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Challenges and opportunities for green transitions adoption in Kenya's textile manufacturing industry

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Introduction: In the face of accelerating climate change as a result of fossils, the textile industry has been considered as a significant industrial contributor to global carbon emissions. In Kenya, this sector is responsible for approximately 56% of total industrial pollution, highlighting the urgent need for a transition to sustainable practices. This study, conducted between September 2023 and August 2024, investigates the opportunities and challenges presented in a green transition and practical efforts toward green transition in selected Kenyan textile mills, specifically at the Thika Cloth Mill and Rivatex East Africa company.

Methods: Utilizing qualitative data analyzed thematically, the research explored demographic influences on sustainability efforts, revealing critical insights into the barriers and potential pathways for green growth in the industry.

Results: Key findings include significant waste generation in spinning and processing departments, high water dependency, reliance on non-renewable energy sources like coal and firewood, and limited awareness of sustainability practices among industry players. Additionally, the sector faces difficulties in sourcing natural fibers due to low domestic cotton production and climate change impacts. However, initiatives such as Rivatex's establishment of a cotton farm, Thika Cloth Mills' use of coffee husks for biomass energy, and exploration of green dyes from natural sources indicate potential pathways toward sustainability. The study concluded that challenges such as inefficient waste management, heavy reliance on non-renewable energy sources, insufficient domestic cotton production, and limited awareness of environmental standards collectively hinder progress toward a greener sector.

Discussions: The findings of the present study highlight the multifaceted challenges impeding Kenya's textile industry from fully embracing sustainable practices. Issues such as inefficient waste management, heavy reliance on non-renewable energy sources, insufficient domestic cotton production, and limited awareness of environmental standards collectively hinder progress toward a greener sector. While initiatives like Rivatex's Bt cotton farming and Thika Cloth Mills' use of coffee husks for energy demonstrate steps toward sustainability, these efforts are sporadic and lack comprehensive industry-wide adoption. The absence of stringent environmental regulations and incentives further exacerbates the situation, allowing unsustainable practices to persist.

KEYWORDS

green transitions, Kenya, manufacturing, sustainability, textile

1 Introduction

"Our Common Future" released in 1987 by the World Commission on Environment and Development, propagates a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland and Khalid, 1987). This sustainable path to development was first discussed in 1992 at the summit organized by the United Nations on Environment and Development. The summit was catapulted by the works of the Club of Rome on limits to growth which emphasizes sustainable use of natural resources due to ecological limits and Rachel Carson's silent spring which laid a foundation for sustainability and Environmental ethics. Henceforth, countries began rethinking their development pathways (Zhang, 2024).

Baneliene and Strazdas (2023) highlight that after the industrial revolution, over the past 67 years, our climate continues to change due to high emission levels from greenhouse gasses (GHGs). Climate change is now a global threat to the environment, society, and economy. Sustainable development is now a top priority for international action through Nationally Determined Contributions (NDCs) and Emission Reduction Targets and Green transition Strategies (Abbass et al., 2022). The escalating impacts of climate change, such as biodiversity loss and unsustainable resource exploitation, have heightened the complexity of intergovernmental actions aimed at addressing these challenges.

Transition literature has emerged to support the discussions around shifting from the fossil-fueled (brown) sector to one dominated by the low-emission (green) sector (Shayegh et al., 2023). Development now considers the green transition important in industrial processes in this critical time where the triple planetary challenge presents a need to conserve the natural freshwater stocks and the ecosystem (Yousaf and Aqsa, 2023; Abbass et al., 2022).

The textile manufacturing industry, while a significant contributor to global employment and economic growth, has increasingly come under scrutiny for its detrimental environmental impacts. Responsible for ~8–10% of global carbon emissions, the heavy use of natural and synthetic resources including cotton, polyester, viscose, water, dyes, energy, and chemicals in manufacturing are ways that the textile manufacturing sector contributes to environmental depletion and climate change (Samant et al., 2024; Filho et al., 2022). Scientists describe it as a "silent killer," waste generating, resource intensive and polluting industry and recent microplastics pollution studies reveal that plastic fiber fragments are a threat to aquatic and human life (Hossain et al., 2022; Filho et al., 2022; Periyasamy and Tehrani-Bagha, 2022).

In Asia, Imran et al. (2023) mention that indirect (scope 3) emissions from manufacturing are highest in the textile spinning process. Similarly, textile production is widely regarded as energy resource hungry. The amount of energy needed for the manufacturing and processing of fiber and fiber-based clothing varies depending on the technology, machinery, and methods yet little attention is given to the environmental impact of textile machines (Palamuru, 2015; Filho et al., 2022). The manufactured textile products have been criticized as unsustainable with short life cycles. The solid, water and air pollution from textiles harm the life of species in the ecosystem affecting our biodiversity (Plakantonaki et al., 2023).

The adoption of sustainable practices in the textile manufacturing industry is important and can significantly address the environmental challenges in textile manufacturing processes (Hossain et al., 2022). Globally, countries like Colombia, Ecuador, and Peru are exploring pathways for carbon neutral textile production, emphasizing investment in clean technology. A low carbon manufacturing pathway that leaves no one behind to support a fair and just transition. Cambodia's government is committed to a just transition in the textile sector aiming for a 30% reduction in GHG emissions by 2030 while in Indonesia environmental regulations in the textile sector are promoted as focus is on sustainable transition through the adoption of renewable energy (Luukkanen et al., 2018).

