to select the required sample of 290 employees from the targeted sectors.

2.3 Data collection

Data were collected using the employees' questionnaire. A questionnaire was deemed suitable due to its flexibility, versatility, and cost-effectiveness (Satrirenjit et al., 2012). The questionnaire was in five sections. The first section focused on employee demographics used as a control in the study. The rest of the sections covered the three exogenous and endogenous variables.

2.4 Data analysis

Data were analyzed using the AMOS software's covariance-based structural equation modeling (SEM). CB-SEM has been tried and tested in social science (Hair et al., 2011). Consequently, it was deemed ideal for this research. The constructs were modeled based on the formative measurement model. Under this model, indicators were functions of the respective latent constructs.

3 Results

3.1 Descriptive results

After cleaning data for missing values and outliers, 191 employers were retained for analysis. This number represented an acceptable 65.9% response rate (Draugalis et al., 2008). The means and standard deviations in Table 1 confirmed that the firms were making consistent efforts to adopt green practices to lead to sustainable development. Energy decarbonization was being given ample attention as demonstrated by agreement in the three indicators, namely greater use of electricity (*M*=4.03, *SD*=.917), expanded carbon capture (*M*=3.91, *SD*=.950), and higher usage of hydrogen in industrial processes (*M*=4.19, *SD*=.767). Greening the scrap pile was also gaining attention based on the response scores in the two indicators, extended producer responsibility (*M*=3.85, *SD*=.884) and product durability and reusability (*M*=3.90, *SD*=.785). Worker protection and enablement equally attract interest among firms in their endeavors to green manufacturing. This worker protection was manifested in the responses to the three indicators, alignment of operational safety to efficient energy and material use (*M*=3.98, *SD*=.788), increased use of work robots (*M*=4.00, *SD*=.858), and increased automation based on artificial intelligence (*M*=3.80, *SD*=.971). Meanwhile, firms were also keen on sustainable development, as illustrated by response scores to its two indicators, disaster risk reduction (*M*=4.12, *SD*=.745) and sustainable production and consumption (*M*=4.07, *SD*=.834).

***Tab .1** Descriptive results*

Variable	Indicators	*M*	*SD*
Energy decarbonization	greater use of electricity (GUE)	4.03	.917
	expanded carbon capture efforts (ECC)	3.91	.950
	higher usage of hydrogen in industrial processes (HHI)	4.19	.767
Scrap pile greening	extended producer responsibility (EPR)	3.85	.884
	product durability and reusability (PDR)	3.90	.785
Worker protection and enablement	aligning operational safety to efficient energy and material use (ASE)	3.98	.788
	increased use of work robots (UWR)	4.00	.858
	increased automation based on artificial intelligence (AAI)	3.80	.971
Sustainable development	disaster risk reduction (DRR)	4.12	.745
	sustainable production and consumption (SCP)	4.07	.834

Source: Survey data (2023)

3.2 Implied correlations

Table 2 shows the implied correlations between the ten indicators measuring the respective latent constructs. The correlations confirmed a lack of Multicollinearity due to the nature of the small correlation coefficients.

***Tab .2** Implied Correlations (Group number 1 - Default model)*

	SPC	DRR	UWR	AAI	ASE	EPR	PDR	ECC	HHI	GUE
SPC	1.000									
DRR	.682	1.000								
UWR	.319	.315	1.000							
AAI	.412	.408	.519	1.000						
ASE	.390	.386	.491	.329	1.000					
EPR	.287	.284	.253	.150	.310	1.000				
PDR	.296	.293	.261	.337	.319	.406	1.000			
ECC	.373	.369	.203	.360	.341	.264	.272	1.000		
HHI	.376	.372	.412	.363	.343	.266	.274	.483	1.000	
GUE	.387	.383	.289	.373	.353	.273	.282	.497	.501	1.000

Source: Survey Data (2023)

