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Socioeconomic Analysis of Rainforest Alliance-Certified Cocoa Agroforestry Systems and Producer Behavior Facing the Cocoa Price Boom: Evidence from Haut-Nkam and Ndé Departments, West Cameroon

Salim Ali Ahmed Ngnemadon[1*], Arnold Billy Tschoung'e Fokou[1], Mukete Ngoe[1], Ali Rajatou Laïla Houmdie[2]

[1]Department of Agricultural Sociology and Economics, Higher Institute of Agriculture, Forestry, Water and Environment (ISABEE), University of Bertoua, Bertoua, Cameroon
[2]Department of Rural Socio-Economics and Agricultural Extension (SERVA), Faculty of Agronomy and Agricultural Sciences (FASA), University of Dschang, Dschang, Cameroon
Email: *salim.ahmed2299@yahoo.fr, fokouarnold@yahoo.com, ngoer@yahoo.com, lailahoumdie@gmail.com

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Abstract

Against the backdrop of a global cocoa price boom (from 1000 to 6100 FCFA/kg between May 2022 and April 2024) and the rapid expansion of sustainable certification (41% of Cameroonian production certified in 2021-2022), this study assesses the socioeconomic effects of Rainforest Alliance (RA) certification on cocoa agroforestry systems in West Cameroon and describes producer behavioural responses to the exceptional price environment. Based on a sample of 105 producers (26 certified, 79 non-certified) surveyed in the subdivisions of Bagangté and Tonga (Ndé Department) and Kekem (Haut-Nkam Department), the study applies cost-benefit analysis, discounted profitability criteria (NPV, BCR, payback period), and binary logistic regression. Certified producers incur significantly higher total costs (319,114 vs 236,491 FCFA/ha, $p < 0.01$) but generate substantially greater revenues (2,494,436 vs 1,425,983 FCFA/ha in 2023/24, $p < 0.001$). The certified system outperforms on all three financial criteria: NPV (1,738,918 vs 847,851 FCFA/ha; +105%), BCR (6.44 vs 4.58), and payback period (1 year vs 1 year 8 months). The logistic model identifies land access (Exp(B) = 5.63; $p < 0.01$), training on cocoa production (Exp(B) = 6.47; $p < 0.05$), and cooperative membership (Exp(B) = 7.77; $p < 0.10$) as significant determinants of certification adoption. The price elasticity of supply is extremely low ($\varepsilon = 0.04$), confirming the structural inelasticity of cocoa production. Fac-

ing the price surge, 96.2% of producers upgraded their equipment and inputs, 86.7% diversified their crops, and 75.2% expanded their cultivated area. The study recommends establishing a meaningful certified-conventional price differential, strengthening participatory training, and improving land tenure security for non-certified producers.

Subject Areas

Environmental Sciences

Keywords

Rainforest Alliance Certification, Cocoa Agroforestry, Financial Profitability, Binary Logistic Regression, Price Elasticity of Supply

1. Introduction

Cameroonian agriculture (the backbone of the national economy, contributing 22.9% of GDP and employing 70% of the active labor force [1]) is navigating two concurrent transitions: a sustainability transition driven by international demand for responsibly sourced commodities, and a market transition triggered by an unprecedented surge in cocoa prices. The farmgate price of cocoa, which stood at 1000 FCFA/kg in May 2022, reached 6100 FCFA/kg in April 2024 [2], a historical high attributable primarily to an 11% fall in global production during the 2023/24 season [3], itself the consequence of poor harvests in the two leading producing countries, Côte d'Ivoire and Ghana.

Simultaneously, the Cameroonian cocoa sector faces mounting regulatory pressure. The EU Deforestation Regulation, adopted by the European Parliament in May 2023, will condition market access from 2025 upon proof that products do not originate from land deforested after December 2020 [4]. This requirement confers heightened strategic importance upon sustainability certifications, particularly Rainforest Alliance (RA) certification, which covered 40% of national production in 2023 [5], up from a mere 3% in 2016 [6].

Despite this rapid expansion, the socioeconomic effects of certification on Cameroonian producers remain insufficiently documented, particularly in the West Region, where cocoa agroforestry systems play a central economic and environmental role. The existing literature presents a mixed picture: whilst some studies demonstrate positive effects on revenues and agricultural practices [7] [8], others emphasize that the stringent requirements of certification tend to exclude smallholders in favor of better-endowed operations [9] [10].