In Turkey, sustainability and circularity within the textile sector are advancing significantly, driven by policies and projects that align with global environmental standards. The Turkish government has launched initiatives to increase the use of renewable energy and sustainable materials, promote transparency across supply chains, and improve waste management processes. This includes encouraging the use of biodegradable fibers and alternative cotton sources, as well as implementing Zero Liquid Discharge systems to manage water use, which is particularly critical given the sector's high water consumption. Turkey's integration with EU standards is also pushing textile companies toward adopting circular economy principles, aiming to reduce waste and carbon emissions to meet stringent EU regulations (World Bank Group, 2025). This shift not only enhances Turkey's competitive position but also prepares the industry for upcoming EU waste disposal restrictions, ensuring compliance with both current and anticipated environmental standards. Recycling efforts by companies like Gama Recycle are further boosting the industry's circularity. Gama focuses on converting PET and textile waste into reusable materials, part of Turkey's broader plan to increase input circularity to 16% and output circularity to 23% within the textile sector (Han et al., 2025).

In Africa, South Africa is pursuing a just green transition that balances economic growth with environmental goals, following the principles outlined in Agenda 2063. African leaders recognize the potential of green industrialization in boosting job creation while safeguarding ecosystems. By prioritizing localized production networks and green investment, Africa can avoid external dependency and foster sustainable growth across sectors like textiles. This approach resonates with calls for Africa to shape its sustainable development independently, optimizing its underdeveloped industrial base for a greener future (Aquilas et al., 2024).

Kenya's textile industry is actively moving toward sustainable practices to align with its 2030 goal of reducing GHG emissions by 30% (ECDPM, 2023). Although Kenya currently lacks a specific policy for sustainable textiles, efforts have accelerated, influenced by global sustainability trends and increasing local demand for eco-friendly products. Initiatives such as the development of the world's first green garment factory in Athi River, built from upcycled containers and supported by USAID and Trade Catalyst Africa, highlight Kenya's commitment to circular economy principles and

resource efficiency in textile production (Trade Catalyst Africa, 2024). This Green transition is in line with broader industry shifts. For example, fashion's global response to climate risks includes a greater reliance on recycled materials and reduced water use to mitigate carbon emissions and climate impacts on production areas (Cornell University, 2023). Furthermore, fast fashion's environmental toll, such as the disposal of textiles in Global South regions, has raised concerns about pollution and public health issues, pushing countries like Kenya to reject low-quality, unsustainable imports in favor of more eco-conscious approaches (Bick et al., 2018).

This study aims to provide an in-depth analysis of the challenges and opportunities for green transition adoption in the textile manufacturing industry in Kenya. Focusing on Thika Cloth Mills and Rivatex East Africa Company, the research seeks to identify the specific challenges these mills face in adopting green technologies and practices, as well as the potential benefits and opportunities that such transitions may offer. The central research questions include: What are the primary obstacles hindering the adoption of green transitions in Kenya's textile manufacturing industry? What opportunities can be leveraged to facilitate this shift?

Due to the burgeoning textile industry and the nation commitment to sustainable development, Kenya provided an ideal setting for this study. The Kenyan government has identified the textile sector as a key area for economic growth and industrialization, as outlined in the Kenya Industrial Transformation Programme (KITP) and Kenya Vision 2030 (Nyaga, 2015). Additionally, Kenya has demonstrated leadership in green growth, with a significant portion of its electricity generation coming from renewable sources (Robina Abuya, 2025). These factors create a conducive environment for investigating the integration of green practices within the textile manufacturing industry. Moreover, the selected mills, Thika Cloth Mills and Rivatex East Africa Company, are among the prominent players in the Kenyan textile sector, making them suitable case studies for understanding the broader industry dynamics related to green transitions.?

This article is organized in various parts. The second part of the article consists of a thorough literature review, followed by the methodology which covers the data collection process, research design and data analysis techniques. Section 4 focuses on the research findings as well as a discussion of the results. Here the findings of the present study are compared with that of previous studies. The conclusion summarized the findings of the study while also discussing the implications and potential contribution of the study.

2 Literature review

2.1 Introduction

This literature review section is an exploration of key themes surrounding the green transition in the textile manufacturing industry, focusing on global and regional efforts to embed sustainability across the value chain. It covers the scope of environmental impacts associated with textile production—including carbon emissions, water use, and chemical pollution—and highlights sustainable innovations and practices such as circular economy models, eco-friendly materials, and clean energy adoption. The review draws on a range of studies, policy documents, and industry reports that provide evidence of challenges and progress, and achievements, particularly in the European Union (EU). It also includes examples from Africa, where countries like Kenya and Ethiopia are integrating green policies into their textile sectors to align with international climate commitments. Additionally, the concept of green transition and its link to circular economy is also explored.

2.2 The concept of green transition in textile manufacturing industry

Green transition aims to reduce energy consumption, minimize waste, and lower lifecycle greenhouse gas emissions while promoting social welfare and economic growth. Countries like Greece, Korea, South Africa, Chile, and Liberia have developed plans involving inclusive climate national contributions and carbon neutrality acts. The Silesia Declaration, adopted during COP24, emphasizes the need for a just transition in response to climate change, highlighting the importance of creating decent work and quality jobs in sustainable sectors (Council of the European Union, 2018). This transition is viewed as a gradual shift away from fossil fuels, addressing vulnerabilities while fostering ecological health and economic resilience (Yang et al., 2024). Textile manufacturing includes all processes involved in converting natural and synthetic fibers into yarns and fabrics. These materials are then utilized to create a variety of end products, such as clothing, carpets, home textiles, medical textiles, and industrial filters.

