Scientific Research Publishing

Open Journal of Business and Management, 2025, 13(5), 3473-3483
https://www.scirp.org/journal/ojbm
ISSN Online: 2329-3292
ISSN Print: 2329-3284

Green Supply Chain Practices and Performance: Evidence from Cocoa Production in Cameroon

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How to cite this paper: Dorcasse, T. T. (2025). Green Supply Chain Practices and Performance: Evidence from Cocoa Production in Cameroon. *Open Journal of Business and Management, 13,* 3473-3483.
https://doi.org/10.4236/ojbm.2025.135185

Received: August 12, 2025
Accepted: September 9, 2025
Published: September 12, 2025

Abstract

This study examines the relationship between green supply chain practices and economic success in the cocoa sector of Cameroon, utilizing secondary data from 2020/21 to 2023/24. The analysis focuses on certification schemes, traceability systems, and best management practices (BMPs) including agro forestry, and their correlation with farm-gate pricing, free-on-board (FOB) export prices, and export earnings. The data indicates that certified cooperatives rose from 85 to 110, certified exports climbed from 40% to 45%, and FOB prices doubled. Environmental improvements, such as a 20% decrease in pesticide application and a 3,000-hectare increase in agro forestry, coincided with significant increases in farm-gate prices and export values. The findings indicate that the incorporation of sustainability in the Supply Chain of Cocoa production in Cameroon improves ecological resilience and bolsters profitability and competitiveness. The report emphasizes the strategic significance of integrating environmental stewardship with market-driven supply chain management.

Keywords

Green Supply Chain Management, Sustainable Cocoa Production, Cameroon Agriculture

1. Introduction

It is an open secret that environmental concerns top the agenda of every country's developmental initiative in recent times. This is to ensure that the current and future generations' economic growth, environmental protection, and social well-being are balanced. The United Nations' SDGs provide a clear and structured way of supporting global sustainability, by focusing on three main areas: the economy, the environment, and the society. To this effect, we see that supply chain contributes significantly to economic growth by creating jobs and facilitating trade. At

the same time, it has a substantial impact on environmental sustainability in terms of resource use, emissions, and waste generation. Socially, supply chains impact labor conditions, equity, and community development. As a result, connecting supply chain activities with the three SDG pillars is critical to attaining green supply chain practices in a bid to attain sustainable development.

Agriculture in Cameroon as well as in other sub-Saharan countries is often linked to unsustainable practices such as Slash-and-burn agriculture, overgrazing, and poor soil management all leading to deforestation, erosion, and biodiversity loss. These approaches, which are frequently motivated by poverty and restricted access to modern agricultural equipment, not only harm the land but also lower its productivity over time, compromising both food security and sustainable development goals. So, having looked at the necessity of a green supply chain practice, it raises the worries of whether or not its performance in an area like sub-Saharan Africa is yielding the necessary results, given that these environmental malpractices are their way of life to the people. Using the area of cocoa production in Cameroon, we will check what effects these Green Supply Chain Practices have on the final performance of this Cash crop. Cocoa being one of Cameroon's top export commodities, contributes for nearly 15% of total agricultural exports (ICCO, 2023), and serves as a major source of income for over 600,000 households (ICCO, 2023) consequently playing a vital role in rural livelihoods and national revenue. Given these factors, it is critical to examine how recent interventions such as farmer training programs, agro forestry adoption, quality control improvements, and traceability systems have changed over time and how they connect to national cocoa performance. A better knowledge of these relationships can help to shape policies that promote sustainability, productivity, and global competitiveness in Cameroon's cocoa business. To better understand the purpose of this study, we will be attempting to answer the question;

Is the adoption of green supply chain practices positively associated with the economic performance of cocoa production in Cameroon?

