The Role of the Green Supply Chain in Achieving Clean Production: An Analytical Study in an Industrial Company

Azzam Abdulwahhab Abdulkareem Alsabbagh
Middle Technical University, Administrative Technical College - Baghdad

DOI:10.37648/ijtbm.v16i02.005

[1]*Received: 28 March 2026; Accepted: 26 Apr 2026; Published: 01 May 2026*

Abstract

The growing environmental awareness among Iraqi consumers and the resulting increase in demand for environmentally friendly products have prompted companies to adopt clean production policies and procedures. This requires supply chains that can handle this type of production. This research paper aims to examine the relationship between green supply chains and their impact on reducing pollution and preserving the environment through the adoption of clean production. The research adopted a descriptive -analytical approach, using a questionnaire as the data collection tool. The questionnaire was distributed to a sample of 225 employees at an Iraqi industrial company, and the responses were analyzed using SPSS and AMOS software.

The research concluded with several findings, including a strong positive relationship and tangible impact of green supply chains on clean production, both in general and through specific supply chain dimensions. Furthermore, achieving clean production requires adopting highly efficient supply chains that provide suitable inputs free from harm to users, workers, and the environment, while also enabling the recycling of production waste.

Keywords: *Green supply chain; clean production; green design; green procurement; green transportation; green marketing; green logistics.*

1. Introduction

The concept of the supply chain has evolved from the traditional model of material procurement, production, and distribution to the Green Supply Chain (GSC) model, which incorporates environmental responsibility due to the growing concern for environmental conservation and sustainability. This concern has intensified as consumers increasingly seek environmentally friendly and health-conscious products. Consequently, adopting a Green Supply Chain has become a competitive advantage for companies seeking to enter and survive in global markets (Sadiku et al., 2019). Supply chain management is a crucial component of any organization's operations, regardless of its type of activity, aiming for profitability and market survival. Effective supply chain management requires the application of all administrative functions—planning, organizing, and controlling—to ensure a successful, efficient, and effective supply chain (Suhardi, 2024). As a result of this growing focus and technological advancements in digital technologies and artificial intelligence, these tools have been integrated into supply chain operations, enabling the processing of massive amounts of data to reach more accurate decisions (Li and Zobel, 2020). This integration of artificial intelligence (AI) technologies has revolutionized traditional supply chain operations by enhancing efficiency, transparency, and decision-making capabilities. This integration is considered a key enabler of efficiency, resilience, and sustainability (Pal et al., 2025). With the introduction of AI tools into industry and the transition to Industry 4.0,

[1] *How to cite the article:* Alsabbagh A.A.A. (May 2026); The Role of the Green Supply Chain in Achieving Clean Production: An Analytical Study in an Industrial Company; *International Journal of Transformations in Business Management,* Vol 16, Issue 2, 49-68, DOI: http://doi.org/10.37648/ijtbm.v16i02.005

the need arose to make necessary changes to the supply chain to adapt and be more efficient and responsive in providing the inputs required by industry (Zhang et al., 2023). Despite all the benefits that AI tools and digital technologies offer to industry and the supply chain, there are many challenges to their adoption, including the high costs of using or adopting these technologies, as well as the skills and expertise required to operate them. However, many manufacturers are still turning to these technologies due to their significant ability to improve supply chain management efficiency (Fosso et al., 2022). Supply chain management (SCM) is considered a key factor in the success of organizations in their business environment, through its ability to build relationships with suppliers and facilitate the inspection, receipt, purchase and supply of materials with high quality, reducing costs (Phahlamohlaka, et al., 2025). Many factors clearly affect the operation of the supply chain, such as political stability, economic crises, and natural disasters (Tshuma et al., 2021). Additionally, the lack of highways, ports, and communication networks can weaken the supply chain's ability to meet its demands (Juma et al., 2022).

2. Literature Review

The supply chain has been the subject of numerous studies and analyses due to its crucial role in the success of industrial and service organizations. Emon (2025), in his study of the consumer goods sector in Bangladesh, analyzed the relationship between key factors affecting supply chain performance, namely flexibility, transparency, supplier collaboration, and technology. The study concluded that the responsiveness of the supply chain plays a critical role in enhancing the effectiveness of the main supply chain drivers in the companies studied within the sector. While Alhajri et al. (2025) focused their study on the system used by Walmart, which contributed to its leadership in its field through inventory management, demand forecasting, and supplier relationships, the study concluded that the system improved the timely exchange of data, increased the number of material suppliers, and facilitated integrated analysis of delivery schedules, all of which contributed to enhancing its competitive advantage. Lawry Okoumba (2025) aimed in his study to present an approach that helps companies adopt enabling factors to increase the resilience of their supply chains, such as supply chain vigilance, clarity, robustness, and speed, with the goal of enhancing their performance. The study concluded that speed, vigilance, and robustness have both positive and negative impacts on supply chain resilience. Boro et al. (2025) presented a comparative study of green supply chain practices in three different industries, assessing the effectiveness of adopting green practices in procurement, production, and logistics. The study found common challenges such as high costs and supply chain complexity, while best practices included supplier collaboration, technology integration, and circular economy principles. Another study examined the relationship between green supply chain management practices and senior management performance in India to understand its impact on low-carbon performance, sustainable manufacturing, and a sustainable society. The study sample consisted of 389 senior, middle, and junior managers working in bag manufacturing companies in India. The study found positive relationships between green product and product design and senior management performance, and that organizations make significant progress toward sustainability when senior management supports the adoption of globally recognized supply chain management practices and implements them effectively (Gupta et al., 2025). Tsikada et al. (2025) also studied the drivers, barriers, and sustainability implications of adopting green supply chain management among small and medium-sized enterprises (SMEs) in South Africa. Through an analysis of several studies, this research is theoretically grounded in the Triple Bottom Line (TBL) framework and the Diffusion of Innovation (DOI) theory. The study concludes that adopting green supply chain management can significantly improve environmental, economic, and social sustainability. However, several obstacles to its implementation exist. The study provides a theoretical framework to explain the relationship between the drivers of global supply chain management, the barriers to adoption, and sustainability outcomes. Nabila et al. (2025) identify how integrating green supply chain management with environmental management practices enhances the performance of environmental entrepreneurship and the interrelationships between these variables. Their contribution to the implementation of sustainable practices in small and medium-sized enterprises (SMEs) within the Indonesian tourism sector is also examined. The study concludes that implementing general supply chain management and environmental project management can improve environmental entrepreneurship performance, enhance operational efficiency, reduce negative environmental impacts, and improve process efficiency by developing environmentally friendly and sustainable business solutions. In their study, Kumar et al. (2025) presented strategic solutions to overcome the challenges faced by small and medium-sized enterprises (SMEs) in adopting green supply chains (GSCM), including financial constraints, technological barriers, and regulatory obstacles, and offered insights into how SMEs can better align with supply chain practices. Huang et al.

