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The Effect of sustainable supply chain management on achieving net zero emissions in chemical manufacturing firms in Nairobi Kenya.

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THE EFFECT OF SUSTAINABLE SUPPLY CHAIN MANAGEMENT ON ACHIEVING NET ZERO EMISSIONS IN CHEMICAL MANUFACTURING FIRMS IN NAIROBI KENYA

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Declaration

Student

This study project is my own work and has not been submitted to any educational institution for the conferral of any award.

Signature:_________ **Date**: 20th June 2026

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Supervisor

This research project has been submitted for evaluation with my endorsement as the University supervisor.

Signature:_______________ **Date**: 20th June 2026

Dr. Farida Abdul

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Dedication

This work is dedicated to my wonderful family, whose unwavering support and encouragement lifted me as I carried out the project. Your love, faith, and belief in me kept me focused. May God bless you abundantly.

Abstract

The chemical manufacturing sector is a significant contributor to greenhouse gas emissions due to its energy-intensive processes and reliance on fossil fuels. Achieving net-zero emissions in this sector requires the adoption of sustainable supply chain practices. This study examined the influence of supply chain diversification, specifically green sourcing, transport diversification, green packaging, and reverse logistics, on carbon emission reduction among manufacturing companies in Nairobi, Kenya. The study was informed by the Natural Resource-Based View Theory, which explains how firms can integrate environmental sustainability, adaptability, and stakeholder expectations into their operations to achieve improved environmental performance. A descriptive research design was employed, targeting a population of manufacturing firms in Nairobi, with a sample drawn from registered firms. Data was collected using structured questionnaires and analyzed using descriptive statistics, Pearson correlation, and multiple regression analysis. The findings revealed that all four supply chain practices are positively associated with net-zero emissions, with green sourcing and transport diversification exhibiting the strongest statistically significant effects. Reverse logistics also contributed positively, while green packaging, though positively correlated, did not have a statistically significant independent effect. The study further found that the supply chain practices jointly explain a substantial proportion of the variation in net-zero emissions, indicating strong explanatory power of the model. The study concludes that the combined implementation of green supply chain practices is critical for achieving net-zero emissions, with integrated approaches yielding stronger environmental outcomes than isolated initiatives. The study recommends that firms prioritize strengthening sustainable procurement policies through green sourcing and invest in low-carbon transport systems due to their strong influence on emission reduction. In addition, organizations should expand reverse logistics systems to enhance recycling, waste recovery, and circularity practices. Although green packaging did not show a statistically significant effect, it should be maintained as a complementary sustainability strategy, with further innovation needed to enhance its impact. Finally, the study emphasizes the importance of fostering supplier development and industry collaboration to support the effective implementation of integrated green supply chain strategies.

Keywords: Supply chain diversification, net-zero emissions, green sourcing, transport diversification, sustainable packaging, reverse logistics.

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Definition Of Terms

Greenhouse Gas (GHG) Emissions	Refers to gases that are emitted into the atmosphere and cause climate change and global warming, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These emissions are mostly caused by energy consumption, transportation, and industrial operations in the chemical manufacturing industry.
Net-Zero Emissions	A state in which the amount of greenhouse gases released into the air is balanced by the amount that is taken out of the air, either naturally or through technology like carbon capture and storage.
Supply Chain Diversification	The process of spreading sourcing, production, and distribution across multiple regions or suppliers to minimize risks, reduce costs, and lower carbon emissions associated with logistics and transportation.
Green Procurement	The practice of buying goods and services with a low environmental effect throughout their lives. It entails selecting suppliers who employ sustainable materials, energy-efficient manufacturing processes, and ethical labor practices.
Sustainable Supply Chain Management	Integrating environmental, social, and economic issues into supply chain activities to reduce negative consequences and enhance long-term sustainability.
Circular Economy	An economic model that aims to minimize waste and make the most of resources by reusing, refurbishing, remanufacturing, and recycling products and materials.
Reverse Logistics	The management system which handles product returns from consumers to manufacturers exists for recycling purposes and reusing or safe disposal to reduce environmental damage.
Carbon Footprint	The measurement of greenhouse gas emissions from direct and indirect sources by individuals or organizations or processes uses units of carbon dioxide equivalent (CO_2e).
Sustainable Packaging	Packaging solutions that reduce environmental impact by utilizing biodegradable, recyclable, or reusable materials and minimizing waste.

Industry 4.0	The fourth industrial revolution is marked by the incorporation of digital technologies like artificial intelligence (AI), blockchain, and the Internet of Things (IoT) into manufacturing and supply chain activities.
Carbon Capture and Storage (CCS)	A technology used to capture carbon dioxide emissions from industrial processes and store them underground or repurpose them to prevent their release into the atmosphere.
Renewable Energy	Energy derived from natural sources such as solar, wind, hydro, and biomass, which are replenishable and generate minimal greenhouse gas emissions.
Green Sourcing	The selection of suppliers and materials that adhere to environmental sustainability principles, such as using renewable resources, reducing pollution, and minimizing waste
Low-Emission Transportation	Transport modes such as electric vehicles, hydrogen-powered vehicles, and rail systems that produce significantly fewer greenhouse gas emissions compared to traditional fossil fuel-based transportation
Environmental Management System (EMS)	A framework that organizations use to systematically manage environmental responsibilities, improve performance, and comply with regulations.
Kenya Green Economy Strategy and Implementation Plan (GESIP)	A national policy framework aimed at promoting sustainable economic growth by integrating green practices into various sectors, including manufacturing, agriculture, and energy.
Sustainable Waste Management	The implementation of practices such as recycling, waste reduction, and proper disposal methods to minimize the environmental impact of industrial waste.
Logistics Optimization	The strategic planning and execution of transportation, warehousing, and distribution processes to improve efficiency, reduce costs, and lower emissions.

Abbreviations And Acronyms

AI	Artificial Intelligence
CCS	Carbon Capture and Storage
CDP	Carbon Disclosure Project
CO_2	Carbon Dioxide
EU	European Union
GESIP	Green Economy Strategy and Implementation Plan
GDP	Gross Domestic Product
GHG	Greenhouse Gas
KAM	Kenya Association of Manufacturers
IEA	International Energy Agency
NEMA	National Environment Management Authority
NCCAP	National Climate Change Action Plan
PwC	PricewaterhouseCoopers
UNEP	United Nations Environment Programme

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter presents the foundation of the study. It provides the background information on the research problem, discusses the key concepts of the study, and presents the context of chemical manufacturing firms in Nairobi. The chapter also outlines the statement of the problem, study objectives, research questions, significance of the study, scope of the study, and concludes with a chapter summary.

1.2 Background

The chemical manufacturing sector is one of the most critical components of industrial development across the globe (Gabrielli, et al., 2023). It plays a pivotal role in supplying raw materials and intermediates to various downstream sectors including agriculture, pharmaceuticals, construction, and consumer goods. In Kenya the sector contributes significantly to the industrial output. However, it faces increasing pressure to comply with environmental regulations, global climate action demands, and market pressures to decarbonize operations (Omar, 2020). Among the global sustainability agendas, Net Zero Emissions has emerged as a central goal, pushing manufacturers to rethink operational and strategic choices, especially within the supply chain.

Globally, companies are embracing Sustainable Supply Chain practices to enhance resilience and support environmental sustainability (Blackhurst, 2011). The COVID-19 pandemic and ongoing geopolitical tensions have further underlined the need for robust, adaptive, and green supply chains. Within this context, supply chain diversification is becoming a tactical response to mitigate disruptions and simultaneously align with net zero goals (DHL, 2021). However, the manufacturing industry, which is carbon-intensive by nature, remains under pressure to strike a balance between economic performance and environmental responsibility. This study sought to assess the effect of supply chain diversification on achieving net zero emissions in manufacturing firms in Nairobi.

1.1.1 Sustainable Supply Chain practices

Sustainable Supply Chain Management refers to the integration of environmental considerations into supply chain activities including sourcing, production, packaging, transportation, and end-of-life product management. GSCM seeks to minimize environmental impacts while enhancing operational efficiency and organizational sustainability. It also lowers risks from environmental, political, or economic disruptions (Jayaram and Kendall, 2021). In modern industry, supply chain diversification supports efficiency and cost reduction. It is also a key component of corporate sustainability. This is especially important as firms aim to reduce their environmental impact (Domenech, 2019).

The chemical manufacturing sector is energy-intensive and highly reliant on fossil fuels. It faces growing pressure to reduce greenhouse gas emissions. Global frameworks such as the Paris Agreement and the European Green Deal urge firms to adopt low-carbon practices and pursue net-zero targets (Bataille, 2020). Research shows that up to 77% of a firm's emissions come from its supply chain (CDP, 2024). This includes emissions from raw material sourcing, production, packaging, transportation, and waste disposal. In response, companies are adopting environmentally responsible supply chain strategies.

This study focuses on four main strategies. These include green sourcing, distribution network diversification, green packaging, and reverse logistics. Green sourcing involves working with suppliers who use sustainable practices. It includes using non-toxic and recyclable materials. It also promotes the use of renewable energy such as solar, wind, or hydro power in production (Chin et al., 2020). In addition, it supports circular economy practices. These practices reduce waste by reusing materials and extending product lifecycles (Geissdoerfer et al., 2017). According to Dechamps et al. (2023), green sourcing reduces upstream emissions and builds resilient supplier networks. Distribution network diversification involves changing supply and delivery routes. It makes the supply chain more flexible and reduces carbon emissions. Companies achieve this by using local warehousing, rail transport, and electric vehicles. They also use digital tools to optimize delivery routes (Lah, 2017). The United Nations Environment Programme (2021) estimates that such strategies can reduce freight emissions by up to 70 percent by 2050.

Green packaging focuses on using materials that are biodegradable, recyclable, or lightweight. This reduces waste and cuts emissions from packaging production and transport. Reusable and lighter packaging also improves fuel efficiency. Morcillo-Bellido et al. (2022) found that such initiatives can cut packaging-related emissions by up to 30 percent. Reverse logistics refers to returning used products or materials back into the supply chain. This includes used packaging, defective items, or recyclable materials. These are collected, processed, and reused or disposed of safely. This reduces environmental waste and conserves resources (Govindan et al., 2015).

Technology also plays a vital role in these strategies. Tools such as artificial intelligence (AI), Internet of Things (IoT), and blockchain help track and manage carbon emissions. These technologies increase transparency. They also support data-driven decisions aligned with sustainability goals (Patro et al., 2024). This study examined the effect of these four strategies green sourcing, diversified distribution, green packaging, and reverse logistics on the achievement of net-zero emissions in chemical manufacturing firms in Nairobi, Kenya.

1.1.2 Net Zero Emissions

Net zero emissions refer to a balance between greenhouse gases released into the atmosphere and those removed or offset. All emissions produced must be matched by actions that absorb or prevent the release of an equivalent amount of carbon dioxide. This balance is essential for limiting global temperature rise. It also helps prevent the worst effects of climate change (United Nations, 2023). To achieve net zero, companies must reduce emissions across all operations. These include energy use, transportation, supply chain activities, and waste disposal. Any remaining emissions must be offset. This can be done through reforestation, carbon capture, or investing in renewable projects.

The Greenhouse Gas (GHG) Protocol is widely used to measure and track emissions. It categorizes emissions into three scopes. Scope 1 covers direct emissions from company-owned sources, such as factory boilers or vehicles. Scope 2 includes indirect emissions from purchased energy, such as electricity or steam. Scope 3 refers to all other indirect emissions across a company's value chain. These come from business travel, product transportation, employee commuting, or product use and disposal (World Resources Institute, 2015). In the chemical manufacturing sector, Scope 3 emissions are often the largest. These emissions are influenced by supply chain choices. Examples include raw material sourcing, packaging materials, and transportation methods. Research shows that sustainable supply chain practices can significantly lower these emissions. McKinsey & Company (2021) estimates that firms can reduce Scope 3 emissions by over 40 percent through supply chain improvements.

The United Nations Environment Programme (2023) also emphasizes cleaner supply chains as critical to achieving net zero goals. Despite increased awareness, global emissions remain high. The Global Carbon Budget (2023) reports that 36.8 billion tons of carbon dioxide were released in 2023. This is a sharp increase from 11 billion tons in 1960. Global decarbonization efforts remain too slow. PwC (2023) reports that carbon intensity is declining by only 2.5 percent annually. To meet the Paris Agreement target of limiting global warming to 1.5°C by 2050, this rate must increase to at least 15.2 percent per year.

Firms must take more aggressive actions to meet net zero targets. This includes shifting to clean energy sources. It also involves partnering with green suppliers, using low-emission transport, and improving energy efficiency. Digital technologies are essential in this process. Tools like artificial intelligence and blockchain enable real-time emissions tracking. They also support transparency and accurate reporting (Patro et al., 2024).

1.1.3 Chemical Manufacturing Firms in Nairobi

The chemical manufacturing sector is a key component of Kenya's industrial landscape, contributing to both economic growth and employment. It includes the production of agrochemicals, paints and resins, cosmetics, personal care products, and chemical converters that support agriculture, construction, and healthcare (Kenya Association of Manufacturers, 2018). The sector is predominantly comprised of private enterprises, with no identified public players. According to Dun & Bradstreet (2024), 127 chemical manufacturing companies operate in Kenya.

Nairobi County functions as a major hub for chemical manufacturing in Kenya. It hosts a variety of firms engaged in the production of agrochemicals, pharmaceuticals, detergents, plastics, cosmetics, and industrial chemicals. These firms vary in scale from large industrial manufacturers to small and medium-sized enterprises (SMEs) and significantly contribute to the national economy. Regulatory oversight is provided by multiple statutory agencies. The Kenya Bureau of Standards (KEBS) ensures product quality and safety, while the National Environment Management Authority (NEMA) oversees environmental compliance. The Pest Control Products Board (PCPB) regulates agrochemical products, and the Pharmacy and Poisons Board (PPB) is responsible for pharmaceutical standards and safety.

As of 2023, KAM reported 127 registered chemical manufacturers in the country, with majority being located in Nairobi and its environs. This study focuses on these firms, all of which are registered with both KAM and NEMA and actively involved in strategic supply chain management. These companies were purposively selected due to their visibility in environmental audits, readiness for policy adoption, and their potential to influence sector-wide transitions toward sustainability.

The chemical and allied sector under KAM comprises 127 registered members, employing over 3,000 people directly and supporting over 5,000 jobs indirectly (KAM, 2018). The industry has an installed production capacity of 35,000 metric tonnes for powder-based chemicals and 50,000 metric tonnes for liquid chemicals annually, with a high utilization rate of 98%. However, the sector relies heavily on imported raw materials, with about 98% sourced externally. This dependence raises production costs and increases vulnerability to global supply chain disruptions.

In 2018, the manufacturing sector contributed 8.4% to Kenya's GDP, with chemical production accounting for 9.8% of the value added in the manufacturing industry by 2022 (World Bank, 2022). Sub-sectors such as paint manufacturing grow by 10–15% annually driven by construction sector demand (KAM, 2018). Prominent firms in this segment include Sadolin Paints, Basco Paints, Galaxy Paints, Solai Paints, and Crown Berger. Similarly, the agrochemical industry plays a crucial role in supporting Kenya's rural economy. In 2017, Kenya imported 14,737 tonnes of pesticides valued at Ksh 12.70 billion, underscoring the sector's importance. However, due to cost advantages of imported finished products, local pesticide formulation has declined by up to 88%, limiting domestic production capacity.

Despite its contributions, the chemical manufacturing sector faces challenges in adopting sustainable practices. It is energy-intensive, reliant on fossil fuels, and generates significant waste (Ronoh, 2020). High initial investment costs and limited access to sustainable raw materials further hinder the adoption of greener technologies. In response, the government introduced the National Climate Change Action Plan (NCCAP), which promotes cleaner production methods, investment in renewable energy, and waste reduction (Ministry of Environment and Forestry, 2018).

Given increasing global pressure to meet environmental standards, Kenyan chemical manufacturers must align their operations with international sustainability frameworks. Embracing green supply chain practices, diversifying raw material sources, and leveraging digital technologies can improve efficiency, build resilience, and advance national climate goals (Griffin, 2018; DHL, 2021). This study explored the measures that chemical manufacturers in Nairobi County are taking to progress toward net-zero emissions.

1.1.4 Emissions in the Chemical Manufacturing Sector

The chemical manufacturing sector is one of the largest contributors to greenhouse gas (GHG) emissions globally. According to the International Energy Agency (IEA, 2022), the chemical industry accounts for approximately 7% of global carbon dioxide (CO_2) emissions, primarily from energy-intensive production processes and supply chain operations. The industry's reliance on fossil fuels for raw materials, energy, and transportation significantly contributes to environmental pollution and climate change (UNEP, 2022). Many multinational firms have implemented carbon reduction strategies, such as green procurement, energy efficiency improvements, and sustainable supply chain management, to mitigate their environmental impact (Griffin, 2018). However, achieving net-zero emissions remains a significant challenge due to the complexity of chemical production and the globalized nature of supply chains (World Economic Forum, 2023).

The chemical manufacturing industry in Africa continues to increase its role in generating industrial emissions. The combination of rapid industrialization and increasing chemical demand for agricultural and healthcare products and consumer goods has resulted in GHG emissions from production facilities along with their logistics and waste disposal activities (Nwokolo, 2023). Northern Ethiopian medium- and large-scale manufacturing industries face multiple barriers to green manufacturing adoption because of financial limitations and insufficient environmental knowledge and technological restrictions and organizational difficulties and government regulations. Research results show that managers' experience and environmental management departments within companies act as major determinants for green practice adoption (Andaregie & Astatkie, 2021).

Furthermore, Maisiri (2021) assessed the barriers to Industry 4.0's sustainable adoption in South Africa's industrial sector. The study found that the main barriers were educational system flaws, young unemployment, cultural constructions, structural inequality, and fragmented task settings. (Maisiri, 2021). These difficulties highlight the necessity of context-specific approaches to encourage the industrial sector's adoption of sustainable technologies. These studies show that the adoption of cleaner manufacturing methods and the implementation of environmental legislation are hampered by a number of similar issues across various African contexts, including financial limitations, technological restrictions, and regulatory challenges.