The present study aims to address this knowledge gap by simultaneously analyzing the comparative profitability of certified and non-certified agroforestry systems, the determinants of certification adoption, and producer behavioral responses to the exceptional price environment observed in 2023-2024. It focuses on the Haut-Nkam and Ndé Departments, which collectively account for approx-

imately 45,000 cocoa producers [11].

The research questions are as follows: 1) Are certified agroforestry systems significantly more profitable than their non-certified counterparts? 2) What socio-economic and institutional factors determine the adoption of certification? 3) How do producers respond behaviourally to a historic cocoa price boom, and does the price elasticity of supply allow rapid production adjustments?

Based on the literature, this study tests two main hypotheses: H_1 states that land tenure and cooperative membership positively influence certification adoption. H_2 posits that certified cocoa agroforestry systems yield higher financial profitability than non-certified ones despite higher production costs.

2. Theoretical Framework and Literature Review

2.1. Theoretical Foundations

Three theoretical frameworks underpin this study. Production function for perennial crops models their dynamics through four phases (gestation, growth, stability, and decline) and justifies an inter-temporal profitability analysis [12]. For cocoa, the full production phase (Phase III) spans 6 to 25 years; it is within this interval (with orchards averaging 21 years of age in our sample) that the differentiated income effects of certification are most pronounced.

Innovation diffusion theory illuminates the adoption of certification as an agro-institutional innovation [13]. His sigmoid curve distinguishes five adopter categories (innovators, early adopters, early majority, late majority, and laggards) and five determinant attributes: relative advantage, compatibility, complexity, trialability, and observability. In our study area, "early adopters" (producers certified for several years) coexist with "late adopters" in the process of joining the RA scheme.

Finally, the theory of agricultural price fluctuations [14] [15] distinguishes exogenous fluctuations (climatic conditions, geopolitical crises) from endogenous ones (market dynamics, Ezekiel's cobweb model, [16]). It posits that demand rigidity amplifies supply variations, and that the structural inelasticity of cocoa production (attributable to orchard maturation delays and investment costs) renders producers particularly vulnerable to price volatility.

2.2. Literature Review

2.2.1. Cocoa Agroforestry Systems and Certification

Cocoa-based agroforestry systems (AFS) deliberately integrate woody species (bush mango (Dacryodes edulis), mango (Mangifera indica), orange (Citrus sinensis), avocado (Persea americana), kola (Cola acuminata)) into cocoa plantations [17]. They provide well-documented agronomic benefits (shade provision, microclimatic regulation, soil fertility maintenance), environmental services (carbon sequestration, biodiversity, water capture), and economic advantages (income diversification) [18] [19].

Rainforest Alliance/UTZ Certified (programs merged in 2018) requires producers to comply with environmental, social, and agricultural standards verified

by an external audit. In Cameroon, this program now covers 40% of national production [5], having been confined to 3% in 2016. This expansion reflects an international dynamic driven by European consumer demand for traceable and sustainably produced commodities.

2.2.2. Impact of Certification on Revenues: Contrasting Evidence

The empirical literature on the income impact of certification presents a nuanced picture. On the positive side, Barbosa de [8] in Brazil and [7] in Central Cameroon demonstrate that RA-certified producers achieve higher revenues and yields than non-certified counterparts, owing to improved agricultural practices and marketing premiums. Reference [20] in Nigeria confirms the profitability advantage of certified production on the basis of NPV. Reference [21] in Ghana reports a BCR of 1.05 for certified versus 0.97 for non-certified producers.

Conversely, reference [22] in Peru finds no significant fair-trade effects on household income, with salaried labor costs absorbing part of the gains. In their critical review of 37 impact studies, reference [23] identifies only 6 concluding that sustainability standards have robust positive effects. Reference [10] emphasizes that it is well-organized, high-volume producers who benefit most from certification, whilst smallholders are frequently excluded by stringent requirements.

This dichotomy underscores the centrality of the institutional context (cooperative structure, certified-conventional price differential, and quality of technical support) in determining the actual impact of certification on producer welfare.

2.2.3. Adoption Determinants and Behavioral Responses to Price Signals

Studies examining the determinants of certification or agro-environmental innovation adoption predominantly employ logit or probit models [24]-[26]. Factors identified in the literature include: educational attainment [27] [28], land access [29], technical training [30], membership of producer organizations [31], and the age of the producer and the orchard.