(2023) re-evaluated the success of Chinese companies in global value chains and their environmental impacts. The researchers provided empirical evidence on the role of ecosystems in coordinating environmental development and enhancing the position of Chinese companies in global value chains, which could help other developing countries successfully transition to a high-quality growth path.

On the other hand, the growing environmental awareness among consumers has led to a shift in demand from products that merely meet basic needs to products that meet needs while also protecting health and the environment. Consequently, clean production has become a crucial area of focus for organizations striving to achieve this in their production processes. A review of the literature reveals that researchers have addressed various aspects of clean production. For example, David et al. (2023), in their research on the pivotal role of clean production in achieving global water security, concluded that the potential of clean production strategies regarding wastewater supports water security. Similarly, Satyro et al. (2023) found that clean production addresses several challenges, including reducing waste and losses, minimizing emissions, optimizing resource utilization, adopting environmentally friendly product development methodologies, and reducing production costs through improved resource use, ultimately leading to increased profitability. Ospino et al. (2023), in their review of research papers examining the relationship between artificial intelligence (AI), clean production, and sustainable performance through a bibliometric analysis of 110 papers in the Scopus and Web of Science databases, concluded that there is a close relationship between AI, clean production, and sustainable performance. Santos et al. (2018), in their study on opportunities for cleaner production in the dairy industry, concluded that dairy industries are potential polluters due to their liquid and solid waste and gaseous emissions. Prigozhin et al. (2023) provided an overview of the main aspects of a cleaner production strategy as a preventative environmental strategy integrated with production processes to make them more efficient. They concluded that clean production is a strategy that can help reduce the environmental impact of various production systems and that there is a need for activities to promote its importance and make it known to various stakeholders, emphasizing the environmental, economic, and social benefits that its implementation can achieve. In their study, Kumar et al. (2024) aimed to identify the key aspects of developing cleaner production policies and to characterize the opportunities and constraints affecting the widespread adoption of cleaner production strategies in Sindh Province, Pakistan, as a representative sample for other regions with similar conditions. The researchers concluded that a supportive environment, rigid legislation, and ambiguous clauses that hinder the implementation of environmental initiatives are among the primary factors impeding the application of cleaner production.

Clean production is a preventative approach that reduces the negative environmental impact of production waste and product residues. Its main focus is identifying the source of waste and outflows to develop a program for reducing emissions and increasing resource productivity through the implementation and recording of clean production options (Satish et al., 2018). Clean production involves modifying existing technologies, processes, products, and work organization to reduce pollution sources and promote recycling for reuse (Santos et al., 2018). The United Nations Environment Program me (UNEP) defines clean production as “the continuous application of a preventive environmental strategy” to processes, products, and services to increase overall efficiency and reduce risks to people and the environment (Chia et al., 2021). Prigozhin et al. (2023) view clean production as an environmental management strategy that involves improving, modifying, or changing processes, products, and services. However, implementation should not be seen as an expense, but rather as an activity that, if its processes are properly designed, aims to increase efficiency and productivity while reducing costs. Proper implementation of clean production technologies enhances a company's image among customers, suppliers, stakeholders, and financial institutions.

2.1 Principles of Clean Production

Godakanda et al. (2023) presented five basic principles of clean production: replacing inputs with less hazardous operating, auxiliary, or raw materials; good management increases material and energy efficiency in the process; and reduces leakage and related losses. It is crucial to train employees to work efficiently, implement internal recycling of materials and energy loops for materials such as water and solvents, optimize technological processes/implement new technologies, enhance process control, redesign processes, modify or replace potentially hazardous processes, improve product lifespan, facilitate repair and recycling, and manufacture or use non-hazardous materials. Satish et al. (2018) define clean production as reducing the quantity and type of toxic waste delivered by minimizing the amount of materials, energy, and water used through substituting materials and resources with less harmful and less toxic alternatives, effective management, changing practices and tools for more efficient options, recovering useful materials from waste, and reprocessing energy, materials, and water. Despite all the benefits, obstacles still hinder the development of clean production, such as individuals' reluctance to change existing methods and practices, concerns that implementing clean production will be costly and require additional resources and processes, and individuals lacking the pathways and knowledge to implement clean production in their production line (Chia et al., 2021). The United Nations Environment Program me (UNEP) and the United Nations Industrial Development Organization (UNIDO) identified four industrial responses to pollution (UNIDO, 2004). The first is for industry to disregard all environmental consequences, leading to significant environmental damage. Secondly, pollution is "mitigated" when it becomes

2.2 Definition and Dimensions of Green Supply Chain Management

Supply chain management is defined as the ability to integrate suppliers, manufacturers, and distributors into a single process that designs, produces, and distributes products and services, delivering them to the customer with the best quality and at the lowest price, according to their preferences (Suhardi, 2024). Researchers have offered numerous and varied definitions of the green supply chain. It is defined as the integration of the concept of sustainable supply chain management with environmentally friendly aspects throughout the entire supply chain. This includes activities from the selection of raw materials to the delivery of the final product to the customer, with the aim of minimizing environmental impact (Gelmez et al., 2024). The application of sustainable supply chain management (GSCM) can include the use of environmentally friendly raw materials, waste management, and energy and water efficiency in business operating strategies (Gadgil, 2024). Green supply chain practices also encompass diverse activities such as waste management, environmental conservation activities, and participation in environmental programs (Sahoo et al., 2021). Green supply chain management (GSCM) is the management of material, information, and capital flows, as well as collaboration among companies along the supply chain, while achieving the goals of the three dimensions of sustainable development. GSCM practices include green procurement, reverse logistics, and stakeholder collaboration to minimize environmental impact while ensuring economic viability. Joshi (2022) defines it as an environmentally sound supply chain management approach to achieving sustainable development through resource conservation, waste reduction, and pollution prevention. (Kumar et al. 2025) view GSCM as a vital strategy for companies aiming to enhance environmental sustainability while improving operational efficiency. (Ikram et al. 2019) define a green supply chain as an interaction between different units that achieves substantial benefits for the three pillars of sustainability (economic, environmental, and social) and establishes a long-term partnership.

The researcher defines a green supply chain as the policies and procedures that an organization applies in all its production practices, as well as in its relationships with suppliers and their involvement in planning new products, ensuring the use of materials that do not harm workers, consumers, or the environment, and that do not lead to the depletion of limited resources.