The garment industry in Indonesia, for instance, is adopting green transition strategies to enhance environmental initiatives performance and reduce GHG emissions in the manufacturing industry through initiatives like the Circular Fashion Partnerships. Research by Nuryanto et al. (2024) in Indonesia's manufacturing industry suggests that green investment and business innovations are also important for sustainability in the textile industry. Green transition is multifaceted and considers the social, ecological, and economic transition processes. Nevertheless, the purview of the green transition has broadened to include innovation and technologies, governance, regulations, laws, and institutional frameworks, market mechanisms, and consumerism as a result, a "leave no one behind" strategy that emphasizes low-carbon development routes offers a climate-safe route to industrialization through green transitions in manufacturing.

Scholars have highlighted the potential disruptive effects of the circular economy, suggesting that it may hinder the textile sector's ability to embrace a green transition (Saha et al., 2024). South Australia's Waste Strategy 2020–2025 emphasizes textile waste management through recovery technologies and local recycling facilities under the TERRESA program. The non-profit sector in Australia processes over 30,000 tons of clothing annually and will further enhance recycling through the "Seamless" product

stewardship scheme, promoting garment recovery and recycling efforts (Gbor, 2024).

The Sustainable Textile Program (2016-2020) was a key initiative in Ethiopia to raise social and environmental standards in textile manufacturing, particularly focusing on eco-friendly practices within textile mills. This initiative aligns with Ethiopia's long-term goal of becoming a leader in organic cotton production by 2032, a strategy meant to support sustainable economic growth while addressing environmental impacts associated with traditional cotton farming. These steps are bolstered by partnerships with organizations like the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the United Nations Industrial Development Organization (UNIDO), which aid Ethiopia in building capacities, attracting sustainable investment, and enforcing social and environmental standards within the industry (UNIDO, 2024).

Moreover, Ethiopia's government has invested in eco-industrial parks (EIPs) to attract foreign direct investment (FDI) while minimizing environmental degradation. The EIPs are designed to centralize and support sustainable practices like waste management, water recycling, and renewable energy usage. For example, the Hawassa Industrial Park features a zero-liquid discharge system, setting a high standard for wastewater management. Programs like the Sustainable Industrial Clusters Project further reinforce these efforts by providing training and promoting fair working conditions, especially for the predominantly female workforce in textiles, thus supporting both environmental and social sustainability.

The key aspects of Green Transition are Sustainability Goals guided by frameworks like the Paris Agreement and the UN's 2030 Agenda for Sustainable Development, which set targets for limiting global temperature rise and reducing inequality. The 17 Sustainable Development Goals (SDGs) developed in 2015 act as a global road map for a sustainable planet toward Agenda 2030. They are divided into 230 indicators and 169 targets, and the textile industry today considers sustainability in various contexts (UNFCCC, 2015; United Nations, 2015).

The circularity angle in a green transition entails shifting from fossil fuels and resource-heavy practices to a circular economy focused on recycling, resource efficiency, and sustainable manufacturing (Zhang, 2024). The green transition is expected to significantly reshape labor markets, creating new opportunities while mitigating job losses in traditional sectors. A recent study highlights that with effective policies, the transition could generate up to 2 million jobs in the EU by 2050. Kekkonen et al. (2023) focused on Estonia's E Initiative as in support of the European Union's (EU) twin transition which includes the digital and green transition. A green transition is vital for balancing the impacts of technological advancements like AI and automation, ensuring equitable job creation. Emphasizing a human-centric approach during green transitions helps mitigate disruptions, fostering resilience among workers (Chabane et al., 2023). Key strategies include designing for human-centered decommissioning to enhance sustainability and applying life cycle thinking in manufacturing to optimize environmental, social, and economic outcomes (Chabane et al., 2023).

The European Union has made commendable strides in advancing green transitions in the textile industry. With the introduction of the Transition Pathway for the Textiles Ecosystem in 2023, the European Commission demonstrated their commitment to promoting circularity, sustainability, and digital innovation across the sector. Since its introduction, small and medium enterprises have been supported in developing recycling infrastructure, in addition to the implementation of the producer responsibility scheme. This has enhanced accountability and ensured end-of-life management of textile products (European Commission, 2024).

In addition to the aforementioned, the EU strategy for Sustainable and Circular Textiles promises a market in the EU where all textile products are durable, recyclable, and largely composed of fibers. This strategy champions the elimination of hazardous substances and the upholding of social rights through the production process. The Pact for Skills is an initiative that has been launched by the EU to upskill and reskill the workforce in green and digital competencies (European Commission, 2024).

The textile manufacturing industry has shown a clear trend toward embedding Environmental, Social, and Governance (ESG) principles, a shift primarily driven by consumer expectations and regulatory demands. Research highlights that effective governance structures, such as a well-defined board and CEO roles, are essential to aligning with ESG targets in the textile sector, directly impacting operational efficiency and sustainability (Bukari et al., 2024). Implementing these structures not only bolsters ESG initiatives but also increases brand reputation, appealing to consumers and investors alike who prioritize sustainability.

ISO standards play a pivotal role in guiding textile companies on their ESG journey. ISO 50001, for example, is particularly relevant for reducing the high energy consumption characteristic of textile production, especially in resource-intensive dyeing and finishing stages. Adopting this standard promotes energy efficiency through continuous monitoring and encourages energy-saving technologies, which both cut costs and reduce environmental impact. This aligns with recent findings that show the adoption of energy-efficient practices and smart factory solutions has helped manufacturers improve ESG ratings, reduce operational costs, and increase transparency in energy use and waste reduction (Mun et al., 2025).