Sub-Saharan Africa encounters major logistics obstacles because of its deficient infrastructure together with slow customs handling and insufficient road and rail networks. The deficiencies result in longer transportation durations and increased fuel usage which produces elevated greenhouse gas emissions. The research by Kuteyi & Winkler (2022) shows that Cameroon has ten times more unpaved road kilometers than paved road kilometers with many roads becoming inaccessible during wet seasons thus causing transportation delays and higher costs. The dysfunctional rail systems in Nigeria force limited road networks to bear additional pressure which results in increased traffic congestion and elevated emissions. (Kuteyi & Winkler, 2022)

Kenya's chemical manufacturing sector plays a crucial role in the country's industrial growth but is also a significant source of emissions. According to the National Environment Management Authority (NEMA, 2022), the sector contributes notably to air and water pollution due to high energy consumption, waste generation, and reliance on fossil fuel-based industrial processes. The Kenya's Third National Greenhouse Gas Inventory Document (NEMA, 2023) highlights those industrial processes, including chemical production, account for a substantial share of greenhouse gas (GHG) emissions, with soda ash production and other chemical-related activities increasing the carbon footprint. Furthermore, the sector's dependence on imported raw materials and long-haul transportation routes exacerbates emissions, as logistics heavily rely on fossil fuel-powered transport systems (Transport & Environment, 2023) . Despite regulatory efforts such as the Kenya Green Economy Strategy and Implementation Plan (GESIP) and initiatives promoting cleaner production, many firms face challenges in transitioning to low-carbon alternatives due to high implementation costs, infrastructure limitations, and limited access to sustainable technologies (Jayaram & Kendall, 2021).

Supply chain diversification stands as a potential solution to reduce emissions in chemical manufacturing operations because of existing challenges. Companies can reduce their carbon emissions while supporting global net-zero goals by choosing local supply locations and different transport solutions and improving their distribution systems (DHL, 2021). This research evaluated how much supply chain diversification has helped chemical manufacturing firms in Nairobi reach their net-zero emission targets.

1.3 Statement of the Problem

Globally, supply chains are responsible for approximately 77% of total corporate greenhouse gas (GHG) emissions. This makes them very critical in climate change mitigation efforts (CDP, 2024). Despite policy commitments under global frameworks such as the Paris Agreement, the European Green Deal, and the UN Sustainable Development Goals, progress towards net-zero emissions remains insufficient (PwC, 2023). The chemical manufacturing sector is particularly problematic, accounting for 7% of global CO_2 emissions due to its high dependence on fossil fuels, energy-intensive operations, and complex supply chains (IEA, 2022). In Kenya, the chemical manufacturing sector plays a crucial role in industrial growth and employment but also significantly contributes to environmental degradation, with industrial processes being among the top sources of GHG emissions (National Environment Management Authority, 2023). According to the Kenya Association of Manufacturers (2018), local firms depend heavily on imported raw materials, inefficient logistics, and outdated waste management systems all of which increase the sector's carbon footprint.

To address this, supply chain diversification has emerged as a key strategy to mitigate emissions, encompassing practices such as green sourcing, transport optimization, green packaging, and reverse logistics (Mishra, Singh, & Govindan, 2023). Empirical studies from developed countries support these approaches. For instance, Gualandris and Kalchschmidt (2016) found that green sourcing significantly reduces carbon emissions in European chemical supply chains. Similarly, Reuters (2024) highlights how alternative fuels and optimized transportation systems in China and India have curbed logistics-related emissions. Green packaging strategies reduce energy and material waste (Food & Wine, 2024), while reverse logistics supports circular economy models through recycling and reuse (Heliyon, 2024). However, these findings are largely context-specific to industrialized or emerging economies, where infrastructure, policy enforcement, and financial resources are comparatively advanced. This creates a critical knowledge gap regarding how these practices perform in developing contexts like Kenya, where firms face unique operational, financial, and infrastructural limitations (Jayaram & Kendall, 2021; Andaregie & Astatkie, 2021; Kuteyi & Winkler, 2022).

Regionally, sub-Saharan Africa's adoption of sustainable supply chain practices remains limited due to technological inadequacy, poor enforcement of environmental regulations, and inconsistent access to capital (UNEP, 2022). Locally, while Kenya has developed frameworks like the National Climate Change Action Plan (NCCAP) and policies promoting cleaner production, enforcement remains weak and adoption rates among manufacturers are low (Ministry of Environment and Forestry, 2018). Although a few studies in Kenya explore sustainability in manufacturing, empirical evidence on the role and impact of Sustainable Supply Chain practices in reducing emissions within the chemical manufacturing sector remains scarce. This limits the ability of both policymakers and industry players to design targeted, context-sensitive, and evidence-based interventions to drive decarbonization.

1.4 Objectives of the Study

1.4.1 General Objective

To assess the effect of supply chain diversification on achieving net-zero emissions in chemical manufacturing firms in Nairobi, Kenya

1.4.2 Specific Objectives

The specific objectives of the study were to:

i. Evaluate the effect of green sourcing on greenhouse gas emissions reduction in chemical manufacturing firms in Kenya.
ii. Determine the influence of distribution network diversification on carbon emission reduction in chemical manufacturing firms in Kenya.
iii. Assess the influence of green packaging on emission reduction in chemical manufacturing firms in Kenya.
iv. Examine the effect of reverse logistics on emission reduction in chemical manufacturing operations.

1.5 Research Questions

i. What is the effect of green sourcing on the reduction of greenhouse gas emissions in chemical manufacturing firms in Kenya?
ii. What is the effect of distribution network diversification on carbon emissions in chemical manufacturing firms in Kenya ?
iii. What influence does green packaging have on the environmental performance of chemical manufacturing firms in Kenya?

iv. What is the effect of reverse logistics on sustainability and emission reduction in chemical manufacturing firms?

1.6 Significance of the Study

This study provides valuable insights on the role of supply chain diversification in achieving net-zero emissions within Nairobi's chemical manufacturing sector. The findings benefit multiple stakeholders, including the government, industry players, researchers, and policymakers, by offering practical recommendations and empirical evidence to support sustainable industrial practices.

Government and Regulatory Bodies

This research will help the relevant oversight institutions such as NEMA and KAM create policies which support sustainable supply chain practices. Research results will enable them to create guidelines that merge supply chain diversification into national climate action strategies. The research delivered essential data about infrastructure spending that enables green supply chain methods as Kenya works to fulfill its Paris Agreement obligations. Additionally, the study provides insights on the infrastructure investments needed to facilitate green supply chain practices. This will support Kenya's commitment to global climate agreements such as the Paris Agreement

In addition, Policymakers and environmental advocates will benefit from data-driven insights that support the development of effective climate policies. The study identified regulatory gaps and difficulties that prevent the adoption of sustainable supply chain practices, allowing policymakers to improve and reinforce existing policies. Furthermore, environmental advocacy organizations may use the research findings to support corporate sustainability programs and push corporations to use greener supply chain methods.

Chemical Industry Players

Chemical manufacturers will learn practical expertise for implementing sustainable supply chain strategies into their operations. The research emphasizes best practices in green procurement, improved distribution networks, green packaging, and reverse logistics, assisting firms in lowering carbon emissions while increasing efficiency. Industry participants may boost regulatory compliance, improve cost-effectiveness, and gain a competitive edge in the global market by complying with sustainability standards.

Researchers

This study contributes to academic knowledge in the field of sustainable supply chain management, particularly in the context of developing economies. By examining the relationship between supply chain diversification and environmental performance, the research fills existing gaps in literature and serve as a foundation for future studies. Scholars can use the findings to explore additional aspects of sustainable manufacturing, particularly in sub-Saharan Africa, where empirical data on this topic remains limited.

1.7 Scope of the Study

This study aimed to examine the effect of supply chain diversification on achieving net-zero emissions in chemical manufacturing firms in Nairobi, Kenya. The focus was on understanding how diversification strategies across various supply chain components can contribute to carbon emissions reduction and improve environmental sustainability within the manufacturing sector.

Supply chain diversification was explored through four key dimensions: green sourcing, distribution network diversification, green packaging, and reverse logistics. Green sourcing refers to the procurement of raw materials from environmentally responsible suppliers, including the adoption of recyclable inputs and renewable energy sources. Distribution network diversification involves expanding and optimizing delivery channels, using low-emission transportation modes, and adopting smart logistics systems to minimize the carbon footprint associated with product distribution. Green packaging encompasses the use of biodegradable, recyclable, or lightweight materials that contribute to reducing emissions during production and transport. Reverse logistics focuses on the retrieval and reprocessing of used products and packaging, with an emphasis on recycling, reusing, or safe disposal, thereby minimizing environmental impact.

The dependent variable in this study was the achievement of net-zero emissions, which was operationalized by measuring the extent to which chemical manufacturing firms reduce their greenhouse gas emissions. The contextual scope of the study was limited to registered chemical manufacturing firms operating within Nairobi County, Kenya. The study specifically focused on firms within the agro-chemicals, paints and resins, and cosmetics and personal care products subsectors. These sectors have been selected due to their significant contribution to the national economy and their high potential for environmental impact.

From a methodological perspective, the study adopted a quantitative research approach. Data were collected using structured questionnaires administered to supply chain managers, operations managers, and sustainability officers within the selected firms. The study utilized both descriptive and inferential statistical methods to analyze the data and determine the relationships between supply chain diversification practices and net-zero emissions. The data collection and analysis were conducted in February- March 2026. The research adopted a cross-sectional design, capturing data at a single point in time to provide a snapshot of the current practices and their effects on sustainability outcomes. This study sought to generate actionable insights that could inform policy and practice in advancing environmental sustainability through diversified supply chain strategies in the Kenyan chemical manufacturing industry.

1.8 Chapter Summary

This chapter provided an overview of the study, highlighting the importance of supply chain diversification in achieving net-zero emissions. The background emphasized the global context and the relevance of the research, while the problem statement identified the knowledge gap in understanding the environmental impact of diversification strategies. The chapter outlined the study's objectives, research questions, significance, and scope, setting the foundation for subsequent chapters that delved into the theoretical framework, research methodology, and empirical findings.

2 CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical Framework

This research relied on the Natural Resource-Based View (NRBV) Theory as its theoretical base. Sustainable Supply Chain practices find their explanation through these theories regarding their contribution to sustainability and emission reduction.

2.1 Theoretical Framework

2.1.1 Natural Resource-Based View (NRBV) Theory

The Natural Resource-Based View (NRBV) theory was developed by Hart (1995) as an extension of the traditional Resource-Based View (RBV). The theory emphasizes the strategic importance of natural resources and environmental capabilities in achieving competitive advantage. NRBV posits that firms can achieve sustained profitability by integrating environmental sustainability into their core strategies through practices such as pollution prevention, product stewardship, and sustainable development (Hart & Dowell, 2011). These principles were particularly relevant in the context of chemical manufacturing, where environmental impact and resource efficiency are critical.

In the context of this study, NRBV provided the foundation for understanding how green supply chain practices such as green sourcing, the use of renewable energy, eco-friendly packaging, and reverse logistics can help chemical manufacturing firms in Nairobi achieve net-zero emissions. For example, Kumar (2023) notes that firms adopting renewable energy and green sourcing significantly reduce their greenhouse gas emissions, contributing directly to sustainability goals. Furthermore, the application of circular economy principles enables companies to reduce reliance on virgin raw materials, minimize waste, and enhance resource efficiency (Domenech, 2019).

Support for NRBV was also found in empirical research. Russo and Fouts (1997) argue that firms with higher environmental performance tend to achieve superior financial outcomes due to better regulatory compliance, reduced operational costs, and increased market demand for sustainable products. However, critics of NRBV argue that the theory lacks specific guidance for practical implementation and may not account for the immediate financial trade-offs involved in sustainable transitions (Aragón-Correa & Sharma, 2003). Additionally, Darnall et al. (2008) highlight that not all firms possess equal access to the resources and capabilities required for adopting sustainable practices. Despite these limitations, NRBV remains a robust theoretical foundation for this study.

The theory offers insights into how sustainable supply chain strategies can enhance environmental and competitive performance.

2.2 Empirical Framework

2.2.1 Effect of Green Sourcing on Greenhouse Gas Emissions Reduction

Empirical studies highlight that green sourcing enhances sustainability by reducing dependence on environmentally harmful suppliers and promoting the use of low-emission inputs. Ivanov and Dolgui (2021) conducted research to study the effects of green procurement on carbon emissions in European manufacturing industries. Their research utilized a combination of case studies alongside econometric modeling and discovered that green sourcing led to a 20% decrease in carbon emissions through the selection of local suppliers who practice environmentally friendly operations and reduced logistics requirements.

Niehaus (2018) investigated supply chain sustainability practices among South African organizations. The author analyzed sustainability and integrated annual reports from 155 companies and found that 80% of companies mentioned inventory management in their reports. Nevertheless, only 2% referenced green sourcing practices such as remanufacturing and reverse logistics, indicating low adoption of sustainable procurement approaches. The study revealed that consumer goods (14.95%) and retail (12.44%) sectors had the highest mean frequencies for discussions on sourcing sustainability. This indicated a greater shift towards suppliers with sustainable production methods to reduce environmental impact. On the other hand, the basic materials sector contributed 57% of total mentions of "carbon tax," demonstrating greater awareness of emissions regulations. Additionally, companies listed on the Socially Responsible Investment (SRI) Index had a significantly higher mean frequency (14.58) for sustainable sourcing discussions compared to non-SRI companies (5.84). This implied that listed companies had a stronger engagement in green sourcing initiatives. The study emphasized the need for increased supplier collaboration and investment in renewable energy to align green sourcing with net-zero targets (Niehaus, 2018).

Namdar and Sawhney (2018) performed research to assess supply chain resilience by studying single sourcing and multiple sourcing approaches. The research team built mathematical models to analyze supply chain responses under different operational risk conditions and disruption situations. Dual sourcing strategies that included green suppliers delivered superior results than single sourcing approaches because they reduced supply chain disruption risks by 35%. Supply chain partners achieved improved recovery rates of 27% and enhanced supply chain resilience by 22% when they implemented green sourcing supported by early-warning systems that monitored operations proactively according to Namdar and Sawhney (2018). The research confirmed that using environmentally responsible supplier contracts together with spot purchasing methods decreased lead time variability by 18%, thus proving green supplier diversification as an essential strategy for stabilizing supply chains and lowering emissions.

Kiongera et al. (2021) conducted research to determine the impact of product diversification strategies on supply chain performance in Kenya's sugar manufacturing sector. Multiple sugar manufacturing companies sent their top-level managers as well as their section heads and supervisors to take part in this descriptive survey study. The implementation of product diversification by companies resulted in a 28% improvement of supply chain efficiency through enhanced resource management and market responsiveness. The introduction of improved cane varieties with reduced chemical and water requirements led to a 22% rise in manufacturing output, which demonstrated the role of green inputs in lowering environmental degradation. The research revealed that companies with environmentally conscious sourcing practices reduced their supply chain interruptions by 19%. Kiongera (2021) proved that green sourcing functions as an essential factor to enhance both supply chain resilience and operational efficiency in Kenya's sugar industry.

The findings from the aforementioned studies collectively reinforce the argument that green sourcing is a viable strategy for reducing carbon emissions and achieving net-zero targets. This study built upon the existing empirical evidence by examining how green sourcing influences net-zero emissions specifically in chemical manufacturing firms in Nairobi, Kenya.

2.2.2 Effect of Distribution Network Diversification on Carbon Emission

Net-zero emissions depend heavily on sustainable transport systems. Nakase et al. (2021) conducted research on Japanese transport diversification strategies to enhance sustainable urban transportation systems. The research analyzed transport diversity through biodiversity indicators which evaluated public transportation systems like biological ecosystems. The research demonstrated that cities implementing multimodal networks decreased their carbon emissions by

35% per person through quantitative modeling and network analysis. The combination of better access and lower prices resulted in a 22% growth of public transportation ridership. The research demonstrated that transportation networks which mirror ecosystems demonstrate increased resistance to events like strikes and infrastructure breakdowns. The study discovered that urban mobility needs transport diversification as an essential element for sustainability.

McKinsey & Company (2024) conducted research about logistics optimization which analyzed how freight and warehousing operations affect global carbon emissions. The research examined three transportation strategies which included route planning and multimodal transport and fleet electrification. Research results based on industry data and carbon footprint assessments demonstrate that logistics operations produce at least 7% of global greenhouse gas emissions. Route optimization through multimodal transport systems enables a 20%–30% decrease in fuel usage. Fleet electrification has the potential to reduce emissions by 50% when adopted across the board by 2030. AI-driven freight management systems will enhance operational efficiency while reducing emissions by an additional 15% through their capabilities. The research findings demonstrated that combining transport diversity with sustainable logistics operations leads to substantial carbon emission reductions while improving operational expenses.

Robinson (2022) examined North American supply chain sustainability approaches. Through their research the scientists evaluated the utility of GIS mapping technology and carbon emission tracing systems to reduce transportation pollution levels. The research studied multiple transport diversification methods through investigations of multimodal logistics integration together with route optimization strategies. Real-time emissions tracking through GIS-based spatial analysis together with case study evaluations helped the researcher measure strategic business improvements in sustainability without impacting cost-effectiveness. The study by Robinson (2022) established that businesses adopting multi-modal transportation systems reduced their transportation emissions by 25% through rail and sea transport substitution of road vehicles thus minimizing fuel requirements. Consolidating Artificial Intelligence applications with Geographic Information System mapping processes optimized delivery routes thus improving operational performance by 12% combined with decreased fuel expenditures by 9% proving the beneficial connection between technology innovations and sustainable logistics. Firms running electric and hybrid freight vehicles decreased their emissions by 30% when they stopped using diesel-powered fleets. Organizations using digital carbon tracking systems can set particular sustainability targets that lead to superior emission reduction results (Robinson, 2022).