. Researchers have not defined specific dimensions for the supply chain. Each researcher has defined the dimensions according to the angle from which they viewed the supply chain. However, the following dimensions are considered to be those agreed upon by most researchers and will be adopted in this study, as follows: (green design, green procurement, green transportation, green marketing, and green logistics)

These are the dimensions that most researchers agree upon and which will be adopted in this study, as follows

- Green Design: This involves developing a product in a way that minimizes its negative environmental impact during its operation and after its lifespan (Mensah et al., 2020).

- Green Procurement: This refers to processes that lead to environmentally friendly purchases that do not harm consumers' health, meet their needs, and ensure environmental protection throughout all stages of the procurement process (Foo et al., 2021).

- Green transport: This is a multifaceted approach to green transport that includes reducing environmental impacts, promoting sustainable planning, rationalizing resource consumption, using environmentally friendly practices, and integrating environmental considerations into transport planning to achieve comprehensive urban sustainability (bin Ali, et al., 2025).

- Green marketing: This is the process of developing, pricing, and promoting products that do not cause any harm to the natural environment (Assumpção, et al., 2019).

- Green logistics: This refers to sustainable practices and technologies adopted in the field of logistics services with the aim of reducing environmental impact. Key areas include transportation, warehousing, packaging, inventory management, enhancing resource efficiency, and meeting consumer demand for environmentally friendly products (Nagy, et al., 2024).

3. Study Methodology

3.1 Problem of the Study

The growing environmental awareness among consumers regarding the demand for environmentally friendly products, coupled with increasing pressure from governments concerning the use of natural resources, has led to a rise in the use of pollution prevention tools and technologies and a reduction in waste generation. Clean manufacturing is one of the most environmentally conscious types of manufacturing, while the supply chain is one of the most important issues that companies must address to achieve clean production. Iraqi industrial companies, like their counterparts worldwide, have moved towards clean production, but they still face difficulties in securing raw materials and the high costs associated with them, due to the lack of a suitable supply chain for their industries. This study aims to assist an Iraqi industrial company in demonstrating the importance of adopting a green supply chain in its operations. Therefore, the study problem is clarified through the following questions:

- Does the company under study follow a suitable supply chain?
- What is the impact of using a green supply chain on the production processes in the company under study?
- Do clean production processes improve by adopting a green supply chain?

3.2 Study Objectives

The specific objectives of this study are as follows

- To determine the relationship between a green supply chain and clean production in an industrial company.
- To study the relationship between the components of a green supply chain and clean production in an industrial company.

4. Study Hypotheses

4.1 The study hypotheses are divided into two main hypotheses, each with five sub-hypotheses, as follows

- The first main hypothesis: There is a statistically significant correlation between green supply chains and clean production.
- The second main hypothesis: There is a statistically significant effect between the green supply chain and clean production.

4.2 This main hypothesis branches into five sub-hypotheses as follows

- There is a statistically significant correlation between green design and clean production.

- There is a statistically significant correlation between green procurement and clean production.
- There is a statistically significant correlation between green transportation and clean production.
- There is a statistically significant correlation between green marketing and clean production.
- There is a statistically significant correlation between green logistics and clean production.

4.3 This main hypothesis branches into five sub-hypotheses as follows

- Green design has a statistically significant impact on clean production.
- Green purchasing has a statistically significant impact on clean production.
- Green transportation has a statistically significant impact on clean production.
- Green marketing has a statistically significant impact on clean production.
- Green logistics has a statistically significant impact on clean production.

5. Practical Aspect

This study examines one of the leading Iraqi industrial companies in the field of producing various electrical goods and devices, starting from huge generators and electrical power transformers, passing through cooling and air conditioning devices, and reaching household electrical appliances. For long periods, the company's sales topped the Iraqi markets and the markets of neighboring countries. However, in recent years, with the economic liberalization of Iraq, the company's sales have declined due to the difficulty of the company keeping pace with the rapid changes in global markets, due to the obsolescence of the technology used. The company is currently working on reassessing its situation and improving product quality from the design stage to the marketing stage in order to satisfy the customer and meet the competition, in addition to seeking to obtain manufacturing and commercial licenses from reputable international companies in the form of investment and partnership.

Adopting clean production is considered one of the ways and methods by which the company can compete with other companies due to the shift in consumer tastes through their search for green products that do not harm the environment and preserve consumer health. To collect the necessary data, 225 questionnaire forms were distributed to the company's employees in the study sample, which numbered 750 employees, and 216 valid forms were returned for measurement.

5.1 Face Validity Test for the Study Measures

The measures used to determine their apparent validity were tested, as the questionnaire was presented to (12) reviewers who were manufacturing experts and professors with relevant experience. The reviewers provided several observations, which were taken into account and the questionnaire was revised accordingly. The questionnaire was then distributed to the study sample.

5.2 Reliability Testing

To assess the reliability and soundness of the questionnaire, and to ensure that responses to its items do not change with different respondents, Cronbach's alpha coefficient was calculated. Table (1) shows the Cronbach's alpha coefficient for the research variables. The test results for the green supply chain ranged between 0.990 for green marketing (high reliability) to 0.976 for green transportation (low reliability). For clean production, the score ranged from 0.983 for recycling (high reliability) to 0.974 for green processes (low reliability). The table shows the results of Cronbach's alpha for the study variables.

Table (1) Cronbach's test results for the study sample data

The variable	Distance	Cronbach's Alpha	Items
Green supply chain	Green design	0.986	6
	Green procurement	0.987	6
	Green transportation	0.976	6
	Green marketing	0.990	6
	Green logistics	0.987	6
Clean production	Reducing material consumption	0.976	5
	Recycling	0.983	5
	Buybacking	0.976	5
	Green operations	0.974	5
	Environmental management	0.976	5

The table was prepared using results from SPSS version 28

5.3 Normality Testing

The normality test was conducted to ascertain the data distribution pattern and determine the optimal statistical method for analysis (parametric or non-parametric). Both kurtosis and skewness tests were performed, using the standard normal Z-distribution value (±1.96) as the criterion for accepting the hypothesis that the data are normally distributed. The results of the kurtosis test showed that the calculated Z-value for both variables exceeded the standard Z-value (±1.96) at a significance level of 0.05, indicating that the variables do not follow a normal distribution. Therefore, non-parametric tests will be used. Table 2 shows the test results for the study sample variables.