2. Review of Related Literature

The transition to sustainable cocoa production has led to an increasing volume of research examining the impact of eco-friendly practices on environmental and economic results. Essougong (2023) provides significant insights into the impact of Best Management Practices (BMPs), including agro forestry, pruning, and soil management, on improving cocoa productivity and environmental resilience in Cameroon. His study shows that, although these methods demonstrate potential for enhancing production and mitigating land degradation, their implementation is inconsistent due to systemic barriers such as restricted access to inputs, insufficient farmer education, and inadequate institutional support. In addition, Vogel et al. (2019) highlight the overarching governance issues within Cameroon's cocoa industry. Their research indicates that overlapping mandates and inadequate coordination across government entities, NGOs, and corporate stakeholders ob-

struct the execution and expansion of sustainability efforts, including certification schemes. Agricultural producers frequently encounter contradictory incentives and disjointed services, which diminish the efficacy of green supply chain improvements. While both studies provide essential insights Essougong from the agricultural perspective and Vogel et al. from a governance viewpoint they fail to evaluate the combined impact of these factors on quantifiable supply chain performance metrics, including cost efficiency, traceability, and market competitiveness.

Concurrently, research from a related area offers further complexity. Otoo (2023), in a case study of PBC Limited in Ghana, demonstrates a definitive statistical correlation between green supply chain orientation encompassing waste reduction, eco-packaging, and supplier compliance and enhanced organisational performance. His findings substantiate the notion that sustainable methods are both ecologically advantageous and commercially astute. This study is limited to one purchasing business and does not investigate farmer-level dynamics or track the dissemination of sustainable practices across the full supply chain. Collectively, these studies underscore a significant deficiency in the literature: although sustainable cocoa production has been examined through the lenses of on-farm practices, governance, and firm-level outcomes, there exists a paucity of integrated evidence from Cameroon that links green supply chain practices among various stakeholders specifically farmers, cooperatives, and buyers with overall supply chain performance. This study aims to provide empirical information regarding the implementation of green supply chain techniques in Cameroon's cocoa business and their resultant performance results throughout the value chain.

Research Gap

That being said, the previous research has taught us a lot about sustainable farming (Essougong, 2023), problems with governance (Vogel et al., 2019), and the performance of green supply chains at the firm level (Otoo, 2023), but none of them have looked at how green supply chain practices at all levels from smallholder cocoa farmers to cooperatives and buyers affect measurable supply chain performance outcomes in Cameroon. This study fills in the blanks by looking at how environmentally friendly practices are used throughout the cocoa value chain in Cameroon. It also looks at how these practices affect things like productivity, cost-effectiveness, tracking, and market access.

To understand the nature of green supply chain practices and their impact on performance in Cameroon's cocoa sector, it is necessary to first define the fundamental ideas that drive this relationship. Among the various sustainability strategies and procedures, three stand out as particularly essential in the Cameroonian context: certification schemes, traceability systems, and best management practices like agro forestry. These principles not only represent the major means of incorporating environmental and ethical norms into the chocolate value chain, but they also serve as essential drivers for increasing farm productivity, market access, and long-term supply chain resilience. The next section delves into each of

them in depth, relying on recent empirical studies and sector-specific initiatives in Cameroon.

2.1. Certification Schemes for Cameroon's Cocoa Sector

Rainforest Alliance, UTZ, and Fair-trade certification programs have all played important roles in Cameroon's sustainable cocoa production. These programs establish environmental and social requirements that manufacturers must adhere to in order to sell into high-value international markets. In exchange, accredited farmers frequently receive training, technical assistance, and price increases. According to a 2021 study published in Frontiers in Sustainable Food Systems, certification in Cameroon has resulted in some improvements in income and environmental practices, but the benefits vary by region and rely heavily on cooperative capacity and market access (Alemagi et al., 2021). Many smallholders are still excluded due to high entry costs and complicated regulatory requirements. Still, for those that do participate, certification can help with traceability, farm management, and supply chain credibility. Certification is a green practice that improves performance, but it has limitations in terms of scalability and equity.

2.2. Traceability: A Tool for Compliance and Market Access

Traceability has become increasingly important in Cameroon's cocoa supply chain, especially in light of the European Union Deforestation Regulation (EUDR), which requires complete transparency about the origin of agricultural imports. Cameroon responded by establishing a national traceability platform, the Cocoa and Coffee Interprofessional Council (CICC), which today includes over 28,000 cocoa plots and uses GPS to track more than 99% of cocoa field locations (Business in Cameroon, 2025). This traceability system enables purchasers to verify deforestation-free sourcing and improves compliance with sustainability criteria. Exporters and cooperatives benefit from improved market access and a lower chance of shipment rejection in foreign ports. Traceability connects farmers' production techniques to global markets and can lead to certification. It is both a green supply chain tool and a performance driver, influencing buyer trust, regulatory compliance, and export preparedness.