Umutoni and Akumuntu (2024) carried out a study to examine the impact of logistics management practices on supply chain performance. The study focused on transport management, warehouse management, and information management in Rwanda's energy sector. The research was based on a case study of Engie Energy Access Rwanda. The researchers used both explanatory and descriptive designs. They applied quantitative and qualitative methods. Data were collected using surveys and interviews with staff at Engie Energy Access Rwanda. The findings showed that transport management plays a key role in improving supply chain performance. Efficient transport systems led to timely deliveries, shorter delivery periods, and better customer satisfaction. These outcomes helped improve competitiveness in the market. The study also found that warehouse management is important in controlling operational costs. Well-managed storage systems led to better use of resources and improved efficiency. In addition, information management was found to support coordination across departments. It also helped improve decision-making in logistics operations (Umutoni & Akumuntu, 2024).

Samita et al. (2020) carried out a study on transport management strategies at Butali Sugar Company Limited. The research examined how these strategies influence procurement performance. The researchers used a descriptive research design. This allowed them to apply both qualitative and quantitative methods in their study. The study found that effective transport management improves procurement efficiency. Organizations that adopted strong transport strategies reduced procurement costs and improved operational outcomes. The results showed a clear link between well-organized transport systems and better procurement performance. The findings confirmed that transport management is a key element for supply chain success. Manufacturing firms that used proper transport systems achieved stronger procurement results. The study offered useful insights into how transportation strategies support procurement operations in Kenyan manufacturing firms. Strategic investments in transport systems were found to lower costs, improve efficiency, and strengthen overall supply chain performance (Samita, 2020).

2.2.3 Green Packaging on Emission Reduction

Green packaging focuses on the use of sustainable materials and eco-friendly designs to reduce environmental impact. This includes biodegradable, recyclable, or reusable packaging materials that minimize carbon emissions during production, transportation, and disposal. Mutinda (2021) investigated how green packaging influences sustainability performance in Kenyan food processing firms. The study used descriptive and explanatory designs and collected data through questionnaires and interviews. The research showed that green packaging practices help firms reduce packaging waste and lower emissions from packaging production. Firms that adopted biodegradable and recyclable packaging materials reduced landfill contributions and production energy use. The study concluded that green packaging supports emission reduction and improves environmental sustainability in chemical manufacturing companies.

Njeru (2020) conducted a study on sustainable packaging adoption among manufacturing firms in Nairobi County. The researcher used a cross-sectional survey design and analyzed data using descriptive and inferential statistics. The findings revealed that companies using eco-friendly packaging experienced measurable reductions in emissions. This was due to decreased material input, reduced energy use, and minimized waste generation. The study emphasized that sustainable packaging technologies play a key role in reducing greenhouse gas emissions from manufacturing and distribution processes.

Chandra and Kumar (2022) analyzed the role of green packaging in reducing emissions across the Indian FMCG sector. The study was based on a combination of survey data and life cycle assessment models. The researchers found that firms that replaced plastic with biodegradable alternatives such as plant-based packaging significantly lowered carbon footprints. Green packaging practices also reduced energy consumption and water pollution levels. The study established that integrating green packaging into supply chains leads to lower emissions and improved compliance with environmental regulations.

According to Liu et al. (2023), emission reduction through packaging innovation depends on material substitution and supply chain redesign. The study used a systematic review approach to evaluate peer-reviewed research on sustainable packaging practices. The results showed that emissions can be cut by up to 30 percent when firms adopt lightweight and recyclable packaging.

The study recommended that manufacturers redesign packaging processes to optimize for reduced emissions and better resource efficiency.

Mwikali and Ndolo (2022) assessed the adoption of green packaging strategies by beverage manufacturers in Kenya. The researchers applied descriptive and correlational designs and gathered data from 50 firms. The results indicated a positive correlation between green packaging and carbon emission reduction. Firms that used returnable bottles and minimal packaging reduced both material waste and emissions linked to logistics. The study confirmed that green packaging contributes directly to emission control and supports environmental sustainability targets.

2.2.4 Reverse Logistics on Emission Reduction

The control of emissions depends on reverse logistics practices which includes recycling initiatives with waste reduction and material reuse methods. Nyarega (2015) performed research to evaluate how reverse logistics influences performance measurements in Kenyan manufacturing organizations. The research gathered information from manufacturing firms through both questionnaire surveys and company documentation. The implementation of reverse logistics practices such as material recycling, product remanufacturing, and waste reduction strategies led to substantial enhancements in firm performance. Although the research shows that businesses with reverse logistics systems achieve better operational results, it does not provide numerical performance evidence in its final analysis. However, Nyarega (2015) confirmed that reverse logistics integration is essential for Kenyan manufacturing firms, not only to improve performance but also to support environmental sustainability through lower waste and emissions. The study delivers essential findings about how reverse logistics systems contribute to both performance and emission control within Kenyan manufacturing operations.

The implementation of waste reduction, material reuse, and recycling practices through reverse logistics also leads directly to emission reduction. In further confirming these benefits, Nyarega (2015) demonstrated that organizations implementing reverse logistics systems experienced environmental improvements driven by reduced energy consumption, minimization of raw material extraction, and reduced landfill use all of which are contributors to greenhouse gas emissions. The research team obtained data from Kenyan government-linked manufacturing firms using structured questionnaires and company reports. Although specific GHG data was not presented, the findings support the understanding that reverse logistics practices form a critical pathway towards emission mitigation in Kenya's manufacturing sector.

Julianelli et al. (2020) studied the connections between reverse logistics and circular economy through an analysis of elements that affect reverse logistics integration in sustainability-focused systems. The authors conducted their research through a systematic literature review to extract critical success factors for reverse logistics in circular economies. The research revealed that strategic alignment, stakeholder engagement, data tracking systems, and performance measurement are necessary to achieve environmental gains through reverse logistics. When these systems are in place, reverse logistics becomes a tool for lowering emissions by returning products into the value chain rather than discarding them. The study emphasized that integrating reverse logistics with circular economy principles drives sustainable production, encourages remanufacturing, and minimizes waste-related emissions (Julianelli et al., 2020). The findings provide actionable insights for emissions-conscious supply chains.

Mumbi (2023) conducted research on sustainable supply chain management practices and their effect on performance for Kenyan horticultural firms. The study noted that Kenya's horticulture sector faces pressures related to market competition, regulatory change, and shocks such as droughts and pandemics (Tanui, 2024). Through descriptive analysis and survey questionnaires, the study demonstrated that sustainable supply chain practices particularly reverse logistics combined with green purchasing positively affected firm performance and environmental sustainability. The integration of reverse logistics contributed to emissions reduction by enabling the reuse of packaging, reduction of product spoilage, and improved end-of-life product handling. Mumbi (2023) concluded that reverse logistics plays a central role in improving customer satisfaction while reducing environmental impact in Kenya's horticultural sector.

Ndumba and Barasa (2022) investigated how circular supply chain approaches, including reverse logistics, affect performance levels in manufacturing firms in Nairobi County. The researchers applied a descriptive methodology and surveyed 100 respondents from 160 firms using stratified sampling. Their findings showed that circular supply chain practices, including reverse logistics, accounted for 89.2% of performance variations among firms. These practices enhanced material recovery, reduced waste disposal, and encouraged product redesigns that minimized environmental impact. The study identified the need for system development to support reverse logistics, green policy frameworks, and sustainable collaborations. The data supports the position that reverse logistics can drive significant reductions in emissions by reducing landfill volumes, cutting transport emissions through returns consolidation, and supporting energy-efficient recycling efforts. This research provides an assessment of circular supply practices among the chemical manufacturing companies in Nairobi.

2.1 Research Gap

Table 2.1: Summary of Literature Review and Research Gap Analysis

Study	Methodology	Key Findings	Research Gap	Focus of the current study
Ivanov and Dolgui (2021)	Mixed-methods: Case studies and econometric modeling	Firms with diversified supply chains experienced a 20% reduction in carbon emissions through localized sourcing and reduced logistics dependency.	Limited research on the impact of supply chain diversification specifically in the chemical manufacturing sector.	Assessing the impact of supply chain diversification on achieving net-zero emissions in chemical manufacturing firms in Nairobi, Kenya.
Niehaus (2018)	Analysis of sustainability and annual reports of 155 companies	80% of companies mentioned inventory management; low adoption of circular economy practices. Strong engagement from SRI companies in sustainability initiatives.	Lack of research on the specific impact of green sourcing in the chemical manufacturing industry in Nairobi, Kenya.	Exploring how green sourcing strategies can contribute to minimizing greenhouse gas emissions in the chemical manufacturing sector.
Namdar & Sawhney (2018)	Scenario-based mathematical modeling	Dual sourcing reduced supply chain disruption risks by 35%. Increased collaboration improved recovery rates by 27%. Proactive warning capabilities enhanced resilience by 22%.	Limited analysis on how transport diversification impacts carbon emissions in the chemical manufacturing industry.	Evaluating the role of transport diversification in minimizing carbon emissions in the supply chain of chemical manufacturing firms.
Kiongera et al. (2021)	Descriptive survey design	Product diversification improved supply chain efficiency by 28%,	Lack of studies addressing the specific impact of green	Investigating how green packaging can influence

		and reduced disruptions by 19%. Increased production output with new cane varieties.	packaging on chemical manufacturing firms in Kenya.	environmental performance in chemical manufacturing firms in Nairobi, Kenya.
Nakase et al. (2021)	Quantitative modeling and network analysis	Multimodal transport networks reduced per capita emissions by 35%. Cities with equitable distribution of transit modes saw a 22% increase in public transport usage.	Limited research on the direct effect of transport diversification on carbon emissions in chemical manufacturing.	Examining the effect of transport diversification on carbon emissions in the supply chains of chemical manufacturing firms.
McKinsey & Company (2024)	Data analysis, carbon footprint assessments, scenario modeling	Multi-modal transport and route optimization reduced fuel consumption by 20-30%. Fleet electrification could lower emissions by up to 50% by 2030.	Few studies on how fleet electrification and route optimization can be integrated into chemical manufacturing supply chains.	Investigating the potential of transport diversification in reducing emissions and supporting sustainability in the chemical manufacturing sector.
C.H. Robinson (2022)	GIS mapping, real-time emission tracking, case study evaluations	Multi-modal transport strategies reduced transportation-related emissions by 25%. Electric/hybrid freight vehicles reduced emissions by 30%.	Research gap on how real-time emission tracking can be used in the chemical manufacturing industry to reduce emissions.	Analyzing the impact of green logistics and transport diversification on sustainability in the chemical manufacturing supply chain.
Umutoni & Akumuntu (2024)	Descriptive and explanatory research	Efficient transportation systems improved supply chain performance, enhancing delivery	Lack of focus on the link between transport diversification and	Assessing the role of transport diversification in reducing operational costs and carbon

	design, surveys and interviews	accuracy, customer satisfaction, and reducing operational costs.	operational cost reduction in chemical manufacturing.	emissions in chemical manufacturing supply chains.
Samita et al. (2020)	Descriptive research design, structured questionnaires	Effective transport management improved procurement performance in manufacturing, leading to cost-effectiveness and higher efficiency.	Insufficient exploration of how transport management contributes to emission reduction in the chemical manufacturing sector.	Exploring the role of transport diversification in reducing carbon emissions and enhancing supply chain efficiency in chemical manufacturing firms.
Nyarega (2015)	Structured questionnaires and company reports	Reverse logistics practices, like recycling and remanufacturing, led to improvements in firm performance.	Research gap in applying reverse logistics to emission reduction in the chemical manufacturing industry.	Examining how reverse logistics can contribute to emission reduction and sustainability in chemical manufacturing firms.
Julianelli et al. (2020)	Systematic literature review	Identified critical success factors for integrating reverse logistics with circular economy practices.	Need for a focus on the effectiveness of reverse logistics in chemical manufacturing, specifically for emission reduction.	Analyzing the effect of reverse logistics on sustainability and emission reduction in the chemical manufacturing industry.

2.2 Conceptual Framework

The conceptual framework below illustrates the relationship between supply chain diversification and net-zero emissions in chemical manufacturing firms.

Independent Variables **Dependent variable**

Conceptual Framework

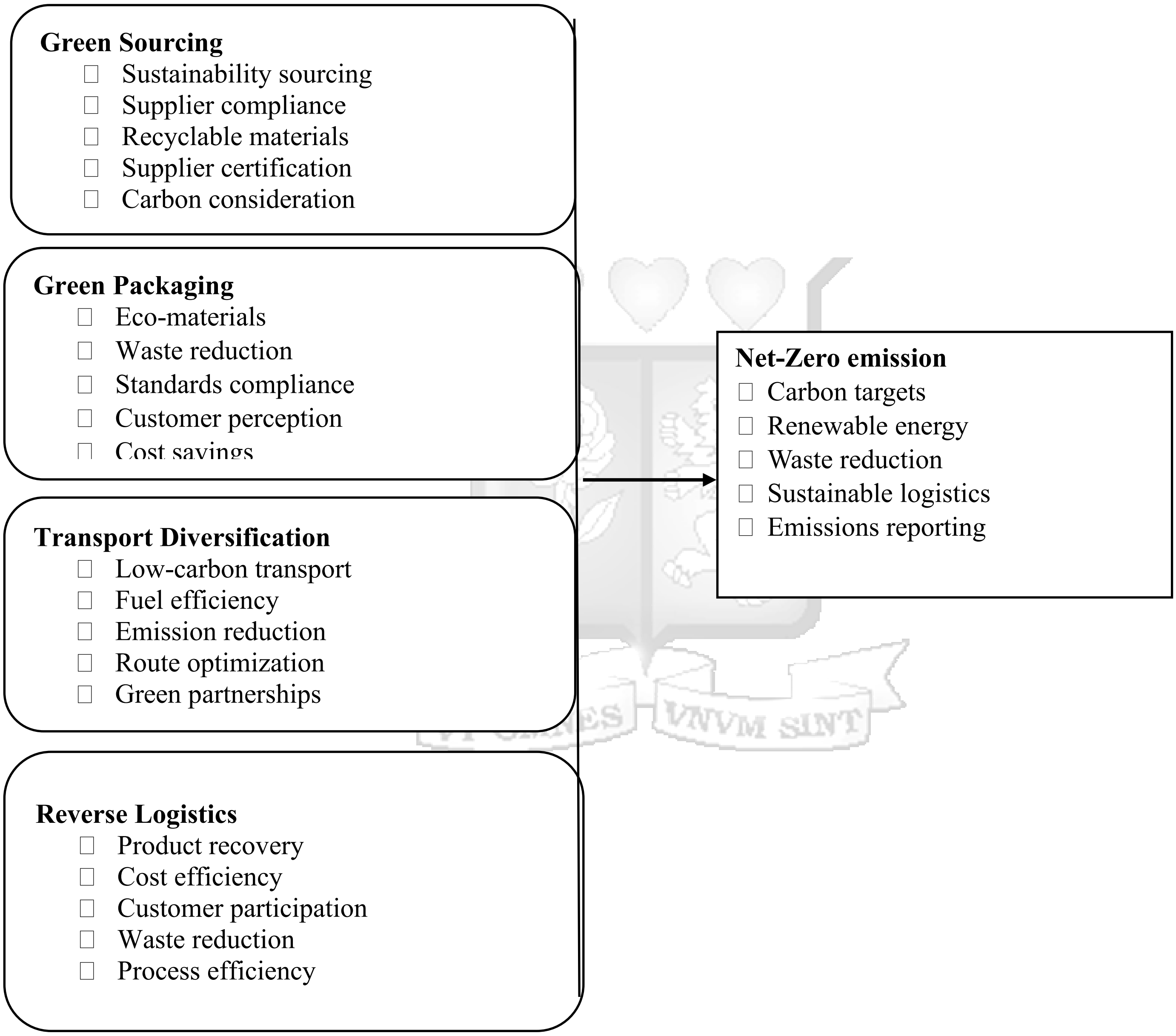


Figure 2.1: Conceptual framework

2.3 Operationalization of Variables

Table 2.2: Operationalization of Variables

Variables	**Indicators**	**Measure**	**Supporting Literature**
Green Sourcing	• Procurement from environmentally sustainable suppliers • Supplier compliance with environmental standards and regulations • Prioritization of renewable or recyclable raw materials • Requirement for suppliers to possess environmental certifications (e.g., ISO 14001) • Consideration of carbon footprint in procurement decisions	5-point Likert Scale (1 = Strongly Disagree to 5 = Strongly Agree)	(Samita, 2020); (Altenburg, 2011); (Akoth Okwako, 2018)
Distribution Network Diversification	• Adoption of low-carbon transportation methods • Implementation of fuel-efficiency initiatives • Investment in transport emission reduction measures • Use of route optimization and shipment consolidation technologies • Collaboration with logistics partners that prioritize low-emission transportation	5-point Likert Scale	(Griffin, 2018); (Andaregie & Astatkie, 2021)
Green Packaging	• Adoption of biodegradable or recyclable packaging materials • Implementation of packaging waste minimization initiatives • Compliance with environmental and	5-point Likert Scale	(Andaregie & Astatkie, 2021)

	sustainability packaging standards • Customer perception of environmentally friendly packaging • Realization of operational cost savings from green packaging practices		
Reverse Logistics	• Recovery and recycling of returned products or materials • Cost savings resulting from reverse logistics initiatives • Customer participation in take-back and recycling programmes • Reduction of waste through reverse logistics practices • Efficiency of reverse logistics operations in minimizing environmental impacts	5-point Likert Scale	(Bataille, 2020); (Bor, 2021)
Net-Zero Emissions *(Dependent Variable)*	• Carbon footprint monitoring and reduction initiatives • Adoption of renewable energy sources • Implementation of waste reduction strategies • Adoption of sustainable logistics practices • Monitoring and reporting progress toward net-zero emissions goals	5-point Likert Scale	(Samita, 2020); (Altenburg, 2011); (Akoth Okwako, 2018)

2.4 Summary

The review of this chapter included relevant theories about supply chain diversification and net-zero emissions alongside empirical studies of sustainability practices and the conceptual basis of this research. The following chapter outlines the research methods which evaluate these relationships within Nairobi's chemical manufacturing industry.

3. CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This section details the research methodology which studies supply chain diversification effects on net-zero emissions in chemical manufacturing businesses operating in Nairobi Kenya. The chapter examines research philosophy together with design, population and sampling, data collection methods, data analysis and presentation, research quality and validity of research instruments.

3.2 Research Philosophy

This study adopted a positivist research philosophy. Positivism is based on the belief that reality exists independently of human perception and can be objectively observed and measured (Alharahsheh, 2020). It emphasizes the use of scientific methods to uncover factual knowledge through empirical observation, structured procedures, and statistical analysis. According to Saunders et al. (2015), positivist researchers seek to explain causal relationships by testing hypotheses using quantifiable data.

The positivist approach is especially relevant to this study because it investigates the impact of Sustainable Supply Chain practices on net-zero emissions in chemical manufacturing firms. These variables are measurable and can be analyzed statistically. By using predefined data collection tools and structured techniques, the study aims to draw generalizable and replicable conclusions. Positivism supported the objective nature of the research, as it focused on observable patterns and causality without researcher bias.

3.3 Research Design

A research design is a structured methodology which directs researchers to address their study objectives according to (Creswell, 2021). This study employed descriptive cross-sectional survey research design to analyze supply chain diversification effects on sustainability and emission reductions for chemical manufacturing firms operating in Nairobi Kenya. Research using the descriptive method aims to create exact descriptions of events and subjects and phenomena. Saunders (2015) described how descriptive cross-sectional survey research design uses quantitative research methods to collect structured data about specific research aspects at one particular time.

The research collected quantitative data by distributing structured questionnaires with closed-ended and open-ended questions to respondents. The flexible nature of descriptive cross-sectional surveys allows researchers to study various supply chain aspects of diversification and sustainability effects thus making this research approach suitable. Wang (2020) demonstrates that descriptive cross-sectional survey methodologies yield high-quality statistical information that benefits academics and industry stakeholders and policymakers through its empirical insights into research variables. The structured format of the survey generates objective results by minimizing bias thus improving both research reliability and validity. An objective evaluation of Sustainable Supply Chain practices and their impact on net-zero emissions in Nairobi-based chemical manufacturing firms was enabled through the selected research design.

3.4 Population and Sampling

3.4.1 Study Population

According to Kothari (2004), a study population consists of all individuals, organizations, or objects that are relevant to the research objectives. This study targeted all 127 registered chemical manufacturing firms in Kenya, the majority of which are located in Nairobi and its environs, as reported by the Kenya Association of Manufacturers (KAM, 2023). These firms are registered with both KAM and the National Environment Management Authority (NEMA) and are actively engaged in strategic supply chain management and environmental compliance.

The unit of analysis for this study was the firm, while the unit of observation was the individual respondent. Data was collected from key informants within each firm who are directly involved in supply chain management and sustainability-related activities. Specifically, the study targeted supply chain managers, operations managers, and sustainability/environmental officers. These respondents were purposively selected because they possess specialized knowledge and practical experience regarding supply chain diversification, net-zero emissions initiatives, environmental compliance, and sustainability practices within their organizations.

Since each firm was expected to provide one respondent from each of the three functional areas, the target respondent population comprised 381 respondents (127 firms × 3 respondents per firm). The selected respondents were considered appropriate because their responsibilities place them at the center of decision-making and implementation of supply chain and sustainability initiatives, thereby enabling them to provide accurate and relevant information aligned with the study objectives.

3.4.2 Sampling

Sampling refers to the process of selecting a subset of individuals or elements from a population to represent the entire population (Kothari, 2004; Creswell, 2021). Given that the study population consisted of 127 registered chemical manufacturing firms, a census approach was adopted at the firm level. Under this approach, all 127 firms were included in the study to ensure comprehensive coverage of the chemical manufacturing sector in Kenya. A census was considered appropriate because the population size was manageable and allowed the researcher to obtain information from all eligible firms, thereby minimizing sampling error and enhancing the representativeness of the findings.

At the respondent level, purposive sampling was employed to identify key informants within each firm. Three respondents were targeted from every firm: a supply chain manager, an operations manager, and a sustainability/environmental officer. These categories of respondents were selected because of their direct involvement in supply chain operations, environmental management, and sustainability initiatives. Where a firm did not have a designated sustainability/environmental officer, another senior officer responsible for environmental compliance or sustainability matters was selected. The use of purposive sampling ensured that information was obtained from individuals with adequate knowledge and experience regarding the study variables. Consequently, the study targeted a total of 381 respondents drawn from the 127 chemical manufacturing firms included in the census. This combination of census and purposive sampling enhanced the quality, reliability, and relevance of the data collected.

3.5 Data Collection Methods

This study relied on primary data, which was collected using structured questionnaires composed of closed-ended questions. This method was appropriate for the study as it ensured consistency across responses, facilitates ease of analysis, and supports the generation of quantifiable data aligned with the study objectives. Structured questionnaires were efficient for studies involving a large number of respondents and help improve the speed and accuracy of data collection (Rassel, 2020).

The questionnaire was organized into three main sections. Section A gathered demographic information, including details such as the respondent's gender, age, level of education, job title, years of experience, and department within the organization. Section B focused on the independent variable, supply chain diversification, and covered five key sub-indicators: supplier diversification, logistics flexibility, local sourcing, digital supply networks, and contract flexibility. Section C assessed the dependent variable, net-zero emissions, through five sub-indicators: carbon footprint reduction, renewable energy adoption, waste reduction, sustainable logistics practices, and green packaging initiatives. Each item in Sections B and C were measured using a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The use of a five-point scale allows for more nuanced responses and better captures the degree of agreement or disagreement among respondents, enhancing the reliability and validity of the data collected.

Data were collected through both digital and physical formats to maximize accessibility and response rates. Respondents had an option of accessing receiving a Google Forms link via email and filling the questionnaire online. For those who preferred or required a physical copy, printed questionnaires were delivered using the drop-and-pick-later method. This approach ensured that respondents have adequate time to complete the questionnaires at their convenience while maintaining follow-up to encourage full participation. To support the data collection process, trained research assistants were engaged. These assistants were briefed on the research objectives, the structure of the questionnaire, and ethical standards, including confidentiality, informed consent, and voluntary participation. Their involvement helped to streamline the administration of questionnaires, offer clarifications to respondents when needed, and enhance the overall response rate and data quality.

3.6 Data Analysis and Presentation

The systematic organization and interpretation of research data through synthesis enables hypothesis testing and conclusion drawing according to Kothari (2004). The data analysis process began with a preliminary phase involving data cleaning, coding, and entry to ensure accuracy and consistency before conducting statistical analysis. This step included checking for missing values, outliers, and logical inconsistencies in responses. Cleaned data were then be coded and entered into Statistical Package for the Social Sciences (SPSS) version 28 software for analysis.

The analysis was conducted in two phases: descriptive and inferential statistics. In the descriptive phase, data was summarized to provide a clear understanding of the characteristics of the dataset. Measures such as means, standard deviations, frequencies, and percentages were used to examine demographic distributions as well as patterns within responses related to supply chain diversification and net-zero emission practices. This helped in identifying general trends and providing context for deeper statistical analysis.

The second phase employed inferential statistical methods to test hypotheses and determine the nature and strength of relationships between variables. Specifically, Pearson correlation analysis was used to assess the linear relationship between each supply chain diversification indicator and net-zero emission measures. The correlation coefficient (R) demonstrates values within the -1 to +1 spectrum indicating perfect negative to perfect positive relationships and zero represents no correlation (Lohr, 2021). Multiple Regression Analysis served to evaluate how Sustainable Supply Chain practices affect net-zero emissions. The technique enabled researchers to identify independent variable effects on dependent variables by managing the impact of additional elements.

The following regression model was used: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$

Where:

Y = Net-zero emissions adoption

β_0 =Constant (coefficient of intercept)

X_1 = Supply chain sourcing diversification

X_2 = Supplier partnership strategies

X_3 = Green logistics practices

X_4 = Regulatory compliance measures

$\beta_1, \beta_2 \beta_3, \beta_4$: Regression coefficients, and,

$\varepsilon$is the error term.

Prior to conducting the regression analysis, a series of diagnostic tests were undertaken to ensure that the assumptions of multiple linear regression were not violated. First, the normality of the data was assessed using skewness and kurtosis statistics, complemented by visual inspection of histograms to determine whether the data approximated a normal distribution. Second, the study tested for multicollinearity among the independent variables using the Variance Inflation Factor (VIF) and tolerance values, where VIF values below 10 and tolerance values above 0.1 indicated the absence of multicollinearity problems. Third, heteroscedasticity was examined through scatter plots of standardized residuals to verify that the variance of errors remained constant across all levels of the independent variables. In addition, linearity tests were conducted using scatter plots to confirm the existence of a linear relationship between the dependent and independent variables. Finally, model fitness was assessed using Analysis of Variance (ANOVA) to determine the overall significance of the regression model at a 95% confidence level.

The research findings were displayed through tables and graphs and charts for easier interpretation by readers. The graphical representations successfully displayed the data patterns together with the identified relationships and essential findings. Data processing and analysis were conducted through the Statistical Package for the Social Sciences (SPSS). The established data analysis process guarantees both statistical validity and reliability in the study results which help explain supply chain diversification effects on sustainability and net-zero emission targets.

3.7 Research Quality

3.7.1 Research validity

Validity refers to the extent to which a research instrument accurately measures the concepts it is intended to measure and adequately addresses the objectives of the study (Clark, 2019). In this study, validity was assessed through face validity, content validity, and construct validity to ensure that the questionnaire appropriately measured the study variables. A pilot study was conducted involving approximately 10% of the target respondents drawn from chemical manufacturing firms that were not included in the main study. The purpose of the pilot study was to assess the clarity, relevance, adequacy, and comprehensibility of the questionnaire items before the commencement of the actual data collection process. Feedback obtained from the pilot respondents indicated that most questions were clear and relevant to the study objectives.

However, minor revisions were made to improve question wording, eliminate ambiguity, enhance the logical flow of the questionnaire, and ensure consistency in the measurement scales. The respondents who participated in the pilot study were excluded from the main study to avoid response contamination and enhance the credibility of the findings.

Face validity was established by evaluating whether the questionnaire items appeared to measure the intended concepts of supply chain diversification and net-zero emissions initiatives. The pilot study findings helped identify and correct any weaknesses in the instrument before full-scale data collection, consistent with the recommendations of Creswell (2021). Construct validity was assessed by examining whether the questionnaire items adequately represented the theoretical constructs under investigation. The pilot study responses were analyzed to determine whether the items effectively captured the dimensions of supply chain diversification and net-zero emissions initiatives as conceptualized in the study framework. Necessary adjustments were made to strengthen the alignment between the questionnaire items and the study constructs.

Content validity was established through expert review. The questionnaire was evaluated by the research supervisor and a supply chain management expert to determine whether the instrument adequately covered all dimensions of the study variables. Their recommendations were incorporated into the final version of the questionnaire. According to Kothari (2004), expert evaluation enhances content validity by ensuring that all relevant aspects of the constructs under investigation are adequately represented in the research instrument.

3.7.2 Research Instrument Reliability

The research instrument demonstrates reliability when it produces equivalent outcomes when researchers administer it under identical conditions. Mugenda & Mugenda (2003) stated that a research instrument demonstrates reliability when it produces dependable data which remains consistent between different measurement occasions. The research instrument reliability was tested through the test-retest reliability method as the primary method in this study. Internal consistency was measured through Cronbach's Alpha coefficient while a reliability coefficient of 0.7 or higher satisfies the requirements of Creswell (2021). The study was evaluated inter-rater reliability through a comparison of its findings to established research mentioned in the literature review. The research instrument achieved reliability when its results match established studies that explore supply chain diversification effects on net zero emissions. The research instrument was adjusted to enhance accuracy when substantial inconsistencies arise.

The research validation technique follows (Kothari, 2004) by establishing reliability through comparison with existing literature.

To ensure the accuracy and reliability of the regression model used in this study, this study tested for normality of the data, linearity, multicollinearity and heteroskedasticity. Normality test was carried out using the Shapiro-Wilk test and the Kolmogorov-Smirnov test because the sample size was small. The study also examined multicollinearity among the independent variables using the Variance Inflation Factor (VIF). the study also tested for linearity using scatter plots to confirm whether the relationship between independent and dependent variables followed a linear pattern. Finality the study tested for homoscedasticity using the Breusch-Pagan test.

3.7.3 Ethical Considerations

Ethical considerations were incorporated into the research. The researcher first sought ethical clearance from the Strathmore University Institutional Scientific and Ethical Review Committee (SU-ISERC). Clearance from the National Commission for Science, Technology, and Innovation (NACOSTI) was also obtained before commencing the study. Before engaging with respondents, the researcher informed them about the objective of the study and sought their informed consent. The researcher reassured participants that their personal data will remain confidential and that the information collected will only be used for the intended study. A note was also included in the questionnaire to encourage respondents to answer honestly and truthfully without fear of intimidation. To maintain anonymity, providing names was optional. Finally, the research findings were reported as accurately and truthfully as possible, without any attempt to conceal the truth.

3.8 Chapter Summary

This chapter has outlined the research methodology, including the research philosophy, design, population and sampling, data collection methods, data analysis techniques, research quality measures, and instrument validity. The next chapter presents the study's findings and analysis.

4. CHAPTER FOUR

4.1 Introduction

The objective of the study was to examine the effect of Sustainable Supply Chain practices (green sourcing, transport diversification, green packaging, and reverse logistics) on the achievement of net-zero emissions. The analysis employed descriptive statistics to summarize the data collected from respondents. The findings are presented through frequency tables, means, and standard deviations, followed by interpretations in relation to sustainable supply chain management practices in the chemical manufacturing sector.

4.2 Response rate

A total of 127 questionnaires were administered to the target respondents. Out of these, 108 were successfully completed and returned, while 19 were not returned or were incomplete and therefore excluded from the analysis. This resulted in a response rate of 85%, as presented in Table 4.1.

Table 4.1: Response Rate

Questionnaires	**Frequency**	**Percentage**
Response	108	85
Non-response	19	15
Total	**127**	**100**

Source: Primary data (2026)

A response rate of 85% is considered high and satisfactory for statistical analysis, as supported by Mugenda and Mugenda (2003), who suggest that a response rate above 70% is adequate for generalization. This indicates that the data collected was sufficient and representative of the study population, thereby enhancing the reliability and validity of the study findings.

4.3 Demographics characteristics of the respondents

4.3.1 Gender of Respondents

The study sought to establish the gender distribution of respondents participating in the survey. The findings presented in Table 4.1 indicate that 53 respondents (51.0%) were female, while 51 respondents (49.0%) were male. This distribution suggests a fairly balanced gender representation among professionals working in chemical manufacturing firms in Nairobi County.

4.3.2 Age of the respondent

The study examined the age distribution of respondents. The results show that the majority of respondents were between 36–45 years (41.7%), closely followed by those aged 25–35 years (40.8%). Respondents aged 46 years and above accounted for 14.6%, while only 2.9% were aged between 18–24 years. The findings indicate that the majority of respondents are mid-career professionals, suggesting that they possess significant industry experience and are likely to have a deeper understanding of supply chain management practices and sustainability initiatives within chemical manufacturing firms.

Table 4.2: Age of Respondents

	Frequency	Valid Percent
18-24 years	3	2.9%
25-35 years	42	40.8%
36-45 years	43	41.7%
46 years and above	15	14.6%
Total	103	100.0%

Source: Primary data (2026)

4.3.3 Highest Education Level

The education level of respondents was also assessed to determine their professional background. The findings reveal that the majority of respondents held a bachelor's degree (42.1%), followed by diploma holders (38.3%). Respondents with master's degrees accounted for 10.3%, while 9.3% had secondary-level education. The results suggest that most respondents possess formal training in technical fields, which enhances their ability to understand and implement sustainability practices such as green sourcing, eco-friendly packaging, and low-carbon logistics strategies.

Table 4.3: Highest Education Level

Education level	**Frequency**	**Valid Percent**
Secondary	10	9.3%
Diploma	41	38.3
Bachelor's degree	45	42.1
Master's Degree	11	10.3
Total	107	100.0

Source: Primary data (2026)

4.3.4 Position Held by Respondents

The study further examined the organizational positions of respondents. As shown in Table 4.4, the largest proportion of respondents fell under the "Other" category (32.4%), which included positions such as production managers, logistics officers, quality assurance managers, environmental compliance officers, managing directors, and plant managers. This was followed by supply chain managers (25.0%), operations managers (21.3%), and sustainability officers (21.3%). The relatively high proportion of respondents classified under the "Other" category can be attributed to variations in organizational structures across chemical manufacturing firms. While the study primarily targeted supply chain managers, operations managers, and sustainability/environmental officers, some firms did not have personnel occupying these exact positions. In such cases, equivalent senior officers with direct responsibility for supply chain management, environmental compliance, logistics, production operations, or sustainability-related functions were purposively selected to participate in the study. These respondents possessed the necessary knowledge and experience regarding the firm's supply chain diversification practices and net-zero emissions initiatives.

The inclusion of respondents from diverse managerial and operational positions enhanced the comprehensiveness of the data by capturing organizational perspectives from individuals directly involved in supply chain operations, environmental management, and strategic decision-making. Consequently, the responses obtained reflected firm-level practices and experiences rather than personal opinions, thereby improving the relevance and reliability of the findings.