Results of the kurtosis and Skewness test for the study sample data Tablet (2)

The variable	Distance	Skewness		Z Skewness	Kurtosis		Z Kurtosis
		Statistic	Std. Error		Statistic	Std. Error	
Green supply chain	Green design	-0.632	0.068	-9.305	-0.077	0.136	-0.567
	Green procurement	-0.618	0.068	-9.094	-0.054	0.136	-0.401
	Green transportation	-0.863	0.068	-12.691	-0.199	0.136	-1.466

	Green marketing	-0.496	0.068	-7.299	-0.427	0.136	-3.143
	Green logistics	-0.635	0.068	-9.338	-0.005	0.136	-0.037
Clean production	Reducing material consumption	-0.274	0.074	-3.678	-1.187	0.149	-7.984
	Recycling	-0.555	0.074	-7.452	-0.55	0.149	-3.7
	Buy backing	-0.435	0.074	-5.846	-0.56	0.149	-3.763
	Green operations	-0.545	0.074	-7.319	-0.471	0.149	-3.169
	Environmental management	-0.442	0.074	-5.938	-0.569	0.149	-3.823

The table was prepared using results from SPSS version 28

6. Analysis of the Study Sample's Responses

The results of the study sample's responses regarding the two variables, green supply chain and clean production, and their dimensions, will be presented in terms of the arithmetic mean, standard deviation, coefficient of variation, and direction of the responses.

6.1 Study Sample's Responses on the Green Supply Chain

- **Table (3) shows the results of the study sample's responses regarding the green supply chain.**

Table (3)Statistical indicators for the green supply chain variable

Distance	Paragraph sequence	Paragraph symbol	Mean	Std. Deviation	Difference Coefficient	Arrangement of paragraphs
Green design	1	G.D1	3.968	0.907	22.85	1
	2	G.D2	3.63	1.062	29.25	5
	3	G.D3	3.801	1.026	27	2
	4	G.D4	3.648	1.028	28.18	4
	5	G.D5	3.574	0.971	27.17	6
	6	G.D6	3.792	0.968	25.54	3
	Total average		3.735	1.002	26.83	
Green procurement	7	G.P1	3.523	1.141	32.38	6
	8	G.P2	3.69	1.003	27.18	3

	9	G.P3	3.861	0.993	25.71	1
	10	G.P4	3.657	0.947	25.88	4
	11	G.P5	3.806	0.925	24.3	2
	12	G.P6	3.593	1.158	32.22	5
	Total average		3.688	1.036	28.09	
Green transportation	13	G.T1	4.051	1.026	25.33	2
	14	G.T2	3.977	1.067	26.84	6
	15	G.T3	4.273	1.05	24.56	1
	16	G.T4	3.995	0.952	23.84	4
	17	G.T5	3.991	1.012	25.35	5
	18	G.T6	4.032	1.106	27.42	3
	Total average		4.053	1.04	25.65	
Green marketing	19	G.M1	3.736	1.016	27.2	2
	20	G.M2	3.87	1.026	26.51	1
	21	G.M3	3.616	0.996	27.53	3
	22	G.M4	3.597	1.039	28.87	4
	23	G.M5	3.579	1.054	29.44	5
	24	G.M6	3.736	1.016	27.2	2
	Total average		3.689	1.028	27.86	
Green logistics	25	G.L1	3.87	1.026	26.51	2
	26	G.L2	3.694	1.078	29.18	4
	27	G.L3	3.699	0.919	24.83	3
	28	G.L4	3.69	1.048	28.41	5
	29	G.L5	3.681	0.967	26.27	6
	30	G.L6	3.898	0.889	22.79	1
	Total average		3.755	0.992	26.43	

Table prepared by the researcher based on SPSS V.24 results

The tab Green Design Dimension: The table shows that the arithmetic mean for this dimension is (3.735), which is at a good level, and its standard deviation is (1.002), while the coefficient of variation for this dimension reached (26.83). As for the items, item (1) achieved the highest arithmetic mean, which reached (3.968), which is at a good level, and its standard deviation was (0.907), while the coefficient of variation was (22.85), which means that the company, when designing its products, strives to make the design easy to manufacture and at the lowest cost. Item (5) achieved the lowest arithmetic mean, which reached (3.574), which is at a good level, and its standard deviation was (0.971), while the coefficient of variation was (27.17), which indicates that the company, when designing its products, does not pay attention to the fact that the raw materials from which those products will be manufactured are not harmful to the environment

- **Green Procurement:** The table shows that the arithmetic mean for this dimension is (3.688), which is at a good level, and its standard deviation is (1.036), while the coefficient of variation for this dimension is (28.09). At the item level, item (9) achieved the highest arithmetic mean, which reached (3.861), which is at a good level, and its standard deviation was (0.993), while the coefficient of variation was (25.71), which means that the company purchases environmentally friendly raw materials. Item (7) achieved the lowest arithmetic mean, which reached (3.523), which is at a good level, and its standard deviation was (1.141), while the coefficient of variation was (32.38), which means that the company does not communicate with various suppliers to reach procurement processes that ensure environmental safety.

- Green Transportation: The table shows that the arithmetic mean for this dimension is (4.053), which is at a good level, and its standard deviation is (1.040), while the coefficient of variation for this dimension is (25.65). At the item level, item (15) achieved the highest arithmetic mean, which reached (4.273), also at a good level, with a standard deviation of (1.050) and a coefficient of variation of (24.56), indicating the company's focus on safety as a key factor in the transportation and handling of materials. Item (14) achieved the lowest arithmetic mean, which reached (3.977), also at a good level, with a standard deviation of (1.067) and a coefficient of variation of (26.84), which means that the company uses environmentally friendly transportation methods.

- **Green Marketing:** The table shows that the arithmetic mean for this dimension is (3.689), which is at a good level, and its standard deviation is (1.028), while the coefficient of variation for this dimension is (27.86). At the item level, item (20) achieved the highest arithmetic mean, which reached (3.870), also at a good level, with a standard deviation of (1.026) and a coefficient of variation of (26.51). This indicates that green marketing represents a marketing opportunity that gives the organization the chance to achieve profits in the long term. Item (23) achieved the lowest arithmetic mean, which reached (3.579), also at a good level, with a standard deviation of (1.054) and a coefficient of variation of (29.44). The company does not provide a detailed, accurate, and credible explanation of its environmentally friendly products.

- **Green Logistics Dimension:** The table shows that the arithmetic mean for this dimension is (3.755), which is at a good level, and its standard deviation is (0.992), while the coefficient of variation for this dimension is (26.43). At the item level, item (30) achieved the highest arithmetic mean, which reached (3.898), also at a good level, with a standard deviation of (0.889) and a coefficient of variation of (22.79), indicating that the company returns its defective products to improve its image with its customers. Item (29) achieved the lowest arithmetic mean, which reached (3.681), also at a good level, with a standard deviation of (0.976) and a coefficient of variation of (26.27), which means that the company does not follow a clear system for product returns policy.