Concerning behavioral responses to price fluctuations, [32] demonstrates that annual price deviations of 30% from the mean are "normal" for internationally traded agricultural commodities. [33] estimates the global price elasticity of cocoa supply at 0.07 in the short run and 0.57 in the long run, confirming the weak responsiveness of production to price signals, a structural feature linked to orchard maturation delays. Faced with this inelasticity, crop diversification emerges as a pertinent adaptation strategy for reducing producers' vulnerability to price volatility [14].

3. Methodology

3.1. Study Area

The study was conducted in the sub-divisions of Bagangté and Tonga (Ndé Department) and Kekem (Haut-Nkam Department), in the West Region of Cameroon. These areas collectively account for approximately 45,000 cocoa producers

[11] and host the main RA-certified cooperatives in the region. The climate is of the highland tropical type, with annual rainfall of 1400 to 2500 mm, mean temperatures of 20˚C - 28˚C, and ferralitic soils well suited to cocoa cultivation. RA certification in the area is administered through the PAD-CACAO/Ouest program, a private value chain development entity.

3.2. Sample Size and Data Collection

The minimum sample size was calculated using [34] formula applied to a population of 21,580 active producers recorded in the three subdivisions [35], with a 95% confidence level (Z = 1.96), a 5% margin of error, and a reference proportion p = 0.083. The resulting minimum sample size is n ≈ 116. In the field, 105 producers were effectively surveyed (9.5% attrition): 26 certified and 79 non-certified, selected through a combination of purposive sampling (identification of high-density cocoa production areas), voluntary recruitment, and snowball sampling. Data collection was carried out between April and June 2024 through semi-structured face-to-face questionnaires. Although the achieved sample of 105 producers fell slightly below the calculated minimum of 116 due to field constraints, this 9.5% reduction is marginal and does not significantly compromise the precision or the overall validity of the statistical analysis.

3.3. Analytical Methods

Four analytical methods were employed. Cost-revenue analysis was used to compare the production cost structures of the two systems (TC = Cm + Ci + Cl [+Cc for certified producers]). Student's t-test was applied to assess the significance of mean differences between certified and non-certified producers (SPSS 23.0). Financial profitability analysis mobilized three discounted criteria at a 15% rate (local microfinance rate) over two seasons: Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Payback Period. Finally, a binary logistic regression model was estimated to identify the determinants of adoption (dependent variable Y = 1 if certified, 0 otherwise), following verification of multicollinearity using the Variance Inflation Factor (VIF < 10). It is important to note that since certification adoption is non-random and voluntary, the comparison between certified and non-certified farms represents an associative relationship rather than a direct causal effect, which may introduce selection bias due to baseline differences in farm size, training, and cooperative membership.

The price elasticity of supply was computed using a market-level contextual indicator using global production and price data from [2], providing a macro-economic backdrop for analyzing local producer behavior.

4. Results and Discussion

4.1. Socioeconomic Characteristics of Producers

Table 1 presents the socioeconomic characteristics of surveyed producers. Cocoa farming remains a predominantly male activity, with men accounting for 85.7%

of the total sample. This gender imbalance reflects the cultural norms of the West Region, where cocoa plantations are traditionally inherited by eldest sons [36] [37], with women accessing cocoa farm ownership primarily through widowhood. The predominance of producers aged 41 - 60 years (57.14% of the sample) corroborates [38]. observation of the progressive aging of cocoa farmers across West and Central Africa, as young people are deterred by the physical demands and uncertain returns of the activity.

Table 1. Comparative socioeconomic characteristics of certified and non-certified producers (N = 105).

Variable	Certified (N = 26)	Non-Certified (N = 79)	Total (N = 105)
Gender (%)			
Male	22.86	62.86	81.90
Female	1.90	12.38	14.29
Age Group (%)			
21 - 30 Years	–	5.71	5.71
31 - 40 Years	–	14.29	14.29
41 - 50 Years	–	31.43	31.43
51 - 60 Years	–	25.71	25.71
≥61 Years	–	22.86	22.86
Educational Level (%)			
Primary	30.77	29.11	29.52
Secondary	53.85	60.76	59.05
Higher Education	11.54	5.06	6.67
No Formal Education	3.85	5.06	4.76
Experience (Years)			
Mean	–	–	15.89
Std Deviation	–	–	±7.83
Min-Max	–	–	2 - 37
Farm Size (ha)			
Mean	4.61	2.61	3.11
Std Deviation	±4.73	±1.95	±3.00
Min-Max	1.0 - 20.0	0.5 - 10.0	0.5 - 20.0

Source: Authors, field survey data (April-June 2024), SPSS.