Table 4.4:Position Held by Respondents

Position Held in the firm	Frequency	Percent
Supply Chain Manager	27	25.0%
Operations manager	23	21.3%
Sustainability Officers	23	21.3%
Others	35	32.4%
Total	108	100.0%

Source: Primary data (2026)

4.3.5 Years of experience of the respondent

Majority of respondents had 6–10 years of experience (43.4%), followed by 3–5 years of experience (41.5%). Respondents with more than 10 years of experience accounted for 10.4%, while those with less than 2 years accounted for 4.7%. This distribution indicates that most respondents possessed substantial experience within the chemical manufacturing sector, suggesting that the insights provided regarding supply chain sustainability practices are informed by practical industry knowledge. This is as provided in table 4.5

Table 4.5: Years of experience of the respondent

Experience of the respondents	Frequency	Percent
Less than 2 years	5	4.7%
3-5 years	44	41.5%
6-10 years	46	43.4%
More than 10 years	11	10.4%
Total	106	100.0%

Source: Primary data (2026)

4.3.6 Company Size

The size of the firms was measured based on the number of employees. The results indicate that 35.8% of firms employ between 50–100 employees, while 33.0% employ fewer than 50 employees. Firms employing more than 250 employees account for 18.9%, while 12.3% employ between 101–250 employees. These findings suggest that the chemical manufacturing sector in Nairobi County is largely composed of small and medium-sized enterprises (SMEs). Company size can influence the level of resources available for implementing sustainability initiatives such as renewable energy adoption, green logistics systems, and waste management programs.

Table 4.6: company size

Number of Employees	Frequency	Percent
Less than 50 employees	35	33.0%
50-100 employees	38	35.8%
101-250 employees	13	12.3%
More than 250 employees	20	18.9%
Total	106	100.0%

Source: Primary data (2026)

4.4 Descriptive Statistics

The study sought to examine the perceptions of stakeholders regarding strategies and practices necessary for achieving net-zero emissions in chemical manufacturing firms. To gather these insights, participants were asked to indicate the extent to which they agreed or disagreed with various statements using a 5-point Likert scale. On this scale, a rating of 1 represented "Strongly Disagree," while a rating of 5 represented "Strongly Agree." For interpretation, mean scores were used to determine the general level of agreement. A mean score between 1.00 and 1.49 was considered to indicate strong disagreement, while a score between 1.50 and 2.49 signified disagreement. Scores ranging from 2.50 to 3.49 indicated neutrality, suggesting that respondents neither agreed nor disagreed with the statement. Mean scores between 3.50 and 4.49 showed agreement, and those between 4.50 and 5.00 represented strong agreement.

In line with Lohr, (2021), ratings of disagreement and strong disagreement were taken to reflect negative disconfirmation, implying that the respondents did not support the statement or found it unsatisfactory. On the other hand, agreement indicated confirmation, meaning the respondents affirmed the statement, while strong agreement suggested positive disconfirmation, reflecting strong endorsement. In addition to reporting mean scores, the study assessed the dispersion of responses using the standard deviation (SD), which indicates how tightly participants' answers cluster around the mean and therefore the degree of consensus or divergence. On the 5-point Likert scale used here, SD values below 0.90 were interpreted as low variability, meaning responses were tightly clustered and respondents showed a high degree of agreement. SDs between 0.90 and 1.25 were taken to indicate moderate variability, reflecting a reasonable spread of opinion on the item. Finally, SDs above 1.25 were interpreted as high variability, signaling that responses were widely scattered across the scale and that participant views on the statement were diverse or contested.

4.4.1 Green Sourcing

The results indicate a high level of adoption of green sourcing practices among chemical manufacturing firms in Nairobi County. The overall mean score was 4.40 (SD = 0.77), suggesting that most firms integrate environmental considerations into their procurement processes. The highest-rated practice was supplier compliance with environmental standards (M = 4.56, SD = 0.586), indicating that companies actively work with environmentally responsible suppliers. Similarly, respondents strongly agreed that their firms source materials from sustainable suppliers (M = 4.50). However, the requirement for supplier environmental certification recorded the lowest mean (M = 4.20, SD = 1.201), suggesting some variability among firms regarding formal certification requirements. Overall, the findings suggest that green procurement practices are well integrated into supply chain operations, contributing to reduced environmental impact and supporting the transition toward net-zero emissions. The feedback was as presented in table 4.7

Table 4.7: Green Sourcing

	Mean	SD
We source our materials from sustainable suppliers	4.50	0.502
Our suppliers comply with environmental standards and regulations	4.56	0.586
Our company prioritizes the use of renewable or recyclable materials	4.36	0.817
We require suppliers to have environmental certifications	4.20	1.201
Our procurement process considers carbon footprint reduction	4.36	0.745
Average	4.40	0.770

Source: Primary data (2026)

4.4.2 Transport Diversification

As shown in table 4.8, transport diversification practices recorded an overall mean score of 4.21 (SD = 1.006), indicating strong agreement that firms are adopting measures to reduce transport-related emissions. The highest-rated statement was collaboration with logistics partners who prioritize low-emission transportation (M = 4.44). This suggests that companies increasingly partner with environmentally responsible logistics providers. Similarly, fuel efficiency improvements (M = 4.40) were widely reported, demonstrating a commitment to reducing fuel consumption and operational costs. However, slightly higher variability in responses suggests that the adoption of low-carbon transport technologies varies across firms, likely due to differences in financial capacity, infrastructure availability, and operational scale.

Table 4.8: Transport Diversification

	Mean	SD
A significant percentage of our shipments use low-carbon transport	4.07	0.839
We have implemented fuel efficiency improvements	4.40	0.910
We have made efforts to reduce transport-related emissions e.g through investing in low carbon emission vehicles	4.02	1.107

We use software or systems to plan delivery routes and consolidate shipments in order to reduce fuel consumption and emissions (e.g., GPS-based route planning, load optimization tools).	4.13	1.244
We collaborate with logistics partners or third-party providers who prioritize low-emission transportation solutions (e.g., electric fleets, route efficiency, carbon offset programs).	4.44	0.930
Average	4.21	1.006

Source: Primary data (2026)

4.4.3 Green packaging

Green packaging practices recorded an overall mean score of 4.32 (SD = 0.840), indicating strong agreement that firms have adopted environmentally friendly packaging solutions. The highest-rated practice was the implementation of packaging waste minimization strategies (M = 4.41). Respondents also agreed that green packaging has resulted in cost savings (M = 4.39), highlighting the economic benefits of sustainable packaging practices. Additionally, respondents indicated that customers perceive their packaging as eco-friendly (M = 4.31), suggesting that sustainable packaging contributes positively to corporate reputation and customer satisfaction. These findings demonstrate that green packaging is increasingly integrated into sustainability strategies within the chemical manufacturing sector. The feedback was as presented in table 4.9

Table 4.9: Green packaging

	M	SD
More than 50% of our packaging is biodegradable/recyclable	4.27	0.943
We have implemented specific measures to minimize packaging waste (e.g., lightweight materials, reusable packaging)	4.41	0.809
Our packaging practices comply with recognized sustainability standards such as those from the Kenya Bureau of Standards (e.g., KS 2921, KS EAS 996), NEMA regulations, or relevant international certifications like FSC or ISO 14001.	4.22	0.813
Customers perceive our packaging as eco-friendly	4.31	0.732
We have realized cost savings as a result of adopting green packaging practices	4.39	0.905

Average	4.32	0.840

Source: Primary data (2026)

4.4.4 Reverse logistics

Reverse logistics practices recorded an overall mean score of 4.15 (SD = 0.943), suggesting that firms actively engage in product recovery, recycling, and waste reduction initiatives. The highest-rated statement was that reverse supply chains are efficient in managing returns and minimizing environmental impact (M = 4.30). Firms also reported cost savings from reverse logistics initiatives (M = 4.29). However, relatively higher variability in responses suggests that the implementation of reverse logistics programs varies across firms, with some companies still developing structured return and recycling systems. Overall, the findings indicate that reverse logistics contributes to waste reduction and supports circular economy principles. The feedback was as shown in table 4.10

Table 4.10:Reverse Logistics

	M	SD
Our company reclaims or recycles a significant percentage of returned or used products	3.99	0.995
We have experienced cost savings as a result of reverse logistics initiatives (e.g., reuse, resale, recycling)	4.29	0.942
Our customers actively participate in return, take-back, or recycling programs we provide	4.03	0.956
Our reverse logistics efforts have led to a measurable reduction in waste sent to landfills	4.14	0.86
Our reverse supply chain is efficient in managing returns and minimizing environmental impact	4.3	0.962
Average	4.15	0.943

Source: Primary data (2026)

4.4.5 Net-Zero Emissions Initiatives

The results show a strong commitment among firms toward achieving net-zero emissions. The overall mean score was 4.22 (SD = 0.995), indicating that most firms have adopted several carbon reduction initiatives. Respondents strongly agreed that their firms implement waste reduction strategies (M = 4.34) and incorporate sustainable logistics practices (M = 4.32). Additionally, companies reported actively monitoring and reporting progress toward net-zero goals (M = 4.20). However, the adoption of renewable energy sources showed relatively higher variability (SD = 1.299), suggesting differences in the extent to which firms have transitioned to renewable energy technologies. The findings demonstrate that chemical manufacturing firms in Nairobi are increasingly aligning their operations with global sustainability and decarbonization goals. The feedback is s summarized in table 4.11

Table 4.11: Net Zero emission initiatives

	Mean	**SD**
Our company has set clear targets and actively monitors its carbon footprint	4.13	0.817
We have adopted renewable energy sources such as solar, wind, hydropower, geothermal, or biomass	4.12	1.299
We have implemented effective waste reduction strategies (e.g., recycling, resource)	4.34	0.897
We incorporate sustainable logistics practices to reduce emissions across the supply chain	4.32	0.952
We regularly monitor, document, and report progress toward our net-zero emissions goals	4.20	1.009
Average	4.22	0.995

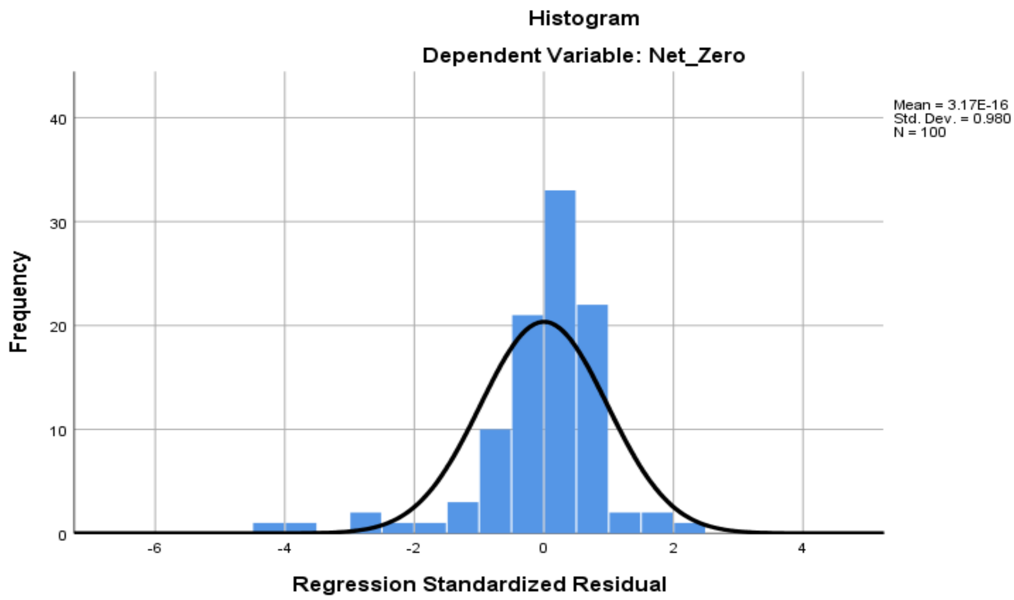
Source: Primary data (2026)

4.5 Inferential Analysis

This section presents the inferential statistical analysis conducted to examine the relationships between Sustainable Supply Chain practices and the achievement of net-zero emissions in chemical manufacturing firms in Nairobi County. Specifically, Pearson correlation analysis was used to determine the strength and direction of relationships between the independent variables (green sourcing, transport diversification, green packaging, and reverse logistics) and the dependent variable (net-zero emissions). In addition, multiple regression analysis was conducted to establish the extent to which these supply chain diversification practices predict the achievement of net-zero emissions.

Before conducting inferential analysis, a normality test was performed to assess whether the data were normally distributed. This was done using a histogram, which indicated a bell-shaped curve, suggesting that the data approximated a normal distribution. Based on this visual assessment, it was concluded that the assumption of normality had been satisfied, thereby justifying the use of parametric statistical techniques in subsequent analyses. This is as shown in figure 4.1.

Figure 4.1: Normality distribution of data



4.5.1 Correlation Analysis

A Pearson correlation analysis was conducted to determine the strength and direction of the relationships between the independent variables (green sourcing, transport diversification, green packaging, and reverse logistics) and the dependent variable (net-zero emissions). The results are presented in Table 4.12. The findings indicate that all the independent variables are positively and significantly correlated with net-zero emissions at the 0.01 significance level, suggesting that improvements in sustainable supply chain practices are associated with increased achievement of net-zero emission targets among chemical manufacturing firms.

Green sourcing shows a strong positive correlation with net-zero emissions ($r = 0.731$, $p < 0.01$). This implies that firms that prioritize sourcing materials from environmentally compliant suppliers and incorporate carbon footprint considerations in procurement processes are more likely to achieve net-zero emission objectives. Transport diversification also demonstrates a strong positive correlation with net-zero emissions ($r = 0.770$, $p < 0.01$). This suggests that firms that adopt low-carbon transportation systems, improve fuel efficiency, and collaborate with environmentally responsible logistics partners tend to achieve better emission reduction outcomes.

Similarly, green packaging has a strong positive relationship with net-zero emissions ($r = 0.754$, $p < 0.01$). This indicates that the adoption of recyclable or biodegradable packaging materials, as well as packaging waste minimization strategies, contributes significantly to reducing the environmental footprint of chemical manufacturing firms. Reverse logistics also shows a moderate to strong positive correlation with net-zero emissions ($r = 0.649$, $p < 0.01$). This finding suggests that firms that implement product return, recycling, and waste recovery systems are better positioned to minimize landfill waste and support circular economy initiatives that contribute to emission reduction. The correlation results demonstrate that Sustainable Supply Chain practices are strongly associated with the achievement of net-zero emissions in chemical manufacturing firms in Nairobi County.

Table 4.12: Correlation Results

Correlations						
		Green Sourcing	Transport Diversification	Green Packaging	Reverse Logistics	Net Zero
Green Sourcing	Pearson Correlation	1	.664**	.656**	.474**	.731**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	107	107	107	103	103
Transport Diversification	Pearson Correlation	.664**	1	.764**	.622**	.770**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	107	107	107	103	103
Green Packaging	Pearson Correlation	.656**	.764**	1	.701**	.754**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	107	107	108	104	104
Reverse Logistics	Pearson Correlation	.474**	.622**	.701**	1	.649**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	103	103	104	104	101
Net Zero	Pearson Correlation	.731**	.770**	.754**	.649**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	103	103	104	101	104
**. Correlation is significant at the 0.01 level (2-tailed).						

Source: Primary data (2026)

4.5.2 Multiple Regression

Multiple regression analysis was conducted to determine the extent to which green sourcing, transport diversification, green packaging, and reverse logistics collectively predict the achievement of net-zero emissions among chemical manufacturing firms.

The model summary results presented in table 4.13 show that the correlation coefficient R = 0.852, indicating a strong positive relationship between the independent variables and net-zero emissions. The coefficient of determination ($R^2 = 0.725$) indicates that 72.5% of the variation in net-zero emissions is explained by the combined influence of green sourcing, transport diversification, green packaging, and reverse logistics. The adjusted R^2 value of 0.714 further confirms that the model provides a strong explanatory power even after adjusting for the number of predictors in the model. This suggests that sustainable supply chain practices play a significant role in determining the achievement of net-zero emissions among chemical manufacturing firms.

The ANOVA results indicate that the regression model is statistically significant (F = 62.685, $p < 0.001$). This implies that the overall regression model significantly predicts net-zero emissions. The significant F-statistic confirms that the combined effect of green sourcing, transport diversification, green packaging, and reverse logistics provides a reliable prediction of net-zero emission outcomes in chemical manufacturing firms. The results were as presented in table 4.14

Table 4.13: Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.852[a]	.725	.714	.42563
a. Predictors: (Constant), Reverse Logistics, Green Sourcing, Transport Diversification, Green Packaging				

Source: Primary data (2026)

Table 4.14:ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	45.424	4	11.356	62.685	.000[b]
	Residual	17.210	95	.181		
	Total	62.634	99			

a. Dependent Variable: Net_Zero
b. Predictors: (Constant), Reverse Logistics, Green Sourcing, Transport Diversification, Green Packaging

Source: Primary data (2026)

Regression Coefficients

The regression coefficients provide insights into the individual contribution of each independent variable to the achievement of net-zero emissions. The results indicate that green sourcing has a positive and statistically significant effect on net-zero emissions ($\beta = 0.333$, $p < 0.001$). This suggests that improvements in sustainable procurement practices significantly enhance the likelihood of achieving net-zero emission targets.

Similarly, transport diversification has a positive and significant effect on net-zero emissions ($\beta = 0.308$, $p = 0.001$). This finding indicates that strategies such as fuel efficiency improvements, route optimization, and collaboration with low-emission logistics providers contribute significantly to emission reduction. Reverse logistics also shows a positive and statistically significant influence on net-zero emissions ($\beta = 0.168$, $p = 0.033$). This suggests that recycling initiatives, product recovery systems, and waste reduction programs contribute to improved environmental performance.

However, green packaging, although positively related to net-zero emissions, was not statistically significant ($\beta = 0.179$, $p = 0.073$) at the 0.05 significance level. This indicates that while environmentally friendly packaging practices contribute to sustainability efforts, their direct effect on achieving net-zero emissions are weaker compared to other supply chain practices.