6.2 Responses of the study sample regarding clean production

Table (4) shows the results of the study sample's responses regarding clean production.

(Table-4) Mean, Standard Deviation and Coefficient of Variance for the Clean Production Variable

Distance	Paragraph sequence	Paragraph symbol	Mean	Std. Deviation	Difference Coefficient	Arrangement of paragraphs
Reducing material consumption	1	RMD1	4.167	0.863	20.7	1
	2	RMD2	4.102	0.983	23.97	2
	3	RMD3	3.519	0.988	28.08	3
	4	RMD4	4.074	1	24.53	4
	5	RMD5	3.495	0.998	28.54	5
	Total		3.871	1.011	26.12	
Recycling	6	REC1	3.87	0.984	25.44	3
	7	REC2	3.995	0.923	23.09	1
	8	REC3	3.412	1.312	38.46	4
	9	REC4	3.954	0.992	25.09	2
	10	REC5	3.278	1.192	36.36	5
	Total		3.702	1.128	30.48	
Repurcaseh	11	REP1	4.046	0.828	20.47	2
	12	REP2	4.13	0.89	21.56	1
	13	REP3	3.574	0.981	27.44	4
	14	REP4	3.222	1.215	37.7	5
	15	REP5	3.588	0.989	27.57	3
	Total		3.712	1.043	28.09	
Green Operations	16	GO1	2.995	1.135	37.89	5
	17	GO2	3.565	0.887	24.88	4
	18	GO3	4.167	0.857	20.57	1

	19	GO4	4.106	0.911	22.19	2
	20	GO5	4.014	0.947	23.6	3
	Total		3.769	1.048	27.81	
Environmental Management	21	EM1	3.264	1.283	39.31	5
	22	EM2	3.519	0.905	25.71	3
	23	EM3	3.412	1.232	36.11	4
	24	EM4	3.843	1.022	26.6	2
	25	EM5	3.884	0.874	22.49	1
	Total		3.584	1.101	30.72	

Table prepared by the researcher based on SPSS V.24 results.

6.3 The table shows

- Reduction: The table shows that the arithmetic mean for this dimension is (3.871), which is at a good level, and its standard deviation is (1.011), while the coefficient of variation for this dimension is (26.12). As for the items, item (1) achieved the highest arithmetic mean, which reached (4.167), which is at a good level, and its standard deviation was (0.863), while the coefficient of variation was (20.70). This means that the company has high efficiency in using raw materials, monitors energy and water consumption, and reduces the negative effects of use. Item (5) achieved the lowest arithmetic mean, which reached (3.495), which is at a good level, and its standard deviation was (0.998), while the coefficient of variation was (28.54), which indicates that the company does not work to reduce the possibility of its employees being exposed to hazardous materials by providing adequate training for employees.

- Recycling: The table shows that the arithmetic mean for this dimension is (3.702), which is at a good level, and its standard deviation is (1.128), while the coefficient of variation for this dimension is (30.48). At the item level, item (7) achieved the highest arithmetic mean, which reached (3.995), which is at a good level, and its standard deviation was (0.923), while the coefficient of variation was (23.09), which indicates that the company works to reduce waste and emissions through recycling programs and reverse logistics, and that the company has an effective system for treating hazardous waste. Item (10) achieved the lowest arithmetic mean, which reached (3.287), which is at a good level, and its standard deviation was (1.192), while the coefficient of variation was (36.36), which indicates that the company does not use recycled materials when designing a new product.

- Repurchase: The table shows that the arithmetic mean for this dimension is (3.712), which is at a good level, and its standard deviation is (1.043), while the coefficient of variation for this dimension is (28.09). At the item level, item (12) achieved the highest arithmetic mean, which reached (4.130), which is at a good level, and its standard deviation was (0.890), while the coefficient of variation was (21.56). This indicates that the company purchases recycled goods and reusable products, which can help reduce negative impacts. Item (14) achieved the lowest arithmetic mean, which reached (3.222), which is at a good level, and its standard deviation was (1.215), while the coefficient of variation was (37.70), which indicates a lack of awareness and understanding among the company's employees regarding the importance of reselling and distributing products.

- Green Processes: The table shows that the mean for this dimension is (3.769), which is at a good level, with a standard deviation of (1.048) and a coefficient of variation of (27.81). At the item level, item (18) achieved the highest mean, which was (4.167), also at a good level, with a standard deviation of (0.857) and a coefficient of variation of (20.57). This indicates that the company uses several processes to treat volatile pollutants during production. Item (16) achieved the lowest mean, which was (2.995), also at a good level, with a standard deviation of (1.135) and a coefficient of variation of (37.89). This means that the factory does not recycle many of the materials that were previously used as inputs for producing the new product.

- Environmental Management: The table shows that the mean score for this dimension is (3.584), which is considered good, with a standard deviation of (1.101) and a coefficient of variation of (3.072). At the item level, item (25) achieved the highest mean score of (3.884), also considered good, with a standard deviation of (0.874) and a coefficient of variation of (22.49). This indicates that the company complies with environmental regulations, which are based on the necessity of preserving the environment and its resources.

- Conversely, item (21) achieved the lowest mean score of (3.264), also considered good, with a standard deviation of (1.283) and a coefficient of variation of (39.31). The responses reflect the company's lack of commitment to implementing ISO 14000 environmental management standards.

6.4 Testing the Study Hypotheses

First, to assess the nature of the relationship between the study variables and whether a correlation existed, Pearson's correlation coefficient was calculated to quantify the degree and direction of the correlation. The correlation value according to this coefficient ranges between (+1) and (-1), and the table shows the distribution of correlation strength.

Table (5) Correlation Coefficient Values

0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
No correlation	Correlation Acceptable			Moderate Correlation			Strong Correlation			Corral Perfect
0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8	-0.9	-1

Source: Daney, C.P,& Reidy,J.(2017).Statisties without maths for psychology (7th.ed), Harlow, Pearson , prentice Hall ,p128

6.5 Testing the first hypothesis

Table (6) shows the correlation values between the independent variable, the green supply chain and its di mensions, and the dependent variable, green production.