Educational attainment is relatively high (over 65% of producers have attained secondary or higher education), a finding that contrasts with the traditional profile of African cocoa farmers and is attributable to the training programs operated

by PAD-CACAO. Certified producers display a slightly higher proportion of university-educated respondents (11.5% vs 5.1%), suggesting that educational attainment facilitates integration into the demands of the certification process [39]. The mean cultivated area is significantly larger amongst certified producers (4.61 ha vs 2.61 ha), an observation that reflects, in part, the minimum economic viability requirements of the RA program, and, more broadly, the fact that certified producers tend to be better capitalized.

4.2. Comparative Analysis of Costs, Revenues, and Profitability

Table 2 presents the comparative cost and revenue structures of the two systems. Consistent with [20] in Nigeria and [40] in Cameroon, certified producers bear significantly higher total costs (319,114 vs 236,491 FCFA/ha; t = 2.869; $p < 0.01$). This difference of 82,622 FCFA/ha is attributable primarily to labor costs more than twice as high (123,123 vs 57,396 FCFA/ha), driven by the specific cultural practices required by certification: seasonal pruning, fortnightly weeding, pod-breaking with a rod, and controlled fermentation and drying.

Table 2. Comparative cost and revenue analysis (FCFA/ha)—student's t-test

Indicator	Certified (FCFA/ha)	Non-Certified (FCFA/ha)	t-Stat.	Sig.
A. Production Cost Structure				
Equipment (depreciated)	102,142	102,142	n.s.	–
Inputs (fungicides, pesticides, fertilizers)	101,046	83,627	n.s.	0.305
Labour	123,123	57,396	–	–
Certification cost (training transport)	10,169	–	–	–
Total mean cost	319,114	236,491	2.869	0.005***
B. Revenues and Profits				
Cocoa sales revenue 2022/23	768,391	443,676	3.266	0.003***
Cocoa sales revenue 2023/24	2,422,221	1,428,860	4.088	0.000***
Associated crop revenues	18,849	24,166	−1.293	0.200n.s.
Total revenue 2022/23	790,684	456,101	3.257	0.003***
Total revenue 2023/24	2,494,436	1,425,983	4.322	0.000***
Net profit 2022/23	471,570	218,305	3.530	0.001***
Net profit 2023/24	2,175,322	1,180,755	4.250	0.000***

Source: Authors, SPSS. ***$p < 0.01$; n.s. = not significant.

Conversely, certified producers' revenues are significantly higher across both seasons analyzed. The revenue gap widened considerably in 2023/24 (difference of +1,068,453 FCFA/ha) compared with 2022/23 (+334,583 FCFA/ha), owing to the global price boom. Certified producers benefit structurally from a dual ad-

vantage: 1) access to cooperative purchase prices generally superior to those offered by informal intermediaries ("coxeurs") who purchase non-certified output; and 2) a 50 FCFA/kg premium granted by Rainforest Alliance in recognition of good agricultural practices. The absence of a significant difference in associated crop revenues ($p = 0.200$) reflects the relative youth of the fruit trees introduced into certified plots, which have not yet reached their full productive potential.

Table 3. Financial profitability analysis of agroforestry systems (discount rate = 15%).

Profitability Criterion	Certified Cocoa	Non-Certified Cocoa	Interpretation
Net Present Value, NPV (FCFA/ha)	1,738,918	847,851	Both systems are profitable; the certified system is superior by +105%
Benefit Cost Ratio, BCR	6.44	4.58	A certified system is more profitable per FCFA invested
Payback Period	1 Year	1 Year 8 Months	Faster return on investment for certified producers

Discount rate: 15% (local microfinance rate). Period: 2 seasons (2022/23 and 2023/24). Source: Authors, calculations from survey data (2024).

Table 3 confirms that both systems are profitable (NPV > 0; BCR > 1), but that the certified system outperforms on all three financial criteria. The NPV of the certified system is twice that of the non-certified system (1,738,918 vs 847,851 FCFA/ha), a finding consistent with [20] in Nigeria (certified NPV: 5,253,237 FCFA/ha). The BCR of 6.44 for certified producers (vs 4.58) signifies that for every FCFA invested, the certified system returns 6.44 FCFA, against 4.58 FCFA for the conventional system, a substantial differential that provides strong economic justification for certification adoption. The shorter payback period for certified producers (1 year vs 1 year 8 months) is facilitated by the RA premium and the greater stability of cooperative purchase prices. These findings validate Hypothesis H_2: the certified agroforestry system is significantly more profitable than the non-certified system.