Table 4.15: Beta coefficients

Coefficients[a]				
Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	-1.181	.413		-2.857	.005
	Green Sourcing	.542	.123	.333	4.404	.000
	Transport Diversification	.296	.086	.308	3.426	.001
	Green_Packaging	.244	.134	.179	1.814	.073
	Reverse Logistics	.175	.081	.168	2.159	.033
a. Dependent Variable: Net_Zero						

Source: Primary data (2026)

Based on the regression results, the model can be expressed as:

$$Net\ Zero = -1.181 + 0.542(GS) + 0.296(TD) + 0.244(GP) + 0.175(RL)$$

Where:

GS= Green Sourcing, TD=Transport Diversification, GP=Green Packaging and RL=Reverse Logistics

This equation indicates that a unit increase in green sourcing leads to the largest improvement in net-zero emissions performance, followed by transport diversification, green packaging, and reverse logistics.

4.6 Chapter Summary

This chapter presented the results of the study based on data collected from chemical manufacturing firms in Nairobi County. The chapter began by presenting the demographic characteristics of the respondents. Descriptive statistics, including means and standard deviations, were then used to summarize the level of implementation of the key supply chain diversification practices examined in the study, namely green sourcing, transport diversification, green packaging, and reverse logistics.

The chapter further presented the inferential statistical analysis used to examine the relationships between the independent variables and the dependent variable, net-zero emissions. Pearson correlation analysis revealed that all the supply chain diversification practices had positive and statistically significant relationships with the achievement of net-zero emissions. Multiple regression analysis was conducted to determine the combined and individual influence of the independent variables on net-zero emissions. The regression model indicated a strong explanatory power. The results further revealed that green sourcing, transport diversification, and reverse logistics had positive and statistically significant effects on the achievement of net-zero emissions. However, although green packaging showed a positive relationship with net-zero emissions, its effect was not statistically significant at the 0.05 level. Overall, the findings of the chapter demonstrate that Sustainable Supply Chain practices play a significant role in supporting the achievement of net-zero emissions within the chemical manufacturing sector. The results highlight the importance of adopting sustainable procurement, transportation, and reverse logistics practices to enhance environmental performance. The next chapter presents the discussion of the findings, conclusions, and recommendations of the study.

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the study findings, discussion of the results in relation to the research objectives, conclusions drawn from the findings, and recommendations for policy and practice within chemical manufacturing firms. The chapter also highlights limitations of the study and proposes areas for further research.

5.2 Discussion of Findings

The study involved respondents drawn from chemical manufacturing firms operating in Nairobi County. The gender distribution was relatively balanced, with 51% female and 49% male respondents, suggesting equitable representation of professionals involved in supply chain and sustainability management within the sector. The age distribution showed that the majority of respondents were between 36–45 years followed by those aged 25–35 years (40.8%), indicating that most participants were mid-career professionals with significant industry experience. In terms of education, the majority held bachelor's degrees, followed by diploma holders, while a smaller proportion possessed master's degrees. This suggests that most respondents had adequate academic training to understand supply chain sustainability practices.

Regarding organizational roles, respondents occupied diverse positions including supply chain managers, operations managers, sustainability officers, and other managerial roles, indicating that the data was obtained from individuals directly involved in operational and strategic supply chain decision-making. Most respondents also possessed significant work experience within the sector. The largest proportion had 6–10 years of experience, followed by 3–5 years, suggesting that participants had sufficient professional exposure to provide informed insights regarding sustainable supply chain practices. In terms of company size, the findings indicated that the sector is dominated by small and medium-sized enterprises (SMEs), with 35.8% employing 50–100 employees and employing fewer than 50 employees. This structure has implications for the financial and technological capacity of firms to implement sustainability initiatives.

5.2.1 Effect of green sourcing on greenhouse gas emissions reduction

The findings of this study indicate a high level of adoption of green sourcing practices among chemical manufacturing firms in Nairobi County. The descriptive statistics suggested that most firms actively integrate environmental considerations into their procurement processes. Respondents strongly agreed that their suppliers comply with environmental standards and that firms source materials from sustainable suppliers. However, the requirement for supplier environmental certification recorded relatively lower agreement, indicating variability in the enforcement of formal environmental certification requirements among firms.

The inferential results further demonstrated a strong positive and statistically significant relationship between green sourcing and net-zero emissions, indicating that firms adopting sustainable procurement practices are more likely to achieve their emission reduction goals. Regression analysis also confirmed that green sourcing has a positive and statistically significant influence on net-zero emissions. This suggests that improvements in sustainable procurement practices significantly enhance the likelihood of achieving net-zero emission targets within chemical manufacturing firms.

These findings are consistent with the empirical study conducted by Ivanov and Dolgui (2021), which examined the effects of green procurement on carbon emissions in European manufacturing industries. Their study found that green sourcing practices contributed to a 20% reduction in carbon emissions, primarily through the selection of environmentally responsible suppliers and the reduction of transportation-related emissions. Similarly, the results of the present study demonstrate that firms in Nairobi that integrate environmental considerations into procurement decisions are more likely to progress toward achieving net-zero emissions.

The findings also align with the work of Namdar and Sawhney (2018), who examined supply chain resilience under different sourcing strategies. Their research demonstrated that dual sourcing strategies involving environmentally responsible suppliers improved supply chain resilience and reduced operational risks. The study also highlighted that green supplier diversification reduced lead time variability and strengthened supply chain stability. In the context of chemical manufacturing firms in Nairobi, the strong adoption of green sourcing practices similarly indicates that firms recognize the dual benefits of sustainable sourcing in improving both environmental outcomes and supply chain reliability.

The results of this study further support the findings of Kiongera et al. (2021), who examined diversification strategies in Kenya's sugar manufacturing sector. Their study found that environmentally conscious sourcing practices improved supply chain efficiency and enhanced operational performance. In particular, the adoption of improved inputs and sustainable sourcing practices contributed to increased production efficiency while reducing environmental degradation. Similarly, the current study shows that firms that prioritize sustainable suppliers and environmentally friendly materials are better positioned to achieve net-zero emission objectives.

However, the findings contrast with those reported by Niehaus (2018), who examined sustainability practices among South African organizations. That study found relatively low adoption of green sourcing practices, with only a small proportion of companies explicitly referencing sustainable procurement strategies in their corporate reports. In comparison, the present study indicates significantly higher adoption of green sourcing practices among chemical manufacturing firms in Nairobi County. This difference may reflect increasing environmental awareness, regulatory pressure, and the growing emphasis on sustainability within global manufacturing supply chains.

The findings of this study reinforce the argument that green sourcing is a critical strategy for reducing environmental impact and achieving net-zero emissions. By prioritizing environmentally responsible suppliers, incorporating renewable or recyclable materials into procurement decisions, and considering carbon footprint reduction during sourcing processes, chemical manufacturing firms in Nairobi are increasingly aligning their supply chain practices with sustainability objectives.

5.2.2 Effect of Transport Diversification on Carbon Emission Levels

The findings of this study indicate that chemical manufacturing firms in Nairobi County have widely adopted transport diversification practices as part of their sustainability initiatives. The descriptive results indicated strong agreement among respondents that firms are implementing strategies to reduce transport-related emissions. Among the specific practices, collaboration with logistics partners who prioritize low-emission transportation was highly rated, suggesting that firms increasingly rely on environmentally responsible logistics providers. Fuel efficiency improvements were also widely reported, demonstrating that companies are investing in operational measures that reduce fuel consumption and improve environmental performance.

However, the slightly higher variability in responses indicates that the adoption of low-carbon transport technologies varies across firms, possibly due to differences in financial capacity, infrastructure availability, and operational scale. The correlation analysis further revealed a strong and positive relationship between transport diversification and net-zero emissions. This finding indicates that firms that adopt strategies such as low-carbon transportation systems, route optimization, and collaboration with environmentally responsible logistics partners are more likely to achieve their net-zero emission targets. The regression results also confirmed that transport diversification has a positive and statistically significant influence on net-zero emissions. This suggests that improvements in transport management and diversification strategies significantly contribute to emission reduction within chemical manufacturing supply chains.

These findings are consistent with the study by Nakase et al. (2021), which examined transport diversification strategies in Japanese urban transport systems. The study found that cities implementing multimodal transport networks reduced carbon emissions by 35% per person, demonstrating that diversified transportation systems can significantly lower environmental impact. Similarly, the results of the present study indicate that firms that diversify their transport systems and adopt low-emission logistics practices are more likely to improve their environmental performance and move toward net-zero emission targets. The findings also support the report by McKinsey & Company (2024), which analyzed logistics optimization and its impact on global carbon emissions. According to the report, logistics operations contribute approximately 7% of global greenhouse gas emissions, and strategies such as route optimization, multimodal transport, and fleet electrification can significantly reduce emissions. The report further indicated that route optimization can reduce fuel consumption by 20%–30%, while fleet electrification could reduce emissions by up to 50% if widely adopted by 2030. These findings reinforce the results of the present study, which show that firms that invest in fuel-efficient systems and collaborate with environmentally responsible logistics partners can significantly reduce transport-related emissions.

Similarly, the results of this study align with the findings of Robinson (2022), who examined supply chain sustainability strategies in North America. The study demonstrated that organizations adopting multimodal transportation systems reduced their transport emissions by 25% through the substitution of road transport with rail and sea transport. The research also found that the use of technologies such as Geographic Information Systems (GIS) and artificial intelligence for route optimization improved operational efficiency while reducing fuel consumption. These findings support the results of the present study, which indicate that route planning systems and delivery optimization tools play an important role in reducing emissions within logistics operations. The results are also consistent with the findings of Umutoni and Akumuntu (2024), who examined logistics management practices in Rwanda's energy sector. Their study found that effective transport management improves supply chain performance by enhancing delivery efficiency, reducing delivery times, and improving customer satisfaction. Efficient transportation systems also improved operational competitiveness by reducing costs and increasing service reliability. In the context of the current study, these findings suggest that transport diversification not only contributes to environmental sustainability but also improves operational efficiency and supply chain performance.

Additionally, the findings support the work of Samita et al. (2020), who examined transport management strategies in Kenyan manufacturing firms. Their study found that organizations that adopted effective transport strategies experienced improved procurement efficiency and reduced operational costs. The study concluded that strategic investments in transportation systems significantly improve supply chain performance. Similarly, the results of the present study indicate that transport diversification strategies such as route optimization, fuel efficiency improvements, and partnerships with environmentally responsible logistics providers contribute significantly to the achievement of net-zero emission targets. The findings of this study demonstrate that transport diversification is a critical component of sustainable supply chain management. By adopting low-carbon transportation systems, improving fuel efficiency, optimizing delivery routes, and collaborating with environmentally responsible logistics providers, chemical manufacturing firms in Nairobi County can significantly reduce transport-related emissions. These practices therefore play an important role in supporting the achievement of net-zero emissions within the manufacturing sector.

5.2.3 Influence of Green Packaging on Emission Reduction

The findings of this study indicate that chemical manufacturing firms in Nairobi County have significantly adopted green packaging practices as part of their sustainability initiatives. The descriptive results show that respondents generally agreed that their organizations are implementing environmentally friendly packaging solutions. The most prominent practice was packaging waste minimization, suggesting that firms are actively reducing packaging materials through lightweight and reusable designs. Respondents also reported that green packaging has led to cost savings, highlighting the economic benefits associated with sustainable packaging practices. In addition, customers were perceived to view the firms' packaging as eco-friendly, indicating that green packaging contributes positively to corporate reputation and customer satisfaction. Overall, these findings demonstrate that green packaging has increasingly become an integral component of sustainability strategies within the chemical manufacturing sector.

The correlation analysis indicates that green packaging has a strong positive relationship with net-zero emissions. This suggests that firms adopting recyclable or biodegradable packaging materials and implementing waste minimization strategies are more likely to reduce their environmental footprint and support emission reduction efforts. However, the regression results show that although green packaging has a positive effect on net-zero emissions, its influence is not statistically significant at conventional significance levels. This implies that while green packaging contributes to environmental sustainability, its direct impact on achieving net-zero emissions is weaker compared to other supply chain practices such as green sourcing and transport diversification. This may be because packaging improvements alone may not generate substantial emission reductions unless they are integrated with broader supply chain strategies, including sustainable sourcing and efficient transportation systems.

These findings partially support earlier studies that emphasize the role of green packaging in reducing environmental impacts. For instance, Mutinda (2021) found that the adoption of biodegradable and recyclable packaging materials helped Kenyan food processing firms reduce packaging waste and lower emissions associated with production processes. The study concluded that green packaging improves environmental sustainability by minimizing waste generation and reducing the energy required during packaging production. Similarly, the present study confirms that firms adopting environmentally friendly packaging practices contribute to sustainability goals, although the direct effect on achieving net-zero emissions may be limited when other supply chain practices are considered simultaneously.

The findings also align with the study conducted by Njeru (2020) on sustainable packaging adoption among manufacturing firms in Nairobi County. The study reported that companies implementing eco-friendly packaging technologies experienced reductions in emissions due to decreased material usage and minimized waste generation. These findings support the descriptive results of the current study, where firms indicated that green packaging practices such as recyclable materials and packaging waste reduction contribute to sustainability and operational efficiency.

Similarly, the results are consistent with the findings of Chandra and Kumar (2022), who analyzed the role of green packaging in reducing emissions in the Indian fast-moving consumer goods sector. Their study established that firms replacing conventional plastic packaging with biodegradable alternatives significantly reduced their carbon footprint and improved compliance with environmental regulations. The study further highlighted that sustainable packaging practices reduce energy consumption and environmental pollution during production and disposal processes.

The findings also support the work of Liu et al. (2023), which emphasized that packaging innovation can significantly reduce environmental impact through material substitution and supply chain redesign. Their systematic review showed that the adoption of lightweight and recyclable packaging materials can reduce emissions by up to 30 percent, particularly when integrated into broader supply chain sustainability strategies. This suggests that the environmental benefits of green packaging are maximized when packaging innovations are combined with other sustainability practices.

In addition, the results align with the findings of Mwikali and Ndolo (2022), who found a positive relationship between green packaging practices and carbon emission reduction among beverage manufacturers in Kenya. Their study revealed that firms that adopted returnable bottles and minimal packaging strategies reduced material waste and logistics-related emissions. The study concluded that sustainable packaging practices contribute to emission control and support environmental sustainability goals.

Overall, the findings of this study indicate that green packaging plays an important role in promoting environmental sustainability within chemical manufacturing firms. However, the regression results suggest that its direct contribution to achieving net-zero emissions is weaker compared to other supply chain strategies such as green sourcing and transport diversification. This implies that while green packaging is an essential sustainability practice, it is most effective when implemented alongside other environmentally responsible supply chain practices that directly influence emission reduction across the production and distribution processes.

5.2.4 Effect of Reverse Logistics on Emission Reduction

The findings of this study indicate that chemical manufacturing firms in Nairobi County have adopted reverse logistics practices as part of their sustainability initiatives. The descriptive results suggest that firms are actively engaging in product recovery, recycling, and waste reduction activities. The most prominent practice is the efficiency of reverse supply chains in managing returns and minimizing environmental impact, indicating that many firms have implemented systems that support environmentally responsible product returns. Firms also report cost savings from reverse logistics initiatives, demonstrating that reverse logistics not only contributes to environmental sustainability but also improves operational efficiency. However, the variation in responses suggests differences in the level of implementation across firms, with some organizations still developing structured return and recycling programs.

The correlation analysis shows that reverse logistics has a positive and significant relationship with net-zero emissions. This indicates that firms that implement product return systems, recycling initiatives, and waste recovery programs are more likely to reduce their environmental footprint and support emission reduction efforts. The regression analysis further confirms that reverse logistics has a positive and statistically significant effect on net-zero emissions. Although the magnitude of its effect is smaller compared to green sourcing and transport diversification, the results demonstrate that reverse logistics still plays an important role in improving environmental performance by reducing waste generation and supporting circular supply chain systems.

These findings support the study by Nyarega (2015), which examined the influence of reverse logistics practices on manufacturing firms in Kenya. The study found that practices such as material recycling, product remanufacturing, and waste reduction strategies improved operational performance while also supporting environmental sustainability. According to the study, reverse logistics contributes to emission reduction by reducing the need for raw material extraction, lowering energy consumption in production processes, and minimizing the amount of waste sent to landfills. Similarly, the findings of the present study show that firms that actively implement reverse logistics practices are better positioned to achieve net-zero emission objectives.

The findings also align with the work of Julianelli et al. (2020), who explored the relationship between reverse logistics and circular economy systems. Their study emphasized that reverse logistics is a critical mechanism for enabling circular supply chains because it allows products and materials to re-enter the value chain instead of being discarded. By recovering products for reuse, remanufacturing, or recycling, firms can reduce waste-related emissions and improve resource efficiency. This perspective supports the results of the current study, which show that reverse logistics initiatives help firms minimize environmental impact through improved waste management and resource recovery.

Similarly, the findings are consistent with the research conducted by Mumbi (2023) on sustainable supply chain management practices in Kenyan horticultural firms. The study reported that reverse logistics significantly contributed to improved environmental sustainability by enabling the reuse of packaging materials, reducing product spoilage, and improving end-of-life product management. These practices ultimately reduced waste generation and emissions associated with production and disposal processes. In the context of the current study, the adoption of similar reverse logistics practices among chemical manufacturing firms contributes to emission reduction and supports sustainability goals.

The findings are also supported by the study conducted by Ndumba and Barasa (2022), which examined circular supply chain practices among manufacturing firms in Nairobi County. Their research found that reverse logistics and other circular supply chain approaches significantly improved organizational performance by promoting material recovery, reducing waste disposal, and encouraging product redesigns that minimize environmental impact. The study further indicated that reverse logistics systems reduce landfill waste and improve recycling efficiency, thereby contributing to emission reduction across manufacturing supply chains.

Overall, the findings of this study demonstrate that reverse logistics is an important component of sustainable supply chain management in chemical manufacturing firms. By implementing product return systems, recycling initiatives, and waste recovery programs, firms are able to reduce landfill waste, improve resource efficiency, and support circular economy principles. Although the magnitude of its effect on net-zero emissions is smaller compared to other supply chain strategies, reverse logistics still plays a significant role in supporting emission reduction and improving environmental sustainability within the manufacturing sector.