Table (6) Results of the test of the relationship between the green supply chain and the dimensions of green production, individually and collectively

The dependent variable	Independent variable / Green supply chain	Green design	green procurement	green transportation	green marketing	green logistics	total
Clean production	R	.864**	.812**	.812**	.878**	.857**	.826**
	Sig	0	0	0	0	0	0
	Z	12.669	11.906	11.906	12.874	12.566	12.46
	Connotation	Moral	Moral	Moral	Moral	Moral	Moral
	Strong, positive correlation	Strong, positive correlation	Strong, positive correlation	Strong, positive correlation	Strong, positive correlation	Strong, positive correlatio n	Strong, positive correlati on

Table prepared by the researcher based on SPSS V.24 results

Table (6) shows a strong correlation between green supply chains and clean production, with a correlation coefficient of (0.826**) at a significance level of (0.000), which is less than the significance level of (0.05). At the same time, the extracted Z-value was (12.460), which is greater than the tabulated Z-value (1.96), indicating the significance of the correlation. Therefore, the first main hypothesis is accepted. Which is based on (there is a statistically significant correlation between the green supply chain as a whole and clean production with its dimensions). This correlation indicates that the company adopts the dimensions of the green supply chain and employs them in order to achieve clean production.

- The correlation coefficient between green design and clean production was (0.864**) at a significance level of (0.000), which is less than the significance level of (0.05) and is considered strong. The extracted Z-value was (12.669), which is greater than the critical Z-value of (1.96), indicating a significant correlation. Therefore, the first sub-hypothesis is accepted, which states that there is a statistically significant correlation between green design and clean production in its various dimensions. This correlation indicates that the company collaborates with suppliers to achieve a clean product, starting from the product design stage.

- The correlation coefficient between green procurement and clean production was (0.812**) at a significance level of (0.000), which is less than the significance level of (0.05) and is considered strong. The extracted Z-value was (11.906), which is greater than the critical Z-value of (1.96), indicating a significant correlation. Therefore, the second sub-hypothesis is accepted, which states that there is a statistically significant correlation between green procurement and clean production in its various dimensions. This correlation indicates that the company is working to provide healthy materials that do not pollute the environment and can be reused for use in manufacturing its products.

- The correlation coefficient between green transportation and clean production was (0.812**) at a significance level of (0.000), which is less than the significance level of (0.05) and is considered strong. The extracted Z-value was (11.906), which is greater than the critical Z-value of (1.96), indicating a significant correlation. Therefore, the third sub-hypothesis is accepted, which states that there is a statistically significant correlation between green transportation and clean production in its various dimensions. This correlation indicates that the company uses environmentally friendly transportation methods to reduce pollution and minimize potential harm to workers, and that clean transportation is essential for maintaining clean production.

- The correlation coefficient between green marketing and clean production was (0.878**) at a significance level of (0.000), which is less than the significance level of (0.05) and is considered strong. The extracted Z-value was (12.874), which is greater than the critical Z-value of (1.96), indicating the significance of the correlation. Therefore, the fourth sub-hypothesis is accepted, which is based on the following: (There is a statistically significant correlation between green marketing and clean production in its dimensions). This correlation indicates that the company is keen to ensure that the marketing of its products, in terms of packaging, advertising, and promotion, does not affect the environment and that there are no wastes that could harm the environment.

- The correlation coefficient between green logistics and clean production reached a value of (0.857**) at a significance level of (0.000), which is less than the significance level of (0.05) and is considered strong. The extracted Z-value was (12.566), which is greater than the critical Z-value of (1.96), indicating the significance of the correlation. Therefore, the fifth sub-hypothesis is accepted, which states that there is a statistically significant correlation between green logistics and clean production in its dimensions. This correlation reflects the company's commitment to providing all production requirements using environmentally friendly materials and equipment that does not contribute to environmental pollution.

6.6 Testing the Second Main Hypothesis and its Sub-Hypotheses

The second main hypothesis and its sub-hypotheses will be tested using a simple linear regression model to determine the impact of green supply chain dimensions on clean production.

Table (7) shows the statistical indicators for analyzing the impact of green supply chain dimensions on clean production.

Table (7) Statistical indicators for analyzing the impact of green supply chain dimensions on clean production

The dependent variable	The independent variable: the green supply chain and its dimensions			t	Adjusted R Square	R Square	F Change	sig
Clean production	Green Design	(α)	0.631	11.596	0.746	0.746	3798.678	0
		(β)	0.867	61.633				
	Green Procurement	(α)	0.963	15.943	0.659	0.659	2498.919	0
		(β)	0.788	49.989				
	Green Transportation	(α)	0.685	10.423	0.659	0.659	2502.971	0
		(β)	0.786	50.03				

	Green Marketing	(α)	0.699	14.014	0.771	0.771	4359.474	0
		(β)	0.86	66.026				
	Green Logistics	(α)	0.608	10.775	0.734	0.734	3572.923	0
		(β)	0.869	59.774				
	Green Supply Chain	(α)	0.491	15.746	0.682	0.682	11589.9	0
		(β)	0.853	107.656				

The table was prepared by the research team based on the results of SPSS V.24

Reviewing Table (7) above reveals that the calculated F-value reached (11589.903), which is higher than the tabulated F-value of (3.94) at a significance level of (0.05). This confirms the third main hypothesis, which states that there is a statistically significant relationship between the green supply chain and clean production.

This means that adopting the green supply chain, with its dimensions of green design, green transportation, green marketing, green procurement, and green logistics, has significantly contributed to improving the company's operations towards cleaner production. Furthermore, the results of the t-test for the regression coefficient (β) for the green supply chain variable showed a value of (107.656), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that the green supply chain has a significant effect in explaining the change in the level of clean production. The marginal slope (β) also reflects a positive effect, as each one-unit increase in the level of the green supply chain leads to an 85% increase in clean production. The corrected coefficient of determination (Adj R^2) shows that the analysis model explains 57% of the changes in the level of clean production.

The results regarding the impact of green design on clean production indicate that the calculated F-value reached 3798.678, which is higher than the tabulated F-value of 3.94 at a significance level of 0.05. This supports the first sub-hypothesis, which states that there is a statistically significant relationship between green design and clean production. This means that green design significantly contributes to the adoption and achievement of clean production. Furthermore, the results of the t-test for the regression coefficient (β) for the green supply chain variable showed a value of (61.633), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that green design has a significant effect in explaining the change in the level of clean production. The marginal slope (β) also reflects a positive effect, as each one-unit increase in the level of green design leads to an 86% increase in clean production. The corrected coefficient of determination (Adj R^2) shows that the analysis model explains 64% of the changes in the level of clean production.

The results regarding the impact of green procurement and clean production indicate that the calculated F-value reached 2498.919, which is higher than the tabulated F-value of 3.94 at a significance level of 0.05. This supports the second sub-hypothesis, which states that there is a statistically significant relationship between green procurement and clean production. This means that the green supply chain's reliance on green procurement has significantly contributed to improving the company's operations towards cleaner production. Furthermore, the results of the t-test for the regression coefficient (β) for the green purchasing dimension showed a value of (49.989), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that green purchasing has a significant effect in explaining the change in the level of clean production. The marginal slope (β) also reflects a positive effect, as each one-unit increase in the level of green purchasing leads to a 79% increase in the level of clean production. Moreover, the corrected coefficient of determination (Adj R^2) shows that the analysis model explains 66% of the changes in the level of clean production.