2.3. Agro forestry and Best Management Practices (BMPs)

At the farm level, green supply chain activities begin with Best Management activities (BMPs), particularly agro forestry, which combines shade trees and ecological ways into chocolate growing. These measures assist to prevent erosion, preserve soil fertility, and promote biodiversity, all while contributing to climate resilience. Agro forestry is not new in Cameroon, but recent sustainability programs have encouraged more structured BMPs such pruning, mulching, composting, and shade regulation. According to research conducted by the International Institute of Tropical Agriculture (IITA) and Wageningen University (Essougong, 2023), farmers that use BMPs have higher yields and are more resilient to pests

and climate shocks. However, adoption remains low due to insufficient extension services and a lack of incentives. Agroforestry and BMPs are fundamental green practices that, when applied properly, have a direct impact on supply chain performance by increasing quality, yield, and sustainability certifications.

While certification, traceability, and BMPs are individually recorded in Cameroon's cocoa literature, no integrated study has yet assessed how these practices, implemented by various supply chain players, jointly influence both environmental and economic performance outcomes. this paper fills a gap in the literature by providing empirical information on the combined impact of green supply chain strategies on cocoa sector performance in Cameroon.

3. Data Source and Analysis

This qualitative, desk-based study examines the association between green supply chain practices and cocoa production performance in Cameroon using secondary data. Academic literature, government studies, industry publications, and policy documents for almost half a decade informs the analysis. Sources were chosen for their relevance to green supply chain management, environmental sustainability, and agricultural performance measures, particularly the chocolate business. In accordance with the study's goal to synthesize existing knowledge and offer actionable insights, this technique provides a full overview of current practices and performance metrics. The study uses trusted reports from Cameroon's cocoa board, agriculture ministry, and international groups. It looks at key documents about green practices like farmer training, cocoa quality, and sustainable farming. These were reviewed to find links between the practices and better cocoa production, such as higher yields and environmental care.

Data was examining and recording in relation to the key supply chain areas when it comes to cocoa production and it's Value Chain in Cameroon. Farmers' training, environmental management, quality control, certification, traceability, and transparency are all essential components of the cocoa supply chain. Firstly, whilst environmental management ensures that farming operations safeguard natural resources and then they are trained provides them with sustainable agricultural skills for better and healthier output in a good environment. Quality monitoring and certification comes in after the farmers have their produce at the end of the farming season, to ensure that the cocoa fulfills both market and sustainability criteria. Lastly is Traceability and transparency across the supply chain which increases accountability and confidence among the other stakeholders, ensuring that sustainable practices are followed from farm till export. **Table 1** below summarizes the findings in sustainable supply chain from 2020-2024.

As seen on **Table 1** below, evidence from the period 2020/21 to 2023/24 indicates a positive correlation between the adoption of green supply chain practices and the economic performance of cocoa production in Cameroon. Advancements in sustainability, including expanded farmer training, increased certification, enhanced traceability, and improved environmental stewardship, have corre-

sponded with significant increases in market value, farm-gate prices, and overall export earnings. The observed trends indicate that the implementation of eco-friendly practices bolsters environmental resilience, improves buyer confidence, and facilitates market access, ultimately resulting in enhanced financial outcomes for producers. Sustainability and economic performance mutually reinforce one another, establishing green supply chain management as a responsible and profitable strategy within the sector.

Table 1. Sustainable supply chain practices.

Category	*Metric*	*2020/21*	*2021/22*	*2022/23*	*2023/24*
Farmer Training Programs	Training Sessions conducted	320		375	390
	Farmers Trained	15,000	16,200	17,500	18,000
	Training Investment (in Million FCFA)	450M	470M	500M	525M
Environmental Management	Certified cooperatives	85	93	102	110
	Shade Trees planted	50,000	54,000	58,000	60,000
	Pesticide Usage Reduction (%)	15	17	18	20
	Agro forestry area (ha)	12,000	13,000	14,000	15,000
	Composting initiatives	35	38	40	42
Quality Control and Certification	Volume graded Grade 1 (kg)	47M	48M	47M	48M
	Certified exports (%)	40	42	43	45
	Quality control Centers	12	13	13	14
	Rejected consignments (%)	3	2	2	2
Traceability and Transparency	Farmers Geo-referenced	20,000	21,000	23,000	25,000
	Export lots tracked	300	320	350	370
	Transparency Audits	2	3	4	5
	Digital traceability adoption (%)	10	15	20	28

Source: Compilation of 2020-2024 reports from the National Cocoa and Coffee Board (NCCB).