3.3 Validations of the structural model

Structural model validations are given in Fig.1

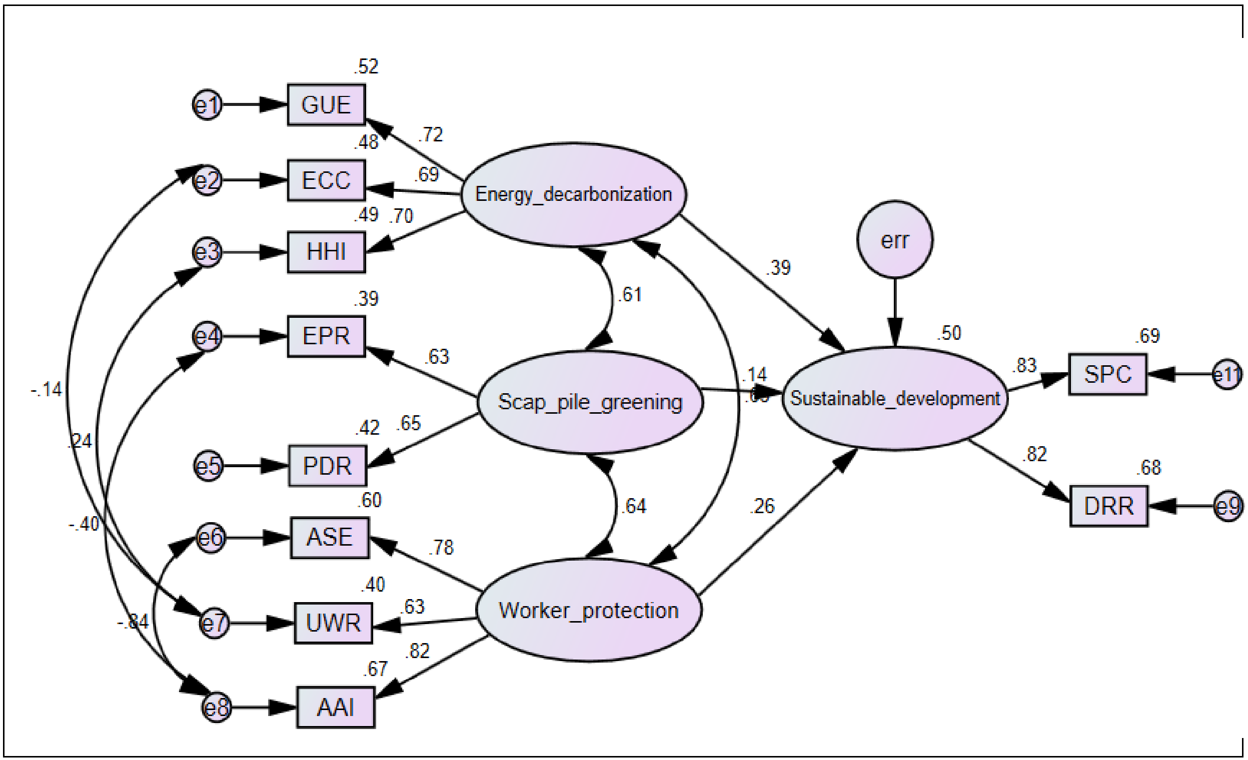

Fig 1. *Structural model validation. Source: Survey Data (2023)*

The default fit indices for the proposed model exceeded the recommended fit indices. This exceeding confirms that the respective latent constructs' indices were unidimensional and that the model generated was a good fit (Table 3).

Tab .3 *Model validation*

Fit indices	Recommended value	Test value
χ^2/df	<5.0	1.376
GFI	>.90	.966
AGFI	>.90	.925
NFI	>.90	.947
RFI	>.90	.905
IFI	>.90	.985
CFI	>.90	.985
TLI	>.90	.972
RMSEA	<.05	.044

Source: Survey Data (2023)

3.4 Estimates

Table 4 shows the regression weights of the default model based on maximum likelihood estimation. The result indicated energy decarbonization, b = .413, SE=.135, p=.002, and worker protection and enablement b=.300, SE=147, and p=.042 were positive and significant predictors of sustainable development. However, scrap pile greening, b =180, SE=185, p=.329, was not a significant predictor of sustainable development.

***Tab .4** Regression Weights: (- Default model)*

			Estimate	S.E.	C.R.	P	Label
Sustainable development	<---	Energy Decarbonization	.413	.135	3.061	.002	significant
Sustainable development	<---	Worker protection	.300	.147	2.038	.042	significant
Sustainable development	<---	Scrap pile greening	.180	.185	.975	.329	Non-significant

Source: Survey Data (2023)

The table provided part of a structural equation modeling (SEM) analysis, and it lists the regression weights (coefficients) for various predictors of "Sustainable development" in the "Default model." The term "Group number 1" suggests that this model pertains to a specific group within the dataset. However, there is no mention of a "Group number 2," which can be confusing. Therefore, wise to remove “group1 and so on”.

3 Discussion

The study confirmed the presumption that green manufacturing directly affected sustainable development, albeit through energy decarbonizing and protecting workers, and enabling them. The regression weight of energy decarbonization was b=.413. The implication was that a unit increase in decarbonization was likely to improve sustainable development by 0.413 %. Similarly, the regression weight for worker protection and enablement was b=.300 indicating a 3 percent increase in sustainable development for each unit percent increase in worker protection and enablement.