Advanced sustainable technologies, such as supercritical CO_2 dyeing, represent a crucial innovation for water conservation, addressing the industry's high water demand. Studies indicate that circular economy principles such as effluent recycling, low liquor ratio dyeing, and reusing dyebaths help reduce water use and minimize wastewater discharge, which are major ESG concerns (Rathi and Kumar, 2021). These practices not only cut costs but also comply with increasing regulatory pressure for waste reduction and environmental protection. Incorporating risk management is essential for aligning textile operations with ESG principles. ISO is developing an International Workshop Agreement (IWA) to help standardize ESG reporting, offering structured indicators for key areas like labor conditions and environmental impacts within supply chains. Standardized reporting frameworks and clear Key performance indicators (KPIs), such as those emphasizing resource efficiency and

waste management, support textile companies in achieving ESG compliance while enabling transparent communication with stakeholders (Mun et al., 2025).

2.3 Green transition and circular economy

The principles of a circular economy emphasize the continual use and regeneration of resources. This is intrinsically linked to the transition to a green economy, a model that aims at reducing environmental risk and ecological scarcities. This connection is pivotal in addressing the escalating crisis of natural resource consumption that outpaces both population growth and economic output. Adopting circular economy strategies such as recycling, reusing, and refurbishing provides business with a unique opportunity to mitigate resource depletion and environmental degradation, thereby facilitating a sustainable green transformation (Martínez, 2024).

The world is experiencing an ever-increasing crisis in natural resource use, which outpaces both population increase and economic productivity. If the global community does not take immediate action to transition to a circular economy (CE), it risks failing to accomplish crucial social, environmental, and climate targets. A CE seeks to maintain resources in use for as long as feasible by using measures such as recycling, reusing, and refurbishing (Martínez, 2024).

Circular economy approach is critical to the green economy because it encourages long-term growth while mitigating environmental impacts such as waste reduction, GHG emissions reduction, and pollution control. Despite its transformational potential, a CE has yet to be fully incorporated into global environmental policies and sectoral practices due to disparities in ability, skills, effort, and knowledge. Industries continue to rely on linear models, owing to antiquated processes and a lack of incentives to implement circular concepts. It is noteworthy that, globally, fewer circular solutions are being implemented, according to the 2024 Circularity Gap Report and the most recent Sustainable Development Goals (SDGs) progress report (SDG Knowledge Hub, 2024).

By encouraging effective resource use and reducing waste, circular economy activities serves as a catalyst for reaching sustainability objectives. For example, the creation of closed-loop systems—where things are made to last, be repaired, and eventually be recycled—can result from the incorporation of circular ideas into many businesses. This strategy lowers GHG emissions linked to the production and disposal processes in addition to conserving raw materials (Martínez, 2024). Moreover, the circular economy fosters innovation and economic resilience by creating new business opportunities and employment avenues (Haar, 2024).

2.4 Green transition and textile manufacturing in Africa

Green Transition in Africa is a recently discovered concept and there is a growing adoption of its practice in many African countries. The general consensus has been that Africa has to become a center for sustainable energy and a pioneer in the creation of low-carbon economies. Most countries, such as Algeria, are moving away from hydrocarbons that emit CO_2 and negatively impact the environment, shifting toward cleaner energy production (Bergougui, 2024). Meanwhile, Angola is diversifying its energy sources and adopting sustainable manufacturing practices (FSDEA Communication Marketing Office, 2025). This transition is significantly supporting the manufacturing industry, particularly the textile sector, in both countries. In Algeria, the shift to renewable energy sources not only reduces environmental impact but also lowers operational costs for textile manufacturers (Bergougui, 2024). By leveraging cleaner energy, these companies can enhance their sustainability profiles, appeal to eco-conscious consumers, and comply with increasing regulatory demands for environmentally friendly practices. This transition fosters innovation in production processes, leading to more efficient use of resources.

Similarly, Angola's efforts to diversify energy sources and promote sustainable manufacturing are creating opportunities for the textile industryc to embrace eco-friendly practices (FSDEA Communication Marketing Office, 2025). While the Green transition is still new, country specific policies and practices are encouraging its implementation. Green transitions in the textile manufacturing industry promote sustainable practices that can drive green growth while addressing climate justice. Many scholars argue that Africa is often exploited as an extraction hub for fossil fuels, detracting from local manufacturing opportunities (Power Shift Africa, 2022). By investing in sustainable textile production, African nations can create jobs and foster economic resilience, ensuring that communities benefit from climate action rather than suffer from environmental degradation. This shift not only reduces carbon footprints but also empowers local economies, aligning with global climate goals and promoting equitable resource distribution.

A recently released study titled "Designing Climate Compatible Industrial Strategies for South Africa" Making South Africa's apparel and textile industries more sustainable is outlined in the Textiles Value Chain (May, 2022). In addition to highlighting the industry's large contribution to greenhouse gas emissions worldwide, it makes recommendations for cutting dangerous chemical use, increasing energy efficiency, and putting zero waste practices into place. The paper highlights that in a nation with high unemployment rates, a fair transition is necessary that strikes a balance between environmental sustainability and job growth.

The Kenya Association of Manufacturers (KAM) is spearheading projects and government regulations aimed at sustainable industrial practices, positioning Kenya as a pioneer in green manufacturing. The National Solid Waste Management Strategy was created by the National Environment Management Authority (NEMA) to direct sustainable solid waste management in Kenya which governs industrial waste in the textile sector such as offcuts, wastewater, and sludge (NEMA, 2014).

In Egypt, the Green Textile Initiative aims to lessen environmental impact by promoting sustainable practices, such as using organic cotton and reducing water and energy use. This initiative is in line with Egypt's Vision 2030, which focuses on sustainable production and effective waste management, fostering innovation and investment in the textile industry (OECD, 2024).