From Table 1 above, we see that, from 2020-2021 to 2023-2024, practically all metrics show an upward trend, pointing to steady advancements in sustainability activities within Cameroon's cocoa supply chain. This suggests a stronger commitment to green supply chain techniques, which also leads to an increase in funding or improve management. For example,

- Training sessions conducted increased from 320 to 390.
- Farmers trained rose steadily from 15,000 to 18,000.
- Training investment increased from 450 million FCFA to 525 million FCFA.
- Certified cooperatives also grew from 85 to 110.

In the same vein, when it comes to quality control;

- Volume graded Grade 1 cocoa fluctuated but overall remained high (~47-48 million kg).

- Certified exports percentage rose from 40% to 45%.
- Quality control centers increased from 12 to 14.
- Rejected consignments reduced from 3% to 2%.

This was undoubtedly impressive however; a positive trend in the supply chain practices was not the main purpose of this study. The question was; Is the adoption of green supply chain practices positively associated with the overall performance of cocoa production in Cameroon? Which is why Table 2 below shows the findings when it comes to the performance of Coca in Cameroon.

It is true that the quality of Coca remained high as seen above but that alone is not a good enough metrics to measure performance. When it comes to the annual Performance of Cocoa and Coffee in Cameroon, The National Cocoa and Coffee Board (2024) of Cameroon evaluates sectored performance through indicators such as total production volumes (kg/tonnes), regional production shares, and exporter market shares and the likes. These metrics assist in tracking output trends, identifying regional strengths, and monitoring the concentration of export activities, offering a clear view of both production capacity and market trends as can be seen in a summarized version bellow.

Table 2. Performance indicators.

Indicatos	2020/21	2021/22	2022/23	2023/24
Domestic trade volume (tonnes)	251,151	295,164	262,112	266,725
Exported Volume	180,000,000	228,920,543	186,754,409	185,613,433
Local processing volume (kg)	180,000,000	228,920,543	186,754,409	185,613,433
Approved export contracts	88,000,000	86,250,000	89,204,772	85,789,063
Farm-gate prices (min FCFA/kg)	630	638	550	655
Farm-gate prices (max FCFA/kg)	1500	1200	750	1150
FOB price average (FCFA/kg)	1350	1349	1290	2845
Monetary mass (FOB Value, FCFA)	220,000 M	285,000M	264,878M	488,836M
Active Exporters	33	40	36	39
Center region share (%)	51	53	54	45
South West region share (%)	24	23	21	22
Littoral region share (%)	15	14	11	18

Source: Compilation of 2020-2024 reports from the National Cocoa and Coffee Board (NCCB).

As seen in Table 2 above, these performance indicators show a mixed but resilient cocoa sector in Cameroon. Domestic traded volumes peaked at nearly 295,000

tons in 2021/22 before falling and partially recovering, suggesting market instability due to global demand movements or local production issues. After 2021/22, export quantities dropped, while local processing volumes remained stable, suggesting domestic value-addition activities. In 2022/23, the minimum price plummeted drastically, demonstrating farmer sensitivity to market shocks. In 2023/24, the maximum price quadrupled. Institutional engagement was consistent, as approved export contracts and active exporters remained steady, although regional market shares varied marginally, with the Centre area losing supremacy to the Littoral region in 2023/24. In 2023/24, FOB price averages and total export values rose, indicating better global prices, trade terms, or currency effects. These data imply that despite output and price instability, the sector has maintained substantial export activity and is benefiting from recent positive price changes, though this may be unevenly distributed.