4.3. Determinants of Certification Adoption

The logistic model achieves sound overall fit ($\chi^2 = 45.946$; $p < 0.001$; Nagelkerke $R^2 = 0.526$; correct prediction = 82.9%). Table 4 presents the detailed results.

The variable representing agroforestry practices was excluded from the final logit specification as it perfectly predicted/separated the certification status, which violates standard logistic regression assumptions.

Three variables emerge as statistically significant. First, land access (Exp(B) = 5.63; $p < 0.01$) is the most robust determinant of adoption. Producers who access land through purchase or other non-hereditary arrangements are 5.6 times more likely to adopt certification than those relying exclusively on inheritance. This finding is counterintuitive at first glance (61% of producers in our sample access

Table 4. Binary logistic regression results—determinants of RA certification adoption (N = 105).

Explanatory Variable	Coef. B	Sig.	Exp(B)	1/Exp(B)	Effect Direction
Gender (1 = male)	−0.889	0.386	0.411	2.433	ns (−)
Age of the producer	0.000	0.999	1.000	–	ns
Number of children	0.025	0.813	1.025	–	ns (+)
Educational level (1 = educated)	0.918	0.640	2.505	–	ns (+)
Legal status (1 = cooperative)	2.050	0.085*	7.771	–	+ sig.*
Land access (1 = purchase/other)	1.728	0.009***	5.632	–	+ sig.***
Cultivated area (ha)	0.146	0.183	1.157	–	ns (+)
Labour type (1 = family)	0.914	0.230	2.493	–	ns (+)
Orchard age (years)	−0.007	0.845	0.993	1.007	ns (−)
Training on cocoa production	1.867	0.034**	6.472	–	+sig.**

N = 105; −2 Log likelihood = 71.591; Nagelkerke R^2 = 0.526; Correct prediction = 82.9%; Omnibus χ^2 = 45.946 (p = 0.000). ***$p < 0.01$; **$p < 0.05$; *$p < 0.10$; ns = not significant. Source: Authors, SPSS.

land through inheritance) but is explained by the fact that holders of a legal land title or secure access are more inclined to invest in practices with a medium-term return on investment, such as certification [29]. RA certification requires a multi-year commitment and investment in orchard renewal, which only producers with strong tenure security are willing to undertake.

Second, training on cocoa production (Exp(B) = 6.47; $p < 0.05$) multiplies the probability of adoption by a factor of 6.5. This result corroborates Groulx-Tellier's [30] findings on the importance of technical support in the adoption of demanding practices, and [25] work on the factors driving the adoption of cocoa agroforests in Central Cameroon. In the field, trained producers progressively abandon poor practices and serve as peer sensitization agents, generating a community diffusion effect consistent with the [13] model.

Third, cooperative or group of common initiative (GIC) membership (Exp(B) = 7.77; $p < 0.10$) confers a decisive institutional advantage in accessing certification, which is structurally channeled through cooperatives in Cameroon (contract signature, internal inspection, and traceability stages). This finding aligns with the international literature on the role of producer organizations in reducing the transaction costs associated with certification standards [9] [41].

Gender, age, household size, educational attainment, cultivated area, and orchard age are non-significant, although their signs are generally consistent with the literature. The non-significance of educational attainment may be attributable to the high proportion of educated producers in the sample (95%), which reduces the variance of this variable. The aberrant coefficient for the "agroforestry practice" variable (Exp(B) = 540,648,017) constitutes a perfect separation artifact in the

logistic model (all certified producers practice agroforestry) rather than a substantive effect, and must be excluded from any causal interpretation. Consequently, this variable was removed from the final reported logit model to ensure the statistical validity and robustness of the remaining parameters presented in Table 4.

4.4. Behavioral Responses to the Price Boom and Price Elasticity of Supply

Table 5 summarises the behavioral responses adopted by producers in the face of the price surge observed between 2022 and 2024. The near-totality of producers (96.2%) upgraded their equipment and increased their inputs, a response consistent with a short-term intensification logic aimed at maximizing the price rent. Crop diversification (86.7% of respondents) reflects a risk-hedging strategy: aware of the historical volatility of cocoa prices, producers seize the favorable conjuncture to build reserves and invest in other food or cash crops. The expansion of cultivated area (75.2%), more pronounced amongst non-certified producers (79.7% vs 61.5%), constitutes the spontaneous response to a favorable price signal, but creates tension with European anti-deforestation requirements.