Lesotho is advancing its wool and mohair sector through the Wool and Mohair Value-chain Competitiveness Project (WaMCoP), which seeks to enhance production methods and implement a certification system for responsible practices (IFAD, 2023).

2.5 Green transitions and textile manufacturing in Kenya

Since pre-colonial times (before 1963), Kenya's textile and apparel sector has experienced significant transformations (Wanduara, 2019). The textiles were first introduced to Kenya's Swahili people by foreign traders, which shifted local preferences regarding clothing. The textile industry then rapidly grew and in the 1980s became the leading manufacturing sector in Kenya employing 30% of the labor force and 200,000 small-scale cotton farmers.

In the Early 1990s the industry faced challenges and a decline from increased competition and mismanagement. Despite these challenges, Kenya is still a major exporter under the African Growth and Opportunity Act (AGOA). Today the sector contributes 7% to the national Export earnings and is recognized as a priority sector in Kenya's Vision 2030 (Thomas, 2025).

The Kenyan government supports green transition in the textile manufacturing industry through the "Buy Kenya, Build Kenya" strategy, along with the Green Strategy and Implementation Plan (GESIP), which underpin efforts to enhance textile manufacturing sustainably. GESIP promotes the adoption of modern green technologies, aligning with Kenya's border industrialization goals to foster economic growth and environmental responsibility. Recent research, including research by Mwasiagi et al. (2023), indicates that integrating sustainable practices in textiles can significantly improve competitiveness and market access, particularly through initiatives like the African Growth and Opportunity Act (AGOA).

Kenya also supports the enhancement of recycling activities and the promotion of sustainable waste practices through the Sustainable Waste Management Act, 2022 which further promotes circularity in Kenya's textile manufacturing industry. By enabling collaborations such as "Closing the Loop," which turns textile waste into premium fibers, it considerably lowers emissions and resource usage (NEMA, 2022).

The inter-county study examined two prominent textile mills in Kenya: Rivatex East Africa Limited in Uasin Gishu County and Thika Cloth Mill in Kiambu County. Rivatex primarily sources cotton from local counties like Homa Bay, Busia, and Kitui, but due to climate change and reduced local production, it imports cotton lint from neighboring countries, including Tanzania and Uganda. Additionally, Rivatex sources polyester fibers mainly from China and South Korea. In contrast, Thika Cloth Mill, established in 1958, produces over one million meters of fabric monthly and specializes in various products, including cotton fabrics, mixed polyester suitings, and school uniforms.

3 Methodology

3.1 Introduction

This section presents the methodology employed in the study. It includes the study location, research design, sample size determination, sampling technique, data analysis methods, and ethical and logistical considerations. The methodology provides a structured framework that guided the research process and supports the validity and reliability of the findings.

3.2 Study location

This research was conducted in two prominent textile milling factories in Kenya: Thika Cloth Mill in Kiambu County and Rivatex in Uasin Gishu County. The study's population consisted of employees working in the two selected industries in Kiambu County and Uasin Gishu Country. The population includes people who oversee textile industry departments at various levels. The population working in the industries is around 850 employees, according to the documents from the finance department of the two textile businesses (researcher reconnaissance).

3.3 Study design

Qualitative research design was employed, incorporating observation checklist and semi-structured interviews. Key informant interviews were conducted with stakeholders from organizations such as the National Environmental Management Authority (NEMA), the Kenya Association of Manufacturers (KAM), the Kenya Bureau of Standards (KEBS), the Ministry of Industrialization, and representatives from GOTS Africa. Additionally, interviews were held with directors and supervisors from Rivatex and Thika Cloth Mill.

3.4 Sample size

The Nassiuma's formula (2001) was used to determine the sample size drawn from a population of 850 persons. Because the study area is small and contains about 850 people working in the textile industry, this formula is applied to a population size of fewer than 10,000 people.

$$n = \frac{NCV^2}{(CV\,2 + (N-1)\,e2)}$$

Where n = Sample size

N = Population

CV = Coefficient of variation (take 0.5)

e = Tolerance of the desired level of confidence, take 0.05% at 95% confidence level

Therefore,

$$n = \frac{NCV2}{(CV2 + (N-1)\,e2)}$$

So,

$$n = \frac{850\ X\ (0.5)2}{(0.5)2+(850-1)(0.05\ )2}$$

$$n = \frac{212.5}{0.25+\ 2.1225}$$

$$n = \frac{212.5}{2.3725}$$

$$n = 89.57$$

$n = 90$ Respondents

Therefore, this study involved 90 respondents.

3.5 Sampling technique

The study utilized purposive sampling as it allowed for the deliberate selection of participants who possess specific expertise and insights pertinent to the green transition in Kenya's textile manufacturing industry. Purposely selecting key stakeholders from organizations such as NEMA, KAM, KEBS, the Ministry of Industrialization, GOTS Africa, and leadership from Rivatex and Thika Cloth Mill enabled the generation of in-depth information directly relevant to the study's objectives. This method ensured the collection of rich, focused data, facilitating a comprehensive understanding of the challenges and opportunities associated with adopting green practices in the sector.

3.6 Data analysis

The qualitative data collected through interviews were analyzed using thematic analysis, following Braun and Clarke's six-phase framework. This process involved transcribing the interviews, familiarizing ourselves with the data, generating initial codes, searching for themes, reviewing and defining these themes, and finally producing the report. Thematic analysis was chosen for its flexibility and effectiveness in identifying patterns within qualitative data.