4. Limitations of Data

This research exclusively utilizes secondary data sourced from governmental statistics, international organizations, and scholarly literature. This technique offers extensive coverage and facilitates year-on-year comparison, but it inherently restricts analytical depth and the capacity to determine causal linkages. The lack of primary data collection, including farmer-level surveys or interviews with cooperatives, limits the study's ability to capture real-world problems, perspectives, and behavioral motivators for green supply chain adoption. To address this issue, various reputable sources were triangulated, including policy reports (MINADER, ONCC), international datasets (ICCO, FAO, World Bank), and independent research (Essougong, 2023; Vogel et al., 2019), to enhance dependability and minimize single-source bias. Future research may enhance this desk-based analysis through the incorporation of surveys, focus groups, or experimental methodologies to bolster causal inference and yield farmer-centered insights.

Also, this research utilizes descriptive statistics and trend analyses to investigate the correlation between green supply chain practices and performance. Although gains in certification, traceability, and agroforestry adoption seem to correlate with rises in FOB and farm-gate prices, the limited dataset precludes rigorous statistical analysis, necessitating that the results be regarded as associative rather than causal. Additionally, secondary sources may possess intrinsic reporting biases; nevertheless, this constraint was alleviated by triangulating several perspectives, including governmental records, international databases, and independent academic studies. Subsequent study utilizing larger datasets and primary data gathering may employ econometric approaches to systematically assess significance and corroborate these findings at the farmer and cooperative levels.

5. Findings

A comparative analysis of performance indicators and sustainable supply chain practices in Cameroon's cocoa industry from 2020/21 to 2023/24 indicates a pos-

itive correlation between the implementation of green supply chain measures and enhancements in market and production outcomes. During the four-year period, investment in sustainability increased consistently, rising from 450 million FCFA in 2020/21 to 525 million FCFA in 2023/24. In the same period, the count of certified cooperatives grew from 85 to 110, while the proportion of certified exports increased from 40% to 45%. The advancements in sustainability seem to have positively influenced market performance: despite fluctuations in domestic traded volume, the FOB average price increased significantly, rising from 1,349 FCFA/kg in 2021/22 to 2,845 FCFA/kg in 2023/24, which constitutes a 111% increase:

$$\text{FOB Price Increase (\%)} = \frac{(2,845-1,349)}{1,349} \times 100 \approx 111\%$$

Improvements in environmental indicators coincided with increases in prices. The number of shade trees planted increased from 50,000 to 60,000, the reduction in pesticide usage improved from 15% to 20%, and agroforestry areas expanded from 12,000 hectares to 15,000 hectares. The maximum farm-gate price increased significantly from 1,480 FCFA/kg in 2022/23 to 6,300 FCFA/kg in 2023/24, representing an approximate rise of 325.7%.

$$\text{Max Farm-Gate Price Increase (\%)} = \frac{(6,300-1,480)}{1,480} \times 100 \approx 325.7\%$$

This significant rise suggests that environmentally friendly production methods, such as pesticide reduction and agro forestry, may attract premium prices in the international market.

Traceability and transparency measures improved, as evidenced by the increase in geo-referenced farms from 20,000 to 25,000, the tracking of export lots from 300 to 370, and the rise in digital traceability adoption from 10% to 28%. These measures likely enhance buyer confidence and decrease rejection rates, with rejected consignments remaining low at 2% over the past three years. The enhancements align with an approximate doubling of the monetary mass (FOB value), increasing from 220 billion FCFA in 2020/21 to 488.8 billion FCFA in 2023/24. Building on this, showing the relationship between Green Supply Chain Practices and the performance indicators is crucial to provide a clear picture of how sustainability initiatives translate into concrete outcomes as bellow.

In **Figure 1** below we make use of FOB price and certified exports (%) since they directly represent a green supply chain practice and a cocoa industry performance outcome. Certified exports (%) indicate how well cocoa quantities follow international sustainability criteria, including traceability, pesticide reduction, and agro forestry. A strong economic indicator, FOB price captures the market value of cocoa at export and signals buyer trust, market access, and competitiveness. Certification gives producers access to premium markets and compliance-driven consumers, allowing them to charge higher FOB prices. This pair effectively shows how sustainable supply chain actions affect economic results. Certified exports (%) and FOB price (FCFA/kg) are shown in the 2020/21-2023/24 dual-axis trend chart.