The results regarding the impact of green transport and clean production show that the calculated F-value reached 2502.971, which is higher than the tabulated F-value of 3.94 at a significance level of 0.05. This confirms the third sub-hypothesis, which states that there is a statistically significant relationship between green transport and clean production. This indicates that the green supply chain's reliance on green transport in its transportation processes has significantly contributed to improving the company's operations towards cleaner production by reducing pollutants and enhancing speed and safety in transport. Furthermore, the results of the t-test for the regression coefficient (β) for the green supply chain variable showed a value of (50.030), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that green transport has a significant effect in explaining the change in the level of clean production. The marginal slope (β) also reflects a positive effect of green transport on clean production, as each one-unit increase in the level of green transport leads to a 78% increase in the level of clean production. Additionally, the corrected coefficient of determination (Adj R^2) shows that the analysis model explains 66% of the changes in the level of clean production.

The results regarding the impact of green marketing and clean production indicate that the calculated F-value reached (4359.474), which is higher than the critical F-value of (3.94) at a significance level of (0.05). This supports the fourth sub-hypothesis, which states that there is a statistically significant effect between green marketing and clean production. This means that adopting green marketing contributed to improving the company's operations towards cleaner production. Furthermore, the results of the t-test for the regression coefficient (β) for the green marketing variable showed a value of (66.026), which is higher than the critical value of (1.984) at a significance level of (0.05). This indicates that green marketing has a significant effect in explaining the change in the level of clean production.

Furthermore, the marginal slope coefficient (β) reflects a positive impact of green marketing on clean production, as each one-unit increase in the level of green marketing leads to an 86% increase in clean production. The corrected coefficient of determination (Adj R^2) also indicates that the analysis model explains 77% of the changes in the level of clean production. Additionally, the results related to the impact of green logistics on clean production show that the calculated F-value reached 3572.923, which is higher than the critical F-value of 3.94 at a significance level of 0.05. This supports the fifth sub-hypothesis, which states that there is a statistically significant relationship between green logistics and clean production.

This means that the green supply chain's reliance on green logistics has significantly contributed to improving the company's operations towards cleaner production. In addition, the results of the (t) test for the regression coefficient (β) for the green supply chain variable showed a value of (59.747), which is higher than the tabulated value of (1.984) at a significance level of (0.05), indicating that green logistics has a significant effect in explaining the change in the level of clean production. Furthermore, the marginal slope coefficient (β) reflects a positive impact of green logistics on clean production levels, as each one-unit increase in green logistics leads to an 87% increase in clean production levels. The corrected coefficient of determination (Adj R^2) also indicates that the analysis model explains 73% of the changes in clean production levels.

7. Conclusions

A review of the results of the correlation and impact test between the independent variable, the green supply chain with its dimensions (green design, green procurement , green transportation, green marketing, and green logistics), and the dependent variable , clean production, reveals a strong correlation and impact relationship, both with the independent variable as a whole and with its individual dimensions. Furthermore, the following is evident:

- The results of the correlation test demonstrate the effectiveness of the green supply chain in improving the transformation of industrial companies towards clean production.
- The company under study does not rely on green supply chain principles in many areas of its operations. Therefore, it needs to implement these principles across all its operations to improve productivity and significantly enhance its competitiveness in the market.

- Iraqi industrial companies, including the company under study, are still not prioritizing the use of environmentally friendly raw materials for their products and are not engaging with suppliers to secure these materials. It is worth noting that such materials are fundamental to clean production.

- A company's credibility depends on the detailed information it provides about its products and its return policy. The study results show that the company did not provide clear and detailed explanations on its products outlining the return process for defective items.

- One of the most important environmental issues for countries and consumers is how to protect the environment from pollution, whether through reducing emissions of gases or production waste, or through reuse and recycling. The study results indicate that the company in question remains uninterested in these issues, despite their importance and their crucial role in today's competitive landscape.

- The responses of the study sample reveal that many workers are not interested in maintaining the work environment or the external environment due to a lack of awareness of the importance of the environment, whether for the company or the individual worker. This lack of interest is exacerbated by the company management's failure to provide sufficient training to workers on the importance of maintaining the work environment in its various aspects, which form the basis for maintaining the health and safety of the individual worker.

Reference

Alhajri, A., Banialnajjar, S., Alfalasi, S., Alghfeli, S., & Ali, M. (2025). Walmart's Retail Link Supply Chain: A Case Study Solution. *International Journal of Supply Chain Management, 10*(1), 52–61. https://doi.org/10.47604/ijscm.3311saxionbibliotheek.libguides

Bin Ali, M. F., & Yusoff, M. A. bin M. (2025). Green transportation: A conceptual framework in campus-to-city integrated public transport. *International Journal of Social Science, Management and Economics Research, 3*(1).

Boro, B. C., Kumar, A., & Saxena, K. (2025). Sustainable supply chain management: A comparative analysis of green practices in manufacturing industries. *Journal of Neonatal Surgery, 14*(7), 923–937.

Chia, X. K., & Hadibarata, T. (2021). Cleaner production: A brief review on definitions, trends and the importance in environmental protection. *Environmental and Toxicology Management, 1*, 23–27. https://doi.org/10.33086/etm.v1i2.2273

Daney, C. P., & Reidy, J. (2017). *Statistics without maths for psychology* (7th Ed.). Pearson Prentice Hall.

David, L. O. O., Nwulu, N., Aigbavboa, C., & Adepoju, O. (2023). Towards global water security: The role of cleaner production. *Cleaner Engineering and Technology, 17*, 100695. https://doi.org/10.1016/j.clet.2023.100695

Emon, M. M. H. (2025). The mediating role of supply chain responsiveness in the relationship between key supply chain drivers and performance: Evidence from the FMCG industry. *Brazilian Journal of Operations and Production Management, 22*(1), e20252580. https://doi.org/10.14488/BJOPM.2580.2025saxionbibliotheek.libguides

Fosso Wamba, S., Queiroz, M. M., Guthrie, C., & Braganza, A. (2022). Industry experiences of artificial intelligence (AI): Benefits and challenges in operations and supply chain management. *Production Planning & Control, 33*(16), 1493–1497.