3.7 Ethical and logical considerations

Participation in this study was voluntary, and no one was forced to provide information or complete questionnaires. Respondents were informed that the study was strictly for educational reasons to uphold their privacy. Respondents were not asked for any information that could have been used to identify them individually. Additionally, Kenyatta University Graduate School wrote an introductory letter, and the National Commission for Science, Technology, and Innovation (NACOSTI) approved the research to be conducted in Selected Textile Industries.

4 Findings and discussions

4.1 Introduction

In this section, the findings on challenges and opportunities for adopting green transitions in Kenya's textile manufacturing industry are presented. While the study targeted 90 respondents for interview, data saturation—where no new information emerges—was reached after 37 interviews. Recurring themes became evident, and additional interviews did not contribute additional novel insights. This confirmed that the collected data sufficiently addressed the research objectives, paving way for the conclusion of further interviews.

Through thematic analysis, the study key findings were obtained, which include Waste Management, Emissions and Waste Reduction Strategies; Sustainable Material Sourcing and Resource Utilization; Political Influence, Governance, and Stakeholder Involvement; Sustainability Practices and Industry Behavior; Environmental Social Governance and Sustainability Reporting; and Green Procurement and Eco Certifications and Standards. Each theme is discussed below, incorporating direct quotations from participants and comparisons with existing literature.

4.2 Waste management, emissions, and waste reduction strategies

Waste management emerged as a critical area for green growth in Kenya's textile industry. Observations and interviews revealed significant solid waste generation in the spinning department, particularly during processes like ring framing and winding. The areas of waste generation and types of waste both solid, air and water waste from the spinning, weaving, and processing departments were accessed through interviews. In the spinning department significant solid waste arises from the spinning of cotton, particularly during processes such as ring framing and winding. This hard waste primarily consists of discarded yarns that cannot be reused, often resulting from mechanical inefficiencies. In contrast, soft waste, made up of fiber remnants from carding and spinning, is typically recyclable for lower-quality yarn production. Thika cloth mill has innovated and converted hard waste into mop twisters, enhancing waste management through repurposing in textile mills.

Interviewee 3 from Thika Cloth mill noted, *"Hard waste primarily consists of discarded yarns that cannot be reused, often resulting from mechanical inefficiencies."*

In the processing departments, wastewater emissions were reported as a major concern. Interviewee 7 from Rivatex Mill stated,

> *"No stringent legislation controls on water use for industries, especially textile, have been set, as they use water as they wish."*

The study also found that air emissions and ash residues from coal boilers presented a significant challenge to green transition. These concern was echoed by Interviewees 21 and 28 who are spinning supervisors at the two textile companies. The interviewees mentioned,

> *"There are carbon emissions from transportation to and from the ginnery to mills through trucks and lorries and the shipping of polyester and dye products from South Africa."*

Interviewees further noted that the petrochemicals sector in Kenya cannot supply local textile mills with polyester.

The findings of the present study align with Mumbi and Watanabe (2021) study, which offered insights into the enormous environmental impact of wastewater emissions from text industries adjacent to River Sosiani in Eldoret, Kenya. The study also highlighted that such emissions are a hindrance to the aspirations for green transition adoption. The study further emphasized the growing body of need for enhanced public participation in water governance to promote better waste management practices and advance toward green transition.

In the study by Gomes et al. (2023) in Bangladesh, it was revealed that there are adverse effects of textile wastewater, especially on freshwater resources. The specific adverse effects mentioned include the obstruction of socio-economic development and hinderance for environmental sustainability initiatives, including green transition. The study also revealed challenges that hinder the sustainability of textile effluent treatment, including the apparent lack of stringent regulations on water use for industries, aligning with the finding of the present study.

On water treatment, the study found that the Mill in Rivatex is practicing wastewater treatment through management of sludge waste through Extraction or separation through the Fielder press machine. The sludge is dried, and PH tested through litmus before it is thrown into the forest. separation of Greece, color separation done in the primary clarifier of the ETP and the use of cow dung in the aeration tank that is added to encourage microorganisms and life in the wastewater.

Interviewee 13 from Rivatex Mill noted,

> *"In the Rivatex Mill, Urea and DAP are also used to make the water more friendly to microorganisms before being released to the Eldowas, a water sewerage company in Eldoret."*

4.3 Sustainable material sourcing and resource utilization

This key finding focuses on the material sourcing and utilization of natural resources in the textile manufacturing processes. The natural resources used in manufacturing production are water, Natural fibers such as BT cotton, viscose, Fuel including firewood while artificial fiber resources used such as Polyester and chemicals such as starch from maize and cassava, PVA as a binder, Softener (oil) to make yarn soft and UREA conserves moisture. The study identified challenges in sourcing natural fibers and the reliance on imported materials.

Interviewee 13, a factory supervisor in spinning shared,

> *"Due to few cotton farmers and climate change, obtaining sufficient raw materials domestically is challenging."*

The study also revealed that the two mills prefer firewood as more efficient sources of fuel for the boilers. It should be noted that energy sources such as firewood and coal contributes to environmental degradation. As such, the preference for firewood raises sustainability concerns. Below is what interviewee 21 from Thika Cloth Mill had to say,

> *"Firewood generally has a higher energy content compared to coffee husks, making it a more efficient fuel source for boilers."*

These insights are consistent with the findings of the "Closing the Loop on Textile Waste in Kenya" initiative, which emphasizes the importance of recycling textile waste into high-quality products to reduce reliance on virgin materials and minimize environmental impact (YesEarth, 2024).

While challenges with sustainable sourcing persist, opportunities exist. The textile industry's reliance on natural fibers like cotton and viscose, alongside synthetic fibers such as polyester, underscores the need for sustainable sourcing practices. Interestingly, as observed during the study, Rivatex has initiated efforts by establishing its own cotton farm to produce Bt cotton, a genetically modified variety known for higher yields and pest resistance. This approach aims to mitigate supply shortages and reduce dependency on imports.