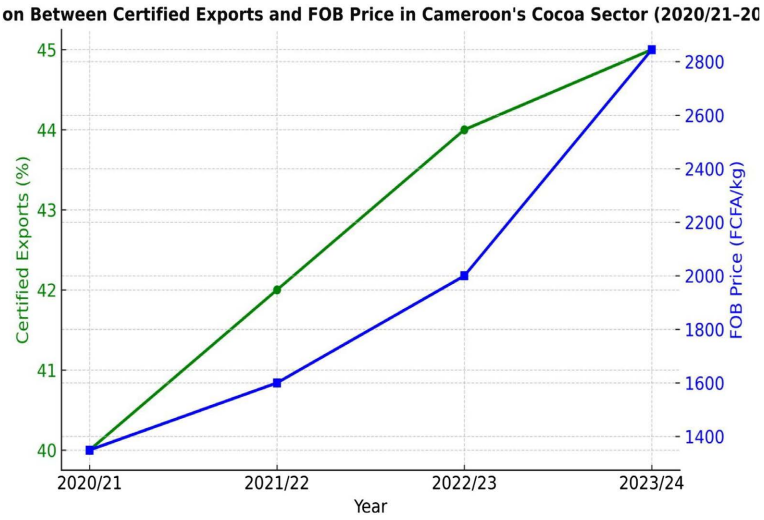

Figure 1. Image generated using DALL·E 2 (OpenAI), 2025.

As seen on **Figure 1**, certification rates and FOB prices are rising together, demonstrating a favorable relationship between sustainability certifications and export market performance. FOB prices more than doubled as certification levels jumped from 40% to 45%. This suggests that increasing certification coverage may has increased buyer confidence, international trade compliance, and Cameroonian cocoa price premiums. The graphic shows that sustainable practices increase sector economic outcomes.

It is worth noting that, although the findings reveal a substantial positive relationship between green supply chain practices and economic outcomes, attributing all improvements solely to certification, traceability, and agroforestry is an oversimplification. Other external forces are likely to have played a role. For example, the rapid increase in FOB prices between 2022 and 2024 was accompanied by worldwide cocoa shortages, increased demand for certified cocoa in the EU, and favorable exchange rate moves. Similarly, government actions, such as minimum farm-gate price adjustments and harsher export rules, impacted market performance. Thus, while green supply chain techniques undoubtedly increased competitiveness, they should be viewed as part of a larger set of interacting drivers affecting sector outcomes.

6. Discussion and Resolution

This study's findings indicate that green supply chain methods enhance the resilience and competitiveness of Cameroon's cocoa business. The increasing certification rates, together with elevated FOB and farm-gate pricing, reflect findings from Ghana (Otoo, 2023), where sustainability-oriented supply chain strategies enhanced organizational performance. The correlation between agro forestry adoption and yield resilience aligns with Essougong (2023), who highlighted the significance of Best Management Practices in enhancing productivity and alleviating land degradation.

This study concurrently emphasizes limitations that align with Vogel et al. (2019), who recognized governance deficiencies and institutional fragmentation within Cameroon's cocoa sector. Notwithstanding progress in traceability and certification, obstacles such as inadequate farmer education, unequal access to certification, and elevated compliance costs persist in hindering inclusion. Alemagi et al. (2021) warn that the advantages of certification are not uniformly distributed across smallholder farmers, a conclusion that is somewhat corroborated here, as price premiums at the sector level do not necessarily result in fair benefits for the smallest producers.

Collectively, these comparisons indicate that although green supply chain techniques enhance performance, their complete potential is constrained by overarching governance, equity, and market characteristics. Enhancing farmer education, reducing certification entry obstacles, and optimizing inter-agency collaboration will be essential for amplifying these advantages. Future investigations may utilize econometric modeling and field surveys to validate the causal relationships identified herein and to guarantee that sustainability benefits are evenly allocated across all participants in the value chain.

In conclusion, Cameroon's experience illustrates that sustainability-focused supply chain reforms are ecologically responsible and economically feasible. Their sustained effectiveness, however, relies on integrating them within a broader framework of market regulation, global economic dynamics, and inclusive governance.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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