5.3 Conclusion

The study sought to assess the effect of supply chain diversification on achieving net-zero emissions in chemical manufacturing firms in Nairobi, Kenya. The findings indicate that green supply chain practices are increasingly being adopted within the sector and collectively contribute to improved environmental performance, consistent with the Natural Resource-Based View (NRBV), which emphasizes that firm capabilities in pollution prevention, product stewardship, and sustainable development are critical drivers of competitive advantage and environmental sustainability. Green sourcing emerged as the most influential practice. Firms that prioritize environmentally responsible suppliers, integrate carbon footprint considerations into procurement, and enforce sustainable sourcing policies demonstrated significant improvements in emission reduction outcomes. This aligns with the NRBV proposition that upstream capability development, particularly through pollution prevention at the input stage, is a key pathway for reducing environmental impact. The results confirm that green sourcing represents a strategic capability that directly enhances net-zero emission performance.

Transport diversification also showed a strong positive relationship with net-zero emissions. Firms implementing low-carbon transport systems, route optimization, fuel efficiency improvements, and collaboration with environmentally responsible logistics providers achieved notable emission reductions. From an NRBV perspective, these practices reflect process-based pollution prevention capabilities that improve operational efficiency while simultaneously reducing environmental harm, thereby strengthening both environmental and strategic performance outcomes.

Reverse logistics was found to positively influence net-zero emissions. The adoption of product return systems, recycling initiatives, and waste recovery programs supports circular economy practices and enhances resource efficiency. In line with NRBV thinking, reverse logistics represents a product stewardship capability that extends environmental responsibility beyond production to the post-consumption stage. Although its effect is relatively smaller compared to green sourcing and transport diversification, it remains an important capability for closing material loops and reducing waste-related emissions. Green packaging is widely adopted, with firms implementing recyclable or biodegradable materials and packaging waste minimization strategies. While it shows a strong positive relationship with net-zero emissions, its direct effect is not statistically significant. Within the NRBV framework, this suggests that green packaging functions more effectively as a complementary product stewardship capability rather than a standalone driver of emission reduction. Its impact is maximized when integrated with broader upstream and downstream sustainability capabilities.

Overall, the study concludes that integrated green supply chain capabilities are essential for achieving net-zero emissions in chemical manufacturing firms. Consistent with the NRBV, firms that develop and coordinate pollution prevention, product stewardship, and sustainable development capabilities across sourcing, transport, packaging, and reverse logistics are better positioned to improve environmental performance. A holistic and capability-driven approach rather than isolated initiatives.

5.4 Recommendation

Based on the study findings, the study makes the following recommendations:

5.4.1 Recommendation for Practice

The findings of this study indicated that Sustainable Supply Chain practices play a significant role in supporting the achievement of net-zero emissions. In practice, firms in the chemical manufacturing sector need to adopt a more integrated approach to sustainability across their supply chains. This begins with strengthening green sourcing practices through deliberate supplier development initiatives such as training, sustainability audits, and long-term partnerships that enable suppliers to meet environmental standards consistently.

In addition, organizations should embed sustainability within their internal procurement systems by incorporating environmental performance indicators into supplier selection, contract evaluation, and employee performance appraisals. This ensures that green practices are not treated as optional but become part of routine operations and organizational culture.

The study also underscores the importance of transport diversification, suggesting that firms should invest in low-emission logistics solutions. This may involve adopting fuel-efficient or electric vehicles, optimizing distribution routes through technology, and partnering with environmentally responsible logistics providers. Similarly, firms should scale up the use of eco-friendly packaging materials while strengthening reverse logistics systems to facilitate recycling, reuse, and proper waste management. Collectively, these measures will enable firms to reduce their carbon footprint while enhancing operational efficiency.

5.4.2 Recommendations for Policy

The results of the study pointed to the need for a supportive policy and regulatory environment to accelerate the adoption of sustainable supply chain practices. Government and regulatory bodies have a critical role to play in creating incentives that encourage firms to invest in green technologies and processes. This can be achieved through tax reliefs, subsidies, and grants targeted at initiatives such as green sourcing, sustainable transportation, and eco-friendly packaging.

At the same time, there is a need to strengthen enforcement of environmental regulations to ensure compliance across the entire supply chain. Clear standards and consistent monitoring mechanisms will help align firm-level practices with national and global sustainability goals. The government can also support the development of enabling infrastructure, such as recycling facilities and clean energy systems, which are essential for the effective implementation of reverse logistics and low-emission transport systems.

Furthermore, fostering collaboration between industry players, research institutions, and development partners will be important in promoting innovation and knowledge sharing. Such partnerships can accelerate the diffusion of sustainable practices and technologies across the sector.

5.4.3 Recommendations for Academia

This study made a meaningful contribution to the body of knowledge on sustainable supply chain management by providing empirical evidence on the relationship between Sustainable Supply Chain practices and the achievement of net-zero emissions within the chemical manufacturing sector. The findings demonstrate that sustainability outcomes are more effectively realized when firms adopt an integrated approach that combines green sourcing, transport diversification, green packaging, and reverse logistics, rather than implementing these strategies in isolation.

Building on these findings, this study provides a foundation upon which future academic work can advance. Scholars are encouraged to adopt integrated and multi-dimensional frameworks when examining sustainable supply chain management, as opposed to focusing on isolated practices. This approach will enable a more comprehensive understanding of how different strategies interact to influence environmental performance.

Further, researchers should expand empirical investigations within developing economy contexts, particularly in Africa, where there remains limited evidence on sustainability transitions in industrial sectors. There is also a need for academics to refine and test theoretical models that incorporate multiple supply chain strategies, in order to better explain and predict sustainability outcomes across different operational environments.

5.5 Suggestions for Further Research

While this study provides important insights, several areas warrant further investigation. First, future research should expand the scope beyond the selected supply chain strategies to include other dimensions such as green manufacturing processes and product life cycle assessment. This would provide a more comprehensive understanding of sustainability across the entire value chain.

Second, future studies could adopt longitudinal research designs to examine how the implementation of green supply chain strategies evolves over time and to assess their long-term impact on both environmental and organizational performance. Such an approach would help establish causal relationships more effectively than cross-sectional studies.

Third, there is a need for comparative studies across different industries or geographical regions to determine whether the relationships observed in this study hold in other contexts. This would enhance the generalizability of the findings and contribute to cross-sectoral learning.

Finally, future research could explore the role of moderating and mediating variables such as firm size, technological capability, regulatory pressure, and organizational culture. Examining these factors would provide deeper insights into the conditions under which green supply chain practices are most effective.

5.5 Suggestions for further Research

This study focused primarily on selected aspects of green supply chain management, particularly in relation to green sourcing, packaging, transportation, and distribution. Future research could explore other components of the green supply chain such as green manufacturing and product life cycle assessment to gain a more comprehensive understanding of sustainable operations. In addition, comparative studies across different sectors or geographical regions could help determine whether similar factors influence the adoption of green supply chain practices in other contexts. Longitudinal studies could also be valuable in assessing how the implementation of green initiatives evolves over time and their long-term impacts on business performance and environmental outcomes.

5.6 Limitations of the Study

While the study offers valuable insights into green supply chain practices, it is not without limitations. First, the study relied on self-reported data from respondents, which may be subject to social desirability bias or inaccurate reporting. To mitigate this, the study ensured anonymity and confidentiality of responses, thereby reducing the likelihood of respondents providing socially desirable answers. In addition, respondents were drawn from relevant managerial positions with adequate knowledge of supply chain practices, which increased the reliability of the information provided. Second, the study was limited to a specific sector and region, which may restrict the generalizability of the findings to other industries or locations.

5.7 Chapter Summary

This chapter summarized the research findings, the discussion of findings and recommendations. The chapter also provides the limitations and recommendations for further research.

References

Ministry of Environment and Forestry. (2018). National Climate Change Action Plan (NCCAP).

Transport & Environment. (2023). *The role of transport in emissions in Africa: Challenges and Solutions.* Retrieved from https://www.transportenvironment.org

Akoth Okwako, J. (2018). Assessing Implementation of Energy Efficiency Practices and Industrial Energy Management: A Case Study of Kenyan Industries . *Master's thesis, PAUWES.*

Alharahsheh, H. H. (2020). A review of key paradigms: Positivism VS interpretivism. Global Academic . *Journal of Humanities and Social Sciences*, 39-43.

Altenburg, T. (2011). *Industrial policy in developing countries: overview and lessons from seven country cases (No. 4/2011). Discussion paper.*

Andaregie & Astatkie, T. (2021). Determinants of the adoption of green manufacturing practices by medium- and large-scale manufacturing industries in northern Ethiopia. *African Journal of Science, Technology, Innovation and Development, 14*(4). Retrieved from https://doi.org/10.1080/20421338.2021.1921898

Aragón-Correa & Sharma, S. (2003). A contingent resource-based view of proactive corporate environmental strategy. . *Academy of management review*, 71-88.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management, 17*(1), 99-120.

Bataille, C. G. (2020). Physical and policy pathways to net-zero emissions industry. . *Wiley Interdisciplinary Reviews: Climate Change*.

Blackhurst, J. D. (2011). An empirically derived framework of global supply resiliency. *Journal of business logistics*, 374-391.

Bor, J. K. (2021). Green supply chain management practices and performance of food and beverage processing sector in Kenya. *Doctoral dissertation, JKUAT-COHRED*.

CDP. (2024). Scope 3 upstream: Big challenges, Simple remedies. *Big Challenges, Simple Remedies*.

Chandra, R. &., & Kumar, S. (2022). Role of Green Packaging in Reducing Carbon Emissions in the FMCG Sector: Evidence from India. *Journal of Sustainable Supply Chains, 8*(3), 112-127.

Chin, T. A. (2020). Green purchasing practices and environmental performance. *International Journal of Supply Chain Management*.

Clark, L. A. (2019). Constructing validity: New developments in creating objective measuring instruments. . *Psychological assessment*, 1412.

Creswell, J. W. (2021). *A concise introduction to mixed methods research.* SAGE publications.

Darnall, N. J. (2008). Environmental management systems and green supply chain management: complements for sustainability?. *Business strategy and the environment*, 30-45.

Dechamps, P. (2023). The IEA World Energy Outlook 2022–a brief analysis and implications. *European Energy & Climate Journal*, 100-103.

Dharmayanti, N. I. (2023). Exploring sustainability management control system and eco-innovation matter sustainable financial performance: The role of supply chain management and digital adaptability in indonesian context. *Journal of Open Innovation: Technology, Market, and Complexity, 9*(3).

DHL. (2021). *Supply chain diversification and sustainability: Strategic imperatives for global firms.* DHL Logistics Report. Retrieved from https://www.dhl.com/content/dam/dhl/global/csi/documents/pdf/supply-chain-diversification-trend-report.pdf

Domenech, T. &.-W. (2019). Transition towards a resource efficient circular economy in Europe: policy lessons from the EU and the member states. . *Ecological Economics*, 7-19.

Donaldson & Preston, L. E. (1995). The stakeholder theory of the corporation: Concepts, evidence, and implications. *Academy of management Review*, 65-91.

Dun & Bradstreet. (2024). *Chemical Manufacturing Companies in Kenya*. Retrieved from https://www.dnb.com/business-directory/company-information.chemical_manufacturing.ke.html

Etikan, I. &. (2017). Sampling and sampling methods. *Biometrics & Biostatistics International Journal*.

European Commission. (2023). *Commission Staff Working Document.*

Food, & Wine. (2024). *Are glass juice bottles really the most sustainable option?* Retrieved from https://www.foodandwine.com/sustainable-packaging-glass-juice-bottles-8698395

Freeman, R. E. (1984). Strategic management: A stakeholder theory. *Journal of Management Studies*, 1-21.

Gabrielli, P., Rosa, L., Gazzani, M., Meys, R., Bardow, A., Mazzotti, M. &., & Sansavini, G. (2023). Net-zero emissions chemical industry in a world of limited resources. *One Earth*, 682-704.

Geissdoerfer, M. S. (2017). The Circular Economy–A new sustainability paradigm? *Journal of cleaner production, 143*, 757-768.

Global Carbon Budget . (2023). Data description paper. *the Creative Commons Attribution*.

Gray, N. M. (2021). Decarbonising ships, planes and trucks: An analysis of suitable low-carbon fuels for the maritime, aviation and haulage sectors. . *Advances in Applied Energy*.

Griffin, P. W. (2018). Industrial energy use and carbon emissions reduction in the chemicals sector: A UK perspective. . *Applied Energy*, 587-602.

Gualandris, J., & Kalchschmidt, M. (2016). Developing environmental and social performance: the role of suppliers' sustainability and buyer–supplier trust. *International Journal of Production Research*, 2470-2486.

Harrison, J. S. (2023). A configurational theory of generalized exchange in stakeholder-oriented firms. *Academy of Management Perspectives*, 16-36.

Hart & Dowell, G. (2011). Invited editorial: A natural-resource-based view of the firm: Fifteen years after. *Journal of management*, 1464-1479.

Hart, S. L. (1995). A natural-resource-based view of the firm. *Academy of management review, 20(4), 986-1014., 20*(4), 986-1014.

Heale, R., & Twycross, A. (2015). Validity and reliability in quantitative studies. Evidence-based nursing. *Evidence-based nursing*, 18(3), 66-67. Retrieved from Evidence Based Nursing: 10.1136/eb-2015-102129

Heliyon. (2024). *Green production, green technology, waste reduction, and energy efficiency: Implications for sustainability.* Retrieved from https://pmc.ncbi.nlm.nih.gov/articles/PMC10709062

IEA. (2022). *CO2 Emissions.* Retrieved from https://iea.blob.core.windows.net/assets/3c8fa115-35c4-4474-b237-1b00424c8844/CO2Emissionsin2022.pdf

IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability.

Ivanov & Dolgui, A. (2021). *A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. Production Planning & Control.*

Jayaram, K., & Kendall, A. (2021). *Africa's green manufacturing crossroads: Choices for a low-carbon industrial future.* McKinsey & Company. Retrieved from https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/africas%20green%20manufacturing%20crossroads/mck-gmr_full%20report_fa-2.pdf

Jensen, M. C. (2002). Value maximization, stakeholder theory, and the corporate objective function. *Business ethics quarterly*, 235-256.

Julianelli, V. C. (2020). Interplay between reverse logistics and circular economy: Critical success factors-based taxonomy and framework. *Resources, Conservation and Recycling*.

KAM, K. A. (2024). Retrieved from https://kam.co.ke/

Kanike, U. K. (2023). Factors disrupting supply chain management in manufacturing industries. *Journal of Supply Chain Management Science*, 1-24.

Kenya Association of Manufacturers. (2018). *Manufacturing in Kenya under Big 4 Agenda.* Nairobi.

Kiongera, N. &. (2021). A SUPPLY CHAIN PERFORMANCE FRAMEWORK FOR SUGAR MANUFACTURING FIRMS IN KENYA: A FOCUS. *trategic journals*, 68-80.

Kothari, C. R. (2004). *Research methodology: Methods and techniques.* New Age International.

Kumar, A. L.-R. (2023). Analysing the adoption barriers of low-carbon operations: A step forward for achieving net-zero emissions. *Resources Policy*, 80.

Kuteyi & Winkler, H. (2022). Logistics challenges in sub-Saharan Africa and opportunities for digitalization. *Sustainability*, 2399.

Lah, O. (2017). Decarbonizing the transportation sector: policy options, synergies, and institutions to deliver on a low-carbon stabilization pathway. *Wiley Interdisciplinary Reviews: Energy and Environment*.

Layzell, D. B. (2020). Building a transition pathway to a vibrant hydrogen economy in the Alberta Industrial Heartland. *Transition accelerator reports, 2(4), 1-59.*, 1-59.

Liu, Y., Zhang, M. &., & Chen, T. (2023). Green Packaging and Emission Reduction: A Systematic Review. *Journal of Cleaner Production*.

Lohr, S. L. (2021). *Sampling: design and analysis.* Chapman and Hall/CRC.

Lund, S. D. (2020). Risk, resilience, and rebalancing in global value chains.

Lusha. (2021). Chemical manufacturing companies in Nairobi. Retrieved from https://www.lusha.com/company-search/chemical-manufacturing/3b7d526ebc/kenya/124/

Macharia, K. K. (2023). Energy Efficiency and Substitution Possibilities in Kenya's Manufacturing Sector . *Doctoral dissertation, University of Nairobi*.

Maisiri, W. v. (2021). Factors that Inhibit Sustainable Adoption of Industry 4.0 in the South African Manufacturing Industry. *Sustainability*.

McKinsey, & Company, &. (2024). *Decarbonizing logistics: Charting the path ahead.* Elliott Tinnes. Retrieved from https://www.mckinsey.com/capabilities/operations/our-insights/decarbonizing-logistics-charting-the-path-ahead

Mishra, R., Singh, R., & Govindan, K. (2023). Net-zero economy research in the field of supply chain management: a systematic literature review and future research agenda. *The International Journal of Logistics Management*, 1352-1397.

Morcillo-Bellido, J. S.-I.-S. (2022). Circular Economy Analysis Applying Ellen MacArthur Model: Spanish Glass Sector Case. *In Ensuring Sustainability: New Challenges for Organizational Engineering*, 13-21.

Mugenda & Mugenda, A. G. (2003). *Research methods: Quantitative & qualitative apporaches.* Nairobi: Acts press.

Mumbi, K. M. (2023). Sustainable Supply Chain Management Practices and Performance of Horticultural Firms in Kenya. *Doctoral dissertation, JKUAT-COHRED*.

Mutinda, J. (2021). Effect of Green Packaging on Sustainability Performance in Food Processing Firms in Kenya.

Mwikali, M. &., & Ndolo, J. (2022). Green Packaging Strategies and Environmental Sustainability in the Beverage Sector in Kenya. *African Journal of Environmental Management, 6*(1), 24-35.