Thika Cloth Mills, for instance, has collaborated with Kenya Seed Company to utilize coffee husks in biomass boilers, demonstrating an industry symbiotic relationship aimed at energy efficiency. Additionally, the installation of solar panels at Thika Cloth Mills represents a step toward integrating renewable energy sources. Despite these initiatives, the continued dependence on non-renewable energy sources poses environmental challenges.

A 2022 report by Fie Consult note that Kenyan apparel companies my face challenges in transitioning to green manufacturing, due to the need for reconfiguring sourcing and production process (Fie Consult, 2022), validating the findings of the present study. Fie Consult (2022), emphasizes the shift toward green manufacturing, highlighting the economic and environmental benefits of such transition.

Both Rivatex and Thika Cloth Mills exhibit high water dependency, with fresh water being integral to dye baths and chemical applications. Innovative approaches, such as Rivatex's exploration of green dyes derived from Mexican Marigold weed, in collaboration with Moi University's textile engineering department, highlight efforts and opportunities to reduce chemical usage and water pollution. The study by Yilmaz et al. (2024) highlights that the global textile industry is increasingly adopting water-saving technologies and sustainable dyeing methods to minimize environmental impact, consistent with the findings of the present study.

4.4 Political influence, governance, and stakeholder involvement

The third theme in the study findings focused on the Political influence, Governance, and Stakeholders involvement and its influence on the Textile manufacturing industry green transition. Rivatex East Africa, according to interviewee 15, was founded in the 1970s but has experienced major external changes, especially following its acquisition by Moi University in 2007 and now the Ministry of industrialization. The Ministries play a crucial role in influencing Rivatex's strategic investments and strategy. The Ministries involved with Rivatex are the Ministry of industrialization, Ministry of Agriculture and The Ministry

of cooperatives. Particularly the ministries of cooperatives and industrialization have supported the Rivatex Mill in obtaining funding for textile machine equipment, improvements, and expansion initiatives.

It is noteworthy that government initiatives play a crucial role in the textile industry's green transition. Interviewee 15 at Rivatex stated,

> *"The Ministries of Industrialization and Cooperatives have supported the Rivatex Mill in obtaining funding for textile machine equipment, improvements, and expansion initiatives."*

Interviewee 15 further stated that government funding has enabled Rivatex to purchase advanced machinery, boosting its production capacity. Additionally, Rivatex has garnered international assistance, including investments from the Indian government and the World Bank, facilitated by the Ministry of Cooperatives efforts to promote cooperative enterprises and strengthen international relations.

However, challenges persist. Interviewee 18 noted,

> *"Since Uhuru Kenyatta left office, the Buy Kenya Build Kenya strategy is not given much government support."*

Additionally, the influx of secondhand clothing undermines local manufacturing and leads to devastating environmental impact. Many respondents highlighted, *"Combating illegal imports of secondhand clothing is essential for supporting local manufacturing."* These findings resonate with the "Trashion Report" by Clean Up Kenya, which revealed that up to 40% of low-quality clothing imported into Kenya results in devastating social and environmental impacts (Clean Up Kenya, 2024).

Beyers (2022) highlighted that green transition requires political goodwill, together with private sector willingness to support and facilitate the transition. The author emphasized that green transition initiatives should remain a political priority for governments, including their successors. This perspective aligns with insights from the EY article, "Six ways that governments can drive the green transition," which highlights that "political short-termism" often hampers long-term sustainability efforts (Friday et al., 2025).

4.5 Sustainability practices and industry behavior

In terms of sustainability practices and industry behavior, the study revealed that there are varying levels of sustainability awareness within the textile industry. Thika Cloth Mill demonstrated a fairly low understanding of sustainability issues such as sustainable development goals, carbon footprint and environmental conservation. This level of understanding results into low adoption of green practices in the textile mills in Kenya and is linked to lack of knowledge, education background and level of training. Interviewee 4 from Thika Cloth Mill mentioned,

> *"Green transition is a complex idea to most people. Making people understand sustainability is quite a challenge."*

Interviewee 28 said,

> *"Discussing sustainability supports a change of mindset but making people understand sustainability is quite a challenge."*

The respondents from the study maintain that making sustainability simple and interesting could help embrace green transition adoption.

In their study, Zhang and Chabay (2020) submitted that "green knowledge" influences sustainability and promote behavior change, agreeing with the position of the present study on the need to improve the knowledge of industry players on green growth. The authors further asserted that as "green knowledge" influences consumption patterns and government policy-making, in principle, it promotes a transition in the content of the economy to that which facilitates long-term sustainability.

In terms of incentives for green transition, the present study found that there were no incentives to encourage sustainability in the textile manufacturing mills. Additionally, the study participants submitted that changing from linear to green practices is challenging as different people have different interests. This is what interviewee 5 had to say,

> *"Changing from linear to green practices is hard for people. Different people will have different interests."*

Kenya has an opportunity to accelerate green transition by implementing green energy incentives which can be based on government initiatives or offered by the private sector. Tryndina et al. (2022) note that tax incentives and fossil fuels subsidies can be applied to support the transition.

4.6 Environmental social governance and sustainability reporting

The present study found that the textile local mills in Kenya are not aware of the environmental social governance tool. There is a significant knowledge gap regarding ESG tools like the Global Reporting Initiative (GRI). This is what interviewee 6 has to say,

> *"Lack of knowledge or training among the supervisors and staff on tools such as the GRI hinders adoption."*

The textile manufacturing sector in Kenya faces significant challenges regarding the absence of green certifications and standards. The lack of knowledge or training among the supervisors and staff on tools such as the Global Reporting Initiative (GRI) which has capacity to support the Kenyan industry with Textiles and Apparel Standard aimed at improving sustainability reporting.

The study also noted that the priority in the mills is to make a profit, more sales and expand their trading to the international markets. There is a construct among the managers

that sustainability is expensive and comes after profits. Interview 7, a manager from one of the mills, stated,

> *"The priority in the mills is to make profit, more sales, and expand their trading to the international markets."*

The obsession with profit maximization over environmental conservation immensely impedes the green transition, as it often makes companies to neglect or underinvest in eco-friendly practices that do not yield immediate or short-term financial gains. The impact of this short-term focus is environmental degradation and slump in long-term economic resilience. For instance, Bour et al. (2024) reveals that companies that emphasize profit over sustainability are less likely to adopt green transition ideas, lead to increased pollution and resource depletion.

4.7 Green procurement and eco certifications and standards

This theme focuses on the procurement of machines and industrial material inputs and textile related Eco certifications. Key informant interviews in the textile manufacturing mills were supervisors and the directors and the Heads of Processing, spinning, and weaving department including the Human Resources managers and procurement officers. This key finding focuses on Spare parts, Fibers, materials and machine sourcing. The key areas in Kenya that provide Thika cloth Mill with cotton are Homabay, Meru, Uyoma, Siaya according to interviewee 35.

The lack of knowledge of the Public Procurement and Disposal Act (PPDA) of 2005 among the procurement team in the Thika cloth Mill and the disconnect of awareness about these policies was evident. Interviewee 22 stated,

> *"There is a lack of adoption of green innovative materials and manufacturing technologies in support of a clean, decarbonized economy."*

There was also a lack of green procurement of textile machines for spinning, weaving, and processing processes focused on sourcing machines that minimize environmental impact during spinning, weaving, and processing. On observation I was able to see the New Machinery such as the Aco −9 which is equipped with Energy Efficiency optimizing energy consumption and incorporates automatic switches to save on energy. The Thika cloth mills and Rivatex mills do not source cotton from any Eco-certified producers. The level of understanding of certification of international standards organizations (ISO) is low and are regarded as expensive and their potential benefits viewed only from an economic perspective.

Additionally, there is low awareness of eco-certifications. The Global Organic Textile Standards (GOTS) African Director stated,

> *"There is low adoption of GOTS in African textile mills."*

Kenyan mills find the costs prohibitive, lacking knowledge and awareness hindering their ability to adopt the standards. The lack of affordability for ISO certifications further complicates the situation, limiting engagement with global sustainability standards although the energy department of Thika cloth mill is positive about energy related ISO standards.

The findings of the present study is consistent with similar observations made in studies outside Kenya. For instance,

These findings are consistent with similar observations made in studies outside Kenya. For instance, Boström and Karlsson (2013), in their analysis of responsible procurement and eco-certification in developing countries, reported that adoption rates are lower in low and middle-income countries due to limited institutional support, lack of consumer pressure and huge implementation costs. Similarly, Saeed et al. (2024), while examining the negative and positive environmental effects of technical trade barrier on resource constrained countries, observed that many manufactures in these countries often view international standards as trade barriers, especially when there is no support from the local government or subsidies to promote compliance.

In a study of Environmental Management System (ISO 14001), Massoud et al. (2010) noted that while awareness of this international standard was relatively high in urban industrial hubs, actual adoption was limited to export-focused firms. The study further observed that local oriented firms viewed such certifications as unnecessary, echoing sentiments found in the present study among Kenyan mills.

5 Conclusions

The findings of the present study highlight the multifaceted challenges impeding Kenya's textile industry from fully embracing sustainable practices. Issues such as inefficient waste management, heavy reliance on non-renewable energy sources, insufficient domestic cotton production, and limited awareness of environmental standards collectively hinder progress toward a greener sector. While initiatives like Rivatex's Bt cotton farming and Thika Cloth Mills' use of coffee husks for energy demonstrate steps toward sustainability, these efforts are sporadic and lack comprehensive industry-wide adoption. The absence of stringent environmental regulations and incentives further exacerbates the situation, allowing unsustainable practices to persist. Addressing these challenges requires a concerted effort involving policy reforms, capacity building, and fostering a culture that prioritizes environmental stewardship alongside economic objectives.

6 Recommendations

6.1 Operational recommendations

In light of the study findings, the following operational recommendations are offered.

- Textile companies in Kenya should enhance waste management systems by implementing robust waste segregation and recycling programs within textile mills to minimize environmental impact and promote resource efficiency.

- The textile industry in Kenya should invest in renewable energy technologies, such as solar and biomass, to reduce dependence on fossil fuels and lower carbon emissions.
- The government of Kenya should support local cotton farmers through training and incentives to boost domestic supply, reducing reliance on imports and promoting sustainable agriculture.
- The textile industry should engage in regular training sessions for employees at all levels to raise awareness about sustainable practices and the benefits of environmental certifications.
- The government should implement green procurement policies, prioritizing the acquisition of eco-friendly materials and machinery that meet international environmental standards to ensure sustainable production processes.

6.2 Recommendations for future research

Future studies in Kenya could look into the potential impact of market-based incentives, such as tax breaks or subsidies, on encouraging green transition and sustainable practices among textile manufacturers.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Centre for Research Ethics and Safety- Kenyatta University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

DA: Conceptualization, Data curation, Methodology, Project administration, Writing – original draft.

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