

**ORIGINAL RESEARCH ARTICLE****OPEN ACCESS****The Impacts Of