Nakase, R. C. (2021). Evaluating hierarchical diversity and sustainability of public transport: From metropolis to a weak transport demand area in western Japan . *Frontiers in Sustainable Cities*, 667-711.

Namdar, & Sawhney, R. &. (2018). Supply chain resilience for single and multiple sourcing in the presence of disruption risks. *International journal of production research*, 2339-2360.

Namdar, J. M. (2024). Diversify or Concentrate? Supply Chain Responses to Policy Uncertainty. *Journal of Supply Chain Management*.

Ndumba, & Barasa. (2022). Influence of Circular Supply Chain Practices on the Performance of Manufacturing Firms in Nairobi County, Kenya. *International Journal of Supply Chain Management*, 34-59.

NEMA, N. E. (2022). *Kenya's third national greenhouse gas inventory document (1990-2022).* Retrieved from https://ke.chm-cbd.net/documents/kenyas-third-national-greenhouse-gas-inventory-document-1990-2022

Nichita, E. M. (2021). Are reported greenhouse gas emissions influencing corporate financial performance. . *Journal of Accounting and Management Information Systems*, 585-606.

Niehaus, G. G.-G. (2018). Investigating supply chain sustainability in South African organisations. *Journal of Transport and Supply Chain Management*, 1-11.

Njeru, A. (2020). Adoption of Sustainable Packaging among Manufacturing Firms in Nairobi County, Kenya. Nairob.

Nwokolo, S. C. (2023). Africa's Path to Net-Zero. *CSR, Sustainability, Ethics & Governance.*

Nyarega, V. M. (2015). Reverse logistics and performance of government owned manufacturing firms in Kenya. *Master's dissertation, University of Nairobi*.

Omar, A. O. (2020). Effect Of Circular Economy Practices On supply Chain Performance Of Chemical And Allied Sector Firms In Kenya. *Master's dissertation*. University of Nairobi.

Patro, P. K. (2024). Blockchain, IoT, and AI-based framework for traceability in carbon capture utilization storage (CCUS) supply chain. *In Proceedings of the 2024 6th Blockchain and Internet of Things Conference*, (pp. 67-73).

Ponomarov & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. . *The international journal of logistics management,* , 124-143.

PwC. (2023). *PwC Net Zero Economy Index* .

Rassel, G. L. (2020). *Research methods for public administrators.* Routledge.

Reuters. (2024). *LNG-fuelled trucking accelerates in Asia, denting diesel demand.* Reuters. Retrieved from https://www.reuters.com/business/energy/lng-fuelled-trucking-accelerates-asia-denting-diesel-demand-2024-10-23

Robinson, C. (2022). Retrieved from https://www.chrobinson.com/en-us/technology/robinson-labs/supply-chain-sustainability/

Ronoh, I. J. (2020). Developing an eco-industrial park; structures and policies: a case study of the KenGen Green Energy Park, Kenya. *M. Sc. Thesis*.

Russo & Fouts, P. A. (1997). A resource-based perspective on corporate environmental performance and profitability. *Academy of management Journal*, 534-559.

Saha, S. S. (2020). Impact of Green Human Resource Management (GHRM) practices in garment industry: Bangladesh perspective. *International Journal of Management and Accounting*, 22-30.

Samita, M. N. (2020). Influence of transport management practices on procurement performance of manufacturing firms in Kenya. A case study of Butali Sugar Company Limited. *The Strategic Journal of Business & Change Management*.

Saunders, M. N. (2015). Understanding research philosophy and approaches to theory development.

Shafaei, A. N. (2020). Green human resource management: A two-study investigation of antecedents and outcomes. . *International Journal of Manpower*, 1041-1060.

Sidhu & Lyons, H. (2021). *Developing Greener Supply Chains.* London, UK: Industrial Strategy Council.

Steiner, B. M. (2023). Mapping the intellectual foundation of low-carbon supply chains: A theory-based literature review on buyer-supplier relationships. *Journal of Cleaner Production*.

Stern, N. &. (2021). Innovation, growth and the transition to net-zero emissions. *Research Policy*.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. Research in science education. *Springer*, 48, 1273-1296. Retrieved from Springer.

Tang, G. C. (2018). Green human resource management practices: scale development and validity. *Asia pacific journal of human resources*, 31-55.

Tanui, J. (2024). Effects of Covid 19 response policies on strategic government deliveries in agriculture and food security sector in Kenya: A case of Kisumu county. *Doctoral dissertation, Maseno university*.

Tien N & Thuc, T. D. (2019). Global supply chain and logistics management.

Tukamuhabwa, B. R. (2015). Supply chain resilience: definition, review and theoretical foundations for further study. *International journal of production research*, 5592-5623.

Umutoni, & Akumuntu, J. (2024). The Influence of Logistics Management Practices on Supply Chain Performance in Energy Sector in Rwanda: A Case of Engie Energy Access Rwanda. *Journal of Procurement & Supply Chain, 8*(2), 48–66. Retrieved from https://doi.org/10.53

UNEP, U. n. (2022). *Green and sustainable chemistry.* Retrieved from https://www.unep.org/topics/chemicals-and-pollution-action/circularity-sectors/green-and-sustainable-chemistry#:~:text=Minimize%20chemical%20release%20and%20pollution,chains%20throughout%20the%20life%20cycle.

United Nations. (2021). *Sustainable transport, sustainalbe development.* Retrieved from https://sdgs.un.org/sites/default/files/2021-10/Transportation%20Report%202021_FullReport_Digital.pdf

Vieira, L. C. (2021). Are the European manufacturing and energy sectors on track for achieving net-zero emissions in 2050? *An empirical analysis. Energy Policy*. Retrieved from https://doi.org/10.1016/j.enpol.2021.112464

Wang, X. &. (2020). Cross-sectional studies: strengths, weaknesses, and recommendations. *Chest*, 65-71.

World Bank. (2022). *Kenya Economic Update (KEU).* Retrieved from https://www.worldbank.org/en/country/kenya/publication/kenya-economic-update-keu

World Economic Forum. (2022). *7 leaders at Davos 2022 on securing sustainable, resilient supply chains, despite global shocks.* World Economic Forum. Retrieved from https://www.weforum.org/stories/2022/05/leaders-supply-chains-davos-2022/

World Economic Forum. (2023). *Annual Report 2022-2023.* Retrieved from https://www3.weforum.org/docs/WEF_Annual_Report_2022-23.pdf

World Resources Institute. (2015). *Power a sustainable future*. Retrieved from https://www.wri.org/top-outcomes/2015-top-outcomes

Yang, J. Z. (2022). The effects of supply chain diversification during the COVID-19 crisis. *International Journal of Operations & Production Management, 42*(1), 45-67.

Zhang & Wang, Z. A. (2022). Asymmetric linkages between renewable energy consumption, financial integration, and ecological sustainability: Moderating role of technology innovation and urbanization. *Renewable Energy*, 1233-1243.

Zhou, Y. M. (2011). Synergy, coordination costs, and diversification choices. *Strategic Management Journal*, 624-639.

Appendices

List of data Chemical manufacturing firms in Nairobi

1) A PLUS PVC Technology Company Limited
2) Alison Products (Kenya) Limited
3) Alkhemy Brands Limited
4) Amaris Chemical Solutions
5) Amiran Kenya Limited
6) Apex Piping Systems Limited
7) Arichem Limited
8) Asool Trading & Investment Limited
9) Associated Battery Manufacturers East Africa Limited
10) ADDix Limited
11) Afrochem Products Limited
12) Athi River Mining Chemicals Division
13) Balm Industries Limited
14) Basco Products (Kenya) Ltd
15) BASF East Africa Limited
16) Beta Healthcare International Limited
17) Benmed Pharmaceuticals Limited
18) Berger Paints Kenya Limited
19) Bidco Africa
20) BioCorn Products

21) Biomerieux Kenya Limited
22) Bimeda Limited
23) Blowpast Kenya Limited
24) BOC Kenya Plc
25) Canon Chemicals Limited
26) Carbacid Investments Limited
27) Chem-Labs Limited
28) Chem-Rectic Limited
29) Chloride Exide Kenya Limited
30) Chrysal Africa Ltd.
31) CKL Africa Limited
32) Cosmos Limited
33) Creative FCB
34) Crown Paints Kenya PLC
35) Crown Industries Limited (Chemicals Division)
36) Darling Company Limited
37) Deluxe Inks Limited
38) Detmax Limited Company
39) Dinlas Pharma (Africa) Limited
40) Dow Chemicals East Africa Limited
41) Dry Chills Limited
42) Eco Chemical Solutions Kenya Limited
43) East African Spectre Limited
44) Egypro Pharma (K) Limited
45) Elys Chemical Industries Limited
46) Faha Graphics Enterprises Limited
47) Fossilcote Limited
48) Galaxy Paints and Coatings Limited
49) Galaxy Pharmaceutical Limited
50) GlaxoSmithKline Limited
51) Glory Paints (Nasib Industrial Products Ltd)
52) Hachfeld Limited
53) Halar Industry Limited
54) Health Classique Limited

55) Henkel Chemicals Kenya Limited
56) Hi-Tech Inks and Coating Limited
57) Huntsman Tioxide (Africa) Limited
58) Industrial Chemical Supplies Limited
59) Insta Products Limited
60) Interconsumer Products Limited
61) Kamili Packers Limited
62) Kansai Plascon Kenya Limited
63) Karatasi Products Limited
64) Kapa Oil Refineries Limited
65) KEL Chemicals Ltd
66) Kenya Veterinary Vaccines Production Institute
67) Kenrom Chemicals Kenya Limited
68) Kenpoly Manufacturers Limited
69) Laboratory and Allied Limited
70) Liege Organics
71) Lubesol Kenya Limited
72) Macnaughton Limited
73) Magnate Ventures Limited
74) Maroo Polymers Ltd
75) Medecins Sans Frontieres Kenya Supply
76) Metro Plastics Kenya Limited
77) Mobimart Systems Limited
78) Muenzer Kenya Limited
79) Murphy Chemicals E.A. Limited
80) Nairobi Polymer Solutions Limited
81) Nemchem International (Kenya) Limited
82) Neuce Paints Kenya Limited
83) Norbrook Kenya Limited
84) Nova Industries Ltd
85) Odex Chemicals Limited
86) Omya East Africa Limited
87) Orbit Products Africa Limited
88) Orbit Chemical Industries Limited

89) Osho Chemical Industries Ltd
90) Packaging Industries Limited (PIL)
91) Pan Africa Chemicals Ltd
92) Panafrican Equipment (Kenya) Limited
93) Philmed Limited
94) Plastics & Rubber Industries Limited
95) Polychem East Africa Limited
96) Polyflex Industries Limited
97) Polysynthetics Eastern Africa Ltd
98) Polytank & Containers Limited
99) Print Parts Limited
100) Prime Chemical Industries Limited
101) Prodigy Healthcare Limited
102) Reckitt Benckiser East Africa Limited
103) Reckitt Benckiser Services (Kenya) Limited
104) Regal Pharmaceuticals Limited
105) Rokas Service Limited
106) Rootooba Limited
107) Royal Vintz Plastics Limited
108) Safepak Limited
109) Sana Hair Company Limited
110) Sea Link Medical Supplies
111) SEWECO Industrial Coatings Company Limited
112) Sika Kenya Limited
113) Silafrica Kenya Limited
114) Soilex Prosolve Ltd
115) Spectra Chemicals Kenya Limited
116) Sphinx Pharmaceuticals Limited
117) Stallion Manufacturers Limited
118) Synresins Limited
119) Syner-Med Pharmaceuticals (Kenya) Limited
120) Terramica Company Limited
121) The Paper House of Kenya Plc
122) Tri-Clover Industries Kenya Limited

123) Twiga Chemical Industries Limited

124) Umoja Rubber Products Ltd

125) Unilever Kenya Limited

126) Velocity Limited

127) Zahra Signs Limited

128) Zain Pharma Limited

129) Zami Chemicals Ltd.

130) Zeetah Healthcare Limited

Data collection tool

Supply Chain Diversification on Net-Zero Emissions in Chemical Manufacturing Firms.

I am a student at Strathmore University conducting a study to assess the impact of **supply chain diversification on net-zero emissions in chemical manufacturing firms**. Your participation in this study is entirely voluntary, and you may choose to withdraw at any time without providing a reason. The information you provide will be used solely for academic research and will be treated with the utmost confidentiality. Your identity will remain anonymous. If you have any questions or require further clarification, you may contact the investigator, **Ian Kiture, via** email at **ikithure@strathmore.edu .** You can also contact my supervisor, Dr. Farida Abdul at Strathmore Business School, Nairobi, via fabdul@srathmore.edu

If you want to ask someone independent anything about this research, please contact the Secretary-**Strathmore University Institutional Ethics Review Board**, P.O. Box 59857-002, Nairobi, or email ethicsreview@strahmore.edu or tel. 0703034375. By signing below, you acknowledge that you have understood the study details and that you voluntarily agree to participate.

	Tick where appropriate
I accept to participate in this survey	
I don't accept to participate in this survey	

SECTION A: Demographic Information

1. **Name of the institution (Optional) ……………………………………………………….**
2. **Gender**

   Male [ ] Female [ ]

3. **Age**
18-24 years [ ] 25-35 years [ ] 36-45 years [ ] 46 years and above [ ]

4. **What is your highest education level**
Secondary [ ] Diploma [ ] Bachelor's Degree [ ] Master's Degree [ ]

Other:……………………………………………………………………………………

5. **Which of the following tittle roles best describe your role**
Supply chain manager [ ] Operations managers [ ] Sustainability officers [ ]

Other: ……………………………………………………………………

6. **Years of Experience in the Chemical Manufacturing Industry**
Less than 2 years [ ]

3–5 years [ ]

6–10 years [ ]

More than 10 years [ ]

7. **Company Size (Number of Employees)**
Less than 50 [ ] 50–100 [ ] 101-250 [ ] More than 250 [ ]

Other: ………………………………………………………………………………………

SECTION B: SUPPLY CHAIN DIVERSIFICATION

8. **Green Sourcing**

Please indicate the extent to which you agree with the following statements. Scale: 1=Strongly disagree, 2=Disagree, 3= Neutral, 4=Agree, and 5= Strongly Agree.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
a) We source our materials from sustainable suppliers					
b) Our suppliers comply with environmental standards and regulations					
c) Our company prioritizes the use of renewable or recyclable materials					
d) We require suppliers to have environmental certifications					
e) Our procurement process considers carbon footprint reduction					

9. Please elaborate on your company's experience with green sourcing practices, what measures have been adopted, what challenges you face, and what factors influence these decisions?

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10. Transport Diversification

Please indicate the extent to which you agree with the following statements. Scale: 1=Strongly disagree, 2=Disagree, 3= Neutral, 4=Agree, and 5= Strongly Agree

	1=SD	2=D	3=N	4=A	5=SA
a) A significant percentage of our shipments use low-carbon transport					
b) We have implemented fuel efficiency improvements					
c) We have made efforts to reduce transport-related emissions e.g through investing in low carbon emission vehicles					
d) We use software or systems to plan delivery routes and consolidate shipments in order to reduce fuel consumption and emissions (e.g., GPS-based route planning, load optimization tools).					
e) We collaborate with logistics partners or third-party providers who prioritize low-emission transportation solutions (e.g., electric fleets, route efficiency, carbon offset programs).					

11. Please describe any specific strategies, tools, or partnerships your company has adopted to diversify transportation methods and reduce emissions

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12. Green Packaging

Please indicate the extent to which you agree with the following statements. Scale: 1=Strongly disagree, 2=Disagree, 3= Neutral, 4=Agree, and 5= Strongly Agree

	1=SD	2=D	3=N	4=A	5=SA
a) More than 50% of our packaging is biodegradable/recyclable					
b) We have implemented specific measures to minimize packaging waste (e.g., lightweight materials, reusable packaging)					
c) Our packaging practices comply with recognized sustainability standards such as those from the Kenya Bureau of Standards (e.g., KS 2921, KS EAS 996), NEMA regulations, or relevant international certifications like FSC or ISO 14001.					
d) Customers perceive our packaging as eco-friendly					
e) We have realized cost savings as a result of adopting green packaging practices					

13. Please describe your company's experience with adopting green packaging practices. Include the specific strategies used, any challenges faced, and the benefits or impact observed

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14. Reverse Logistics

Please indicate the extent to which you agree with the following statements. Scale: 1=Strongly disagree, 2=Disagree, 3= Neutral, 4=Agree, and 5= Strongly Agree

	1=SD	**2=D**	**3=N**	**4=A**	**5=SA**
a) Our company reclaims or recycles a significant percentage of returned or used products					
b) We have experienced cost savings as a result of reverse logistics initiatives (e.g., reuse, resale, recycling)					
c) Our customers actively participate in return, take-back, or recycling programs we provide					
d) Our reverse logistics efforts have led to a measurable reduction in waste sent to landfills					
e) Our reverse supply chain is efficient in managing returns and minimizing environmental impact					

15. Please describe how your company implements reverse logistics practices. Include any specific programs, challenges faced, and the outcomes or benefits experienced.

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SECTION C

16. Net-Zero Emissions Initiatives

Please indicate the extent to which you agree with the following statements. Scale: 1=Strongly disagree, 2=Disagree, 3=Neutral, 4=Agree, and 5= Strongly Agree

	1=SD	**2=D**	**3=N**	**4=A**	**5=SA**
a) Our company has set clear targets and actively monitors its carbon footprint					
b) We have adopted renewable energy sources such as solar, wind, hydropower, geothermal, or biomass					
c) We have implemented effective waste reduction strategies (e.g., recycling, resource)					
d) We incorporate sustainable logistics practices to reduce emissions across the supply chain					
e) We regularly monitor, document, and report progress toward our net-zero emissions goals					

17. What steps has your company taken to reduce carbon emissions and move toward net-zero?

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18. Do you have any additional comments or suggestions on achieving net-zero emissions in chemical manufacturing firms?

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Thank you for your participation