Gadgil, M. (2024). The role of green supply chain management in enhancing corporate sustainability performance. *Universal Research Reports, 11*(4), 175–180. https://doi.org/10.36676/urr.v11.i4.1347

Gelmez, E., Özceylan, E., & Mrugalska, B. (2024). The impact of green supply chain management on green innovation, environmental performance, and competitive advantage. *Sustainability, 16*(22), 9757. https://doi.org/10.3390/su16229757

Godakanda, I., & Mekala, K. G. H. (2023). Introduction of cleaner production and sustainable development goals. *Journal of Research Technology & Engineering, 4*(2), 160–172.

Gupta, P., Sharma, Y., Chauhan, A., Parewa, B., Rai, P., & Naik, N. (2025). Investigation of green supply chain management practices and sustainability in Indian manufacturing enterprises using a structural equation modeling approach. *Scientific Reports, 15*, 14909. https://doi.org/10.1038/s41598-025-95940-9

Huang, J., Zhong, Y., & Zhang, Y. (2023). Does environmental regulation of cleaner production affect the position of enterprises in global value chains? A quasi-natural experiment based on the implementation of cleaner production. *Sustainability, 15*, 10492. https://doi.org/10.3390/su151310492

Ikram, M., Zhou, P., Shah, S., & Liu, G. (2019). Do environmental management systems help improve corporate sustainable development? Evidence from manufacturing companies in Pakistan. *Journal of Cleaner Production, 226*, 628–641.

Joshi, S. (2022). A review on sustainable supply chain network design: Dimensions, paradigms, concepts, framework and future directions. *Sustainable Operations and Computers, 3*, 136–148.

Juma, R., & Mhando, A. (2022). Understanding operational risks in Tanzanian supply chains. *Journal of African Business, 23*(4), 439–458.

Kumar, K., R, S., Saravanakumar, A., P, S. J., & Kapoor, P. (2025). Green supply chain management: Key challenges, emerging trends, and strategic solutions for sustainable business practices. *European Economic Letters, 15*(2).

Kumar, L., Naqvi, S. A., Deitch, M. J., Khalid, M. J., Naeem, K., Amjad, A. Q., Kumar, A., Gebremicael, T. G., & Arshad, M. (2024). Opportunities and constraints for cleaner production policy in the developing world: A case study of Sindh Region, Pakistan. *Environment, Development and Sustainability, 26*, 4391–4434. https://doi.org/10.1007/s10668-022-02889-0

Li, Y., & Zobel, C. W. (2020). Exploring supply chain network resilience in the presence of the ripple effect. *International Journal of Production Economics, 228*, 107693. https://doi.org/10.1016/j.ijpe.2020.107693

Loury Okoumba, W. V. (2025). Exploring the link between supply chain resilience and organisational performance. *South African Journal of Economic and Management Sciences, 28*(1), a6177. https://doi.org/10.4102/sajems.v28i1.6177

Muzamwese, T. C. (2024). Emerging challenges for cleaner production networks: The decline of the Global Resource Efficient and Cleaner Production Network (RECPnet). *Circular Economy and Sustainability, 4*, 2313–2337. https://doi.org/10.1007/s43615-024-00386-2

Nabilla, A., Widiyanesti, S., & Anggadwita, G. (2025). The role of green supply chain management and environmental management practices in enhancing enviropreneurship performance based on evidence from Indonesian tourism SMEs. *Discover Sustainability, 6*, 737. https://doi.org/10.1007/s43621-025-01629-4

Nagy, G., & Szentesi, S. (2024). Green logistics: Transforming supply chains for a sustainable future. *Advanced Logistic Systems – Theory and Practice, 18*(3), 29–42. https://doi.org/10.32971/als.2024.026

Ospino, A. E. S., Guardo, F. A. P., Castellano, H. R. Z., & Fajardo-Moreno, W. S. (2023). Artificial intelligence and clean production on the way to sustainability: A systematic literature review. In *21st LACCEI International Multi-Conference for Engineering, Education, and Technology*.

Pal, S., Banerjee, G., Bajaj, A., Tank, S., & Tank, B. K. (2025). The impact of AI on global supply chain management: A review of literature. *South Eastern European Journal of Public Health, 26*(S1).

Phahlamohlaka, K., & Mpungose, S. (2025). Assessing the impact of supply chain practices on operational efficiency and service delivery in local municipality (LM). *International Journal of Business Ecosystem & Strategy, 7*(2), 14–34.

Prigozhin, V., Zheng, W., & Lee, F. (2023). Implementing cleaner production technologies: General aspects. *E3S Web of Conferences, 392*, 01006. https://doi.org/10.1051/e3sconf/202339201006

Sahoo, S., & Vijayvargy, L. (2021). Green supply chain management practices and its impact on organizational performance: Evidence from Indian manufacturers. *Journal of Manufacturing Technology Management, 32*(4), 862–886. https://doi.org/10.1108/jmtm-04-2020-0173

Santos, F. F., Quiroz, R. de C. S., & Neto, J. A. de A. (2018). Evaluation of cleaner production application in dairying techniques of Southern Bahia. *Gestão & Produção, 25*(1), 117–131. https://doi.org/10.1590/0104-530X2234-16

Satish, J., & Nagesha, N. (2018). Cleaner production: A brief review of the literature. *Today's Materials: Proceedings, 5*, 17944–17951.

Satyro, W. C., Contador, J. C., Monken, S. F. d. P., Lima, A. F. d., Soares Junior, G. G., Gomes, J. A., Neves, J. V. S., do Nascimento, J. R., de Araújo, J. L., Correa, E. d. S., et al. (2023). Industry 4.0 implementation projects: The cleaner production strategy—a literature review. *Sustainability, 15*, 2161. https://doi.org/10.3390/su15032161

Suhardi, A. R. (2024). Implementation of supply chain management and strategic processes in total quality management to improve operational performance. *Quality Innovation Prosperity, 28*(3), 139–162. https://doi.org/10.12776/qip.v28i3.2089

Tshuma, M., & Moyo, J. (2021). Challenges in supply chain management in Africa during the COVID-19 pandemic: Lessons from Tanzania. *African Journal of Business Management, 15*(8), 215–228.

Tsikada, C., Wimbayi, C., & Ayandibu, A. O. (2025). The adoption of green supply chain management in entrepreneurship and its impact on business sustainability: Lessons for South African SMEs. *Future Business Journal, 11*, 198. https://doi.org/10.1186/s43093-025-00617-4

UNIDO. (2004). *Guidance manual: How to establish and operate cleaner production centres*. https://open.unido.org

Zhang, G., Yang, Y., & Yang, G. (2023). Smart supply chain management in Industry 4.0: The review, research agenda and strategies in North America. *Annals of Operations Research, 322*, 1075–1117. https://doi.org/10.1007/s10479-022-04689-1