The finding showing that energy decarbonization impacted sustainable development positively reflects the finding by Sachs et al. (2019). According to Sachs et al. (2019), energy decarbonization belongs to a group of six sustainable development goals (SDG) transformation actions. Indeed, decarbonization of energy systems advocates using energy sources such as solar, nuclear, and wind that emit less carbon dioxide than the currently favoured fossil fuel sources like natural gas, oil /petroleum, and coal. These endeavors are likely to save the planet from the imminent sixth extinction. It is argued that whereas the previous extinction events were functions of natural phenomena, human activity leaning towards climate change, energy and water use, and unsustainable use of land are driving earth towards the sixth mass extension (Torres-Romeo et al., 2020).

The finding that worker protection and enablement was a positive determinant of sustainable development underscores the importance of manufacturing firms to providing safety and autonomy to workers in their endeavors to go green. Employees are often at the center of managing and preventing occupational risks and hazards. According to the International Labor Organization (ILO), a truly green job should integrate health and safety into the design, procurement, maintenance sourcing, and recycling (ILO, 2012). Besides, the finding on workers' safety is consistent with others. For instance, Rowe et al. (2018) acknowledge that meeting sustainable development goals requires that workers' health be given priority. Meanwhile, Hinze et al. (2013) demonstrated that sustainable construction was realized by improving the safety and health of construction workers.

However, the finding that greening the scrap pile had no significant effect on sustainable development was unexpected and opened up room for further research on the scrap pile construct. Moreover, the finding contradicts previous findings on scrap piles, commonly referred to as extended producer responsibility. Kibert (2004) identifies scrap pile greening as extended producer responsibility to achieve sustainable development. Mastos et al. (2020) identify industry 4.0 in the supply chain as an IOT tool to manage scrap metal.

However, the research confirmed that green manufacturing offers revolutionary and innovative advances in production and efficient processes that do not degrade the environment through waste or pollution. With the earth on the brink of the sixth mass extinction, manufacturing should be green to achieve sustainable development. Green manufacturing will not only reduce the use of natural resources and energy and lower carbon footprint but will also optimize manufacturing technology advancements.

4 Conclusions and implications

The findings and subsequent discussion led to the conclusions that manufacturing firms consume substantial amounts of energy and predominantly rely on fossil fuel sources such as coal, natural gas, and petroleum. These sources emit harmful greenhouse gases into the environment. Consequently, energy decarbonization—replacing fossil fuel sources with cleaner alternatives—promotes sustainable development within manufacturing firms. Although recycling some of the scrap produced during manufacturing (a practice known as greening the scrap pile) is beneficial, it does not significantly contribute to sustainable development. In contrast, green manufacturing not only protects the environment but also safeguards workers' health and safety. This dual protection ultimately enhances sustainable development.

The positive impact of energy decarbonization on sustainable development underscores the importance for manufacturing firms to transition away from fossil fuels to protect the environment and conserve energy. With the earth on the brink of a sixth mass extinction, the manufacturing sector must adopt green practices to help avert this environmental crisis.

The findings have important implications for policymakers. They suggest that encouraging and possibly mandating green practices in manufacturing can be an effective strategy to achieve national and global sustainability targets. Policymakers could consider providing incentives for firms that adopt sustainable practices, such as tax breaks, subsidies, or recognition programs. Additionally, developing clear guidelines and frameworks for green manufacturing can help standardize practices across the industry. Meanwhile, manufacturing firms ought to give worker safety the attention it deserves. Workers are at the center of achieving targets set to protect the environment.

For managers in the manufacturing sector, the study highlights the strategic importance of integrating green practices into supply chain operations. Firms that proactively adopt these practices may enjoy long-term benefits, including cost savings from improved efficiency, enhanced brand reputation, and better compliance with environmental regulations. Managers should consider investing in technologies and training that facilitate greener operations and continuously seek innovative ways to reduce environmental impact.

While this study was conducted in Eldoret town, which hosts a diverse array of nationally recognized manufacturing firms, it is important to recognize that the unique characteristics of Eldoret may influence the findings. The town's status as a manufacturing hub may not be representative of other towns or regions with different economic and industrial profiles. As such, the generalizability of the results to other towns or regions should be approached with caution. Future research should consider conducting similar studies in various towns and regions to assess the consistency and applicability of the findings in different contexts. Comparative studies across multiple locations could enhance the external validity of the research and provide a more comprehensive understanding of the factors influencing manufacturing firms across diverse settings. Additionally, longitudinal studies could provide insights into the long-term effects of green practices on supply chain sustainability. The contradictory finding regarding the effect of greening the scrap pile on sustainable development requires that future studies interrogate greening the scrap pile further using different approaches for external validity to be realized.

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