Table 5. Producer behavioral responses to the cocoa price boom (2023-2024).

Behavioural Response	Certified (N = 26)	Non-Certified (N = 79)	Total (N = 105)	% Total
Expansion of cultivated area	16 (61.5%)	63 (79.7%)	79	75.2%
Improved equipment & inputs	24 (92.3%)	77 (97.5%)	101	96.2%
Crop diversification	22 (84.6%)	69 (87.3%)	91	86.7%

Price elasticity of supply $\varepsilon = 0.04$ (inelastic supply). Source: Authors, field survey data (April-June 2024). ε computed from ICCO [2] data.

The calculated price elasticity of supply ($\varepsilon = 0.04$) reveals near-total inelasticity of cocoa production in the short run. A 1% increase in price yields only a 0.04% increase in the quantity supplied. This result is consistent with [33] global estimate ($\varepsilon = 0.07$ in the short run), and is explained by the biological constraints inherent to perennial cultivation (a 3 - 6 year lag before a new orchard reaches full production), land unavailability and saturation of existing cultivable areas, and prohibitive investment costs for smallholders. This inelasticity confirms that the observed behaviors (intensification, equipment upgrading, diversification) represent optimization responses to existing production rather than genuine supply increases. It is critical to specify that this global price-elasticity ($\varepsilon = 0.04$) acts as a market-level ICCO data, rather than an elasticity estimated directly from individual Cameroonian producer data. It provides the broader economic backdrop within which the local behavioral boundary must be understood.

It is particularly noteworthy that certified producers are proportionately less likely to expand their cultivated area (61.5% vs 79.7%) and more oriented towards intensification (improved practices, better equipment). This differentiated behav-

ior illustrates the disciplining effect of RA certification, which prohibits the extension of cocoa farms into forested areas and instead encourages sustainable intensification within existing plots. This is precisely the behavior that the EU Deforestation Regulation will reward from 2025 onwards, positioning certified producers favorably in international competition.

4.5. Study Limitations

Finally, a key contextual limitation of this study is that data regarding the exact duration or tenure of Rainforest Alliance certification for each certified producer was not collected. Consequently, the observed socioeconomic and profitability differences reflect a situational snapshot of exposure rather than an analysis of the cumulative, long-term impacts of certification tenure on producer behavior.

5. Conclusions and Recommendations

This study demonstrates that Rainforest Alliance certification generates substantial and measurable economic benefits for cocoa producers in West Cameroon, even though it entails significantly higher production costs. The superiority of the certified system across all three profitability criteria (NPV: +105%; BCR: 6.44 vs 4.58; payback period: 1 year vs 1 year 8 months) is robust and holds in the context of the 2023-2024 price boom. The key drivers of adoption (land tenure security, technical training, and farmer organization membership) provide precise levers for public policy and development actors.

The extremely low price elasticity of supply ($\varepsilon = 0.04$) underscores the structural vulnerability of producers to price volatility: even in the face of a historic 510% price increase between 2022 and 2024, production cannot adjust rapidly. In this context, crop diversification and the sustainable intensification of existing orchards (both of which certification actively encourages) constitute the most effective adaptation strategies.

The study's recommendations are directed at three categories of actors. For the Cameroonian Government: stabilize prices through a guaranteed minimum price mechanism, harmonize certification regulations, and align input and planting material support programs with producers' seasonal needs. For certification institutions (RA/UTZ): establish a meaningfully larger certified-conventional price differential (currently limited to 50 FCFA/kg), support the renewal of aging orchards (mean age of 21 years in our sample), and raise awareness amongst producers not yet engaged. For producers: prioritize cooperative affiliation to access training and certification, maintain farm accounting records to optimize management decisions, and adopt cultural practices that anticipate the requirements of European anti-deforestation regulations.

This study is subject to several limitations. The sample size (n = 105, including only 26 certified producers) constrains the statistical power of some tests. The reliance on producers' recall for multi-year accounting data introduces a risk of reporting bias. The geographical restriction to two departments in the West Region

calls for comparative studies covering other producing regions. Finally, longitudinal studies would enable better capture of the time-evolving effects of certification, including the impact of the EU Deforestation Regulation from 2025.

Conflicts of Interest

The authors declare no conflicts of interest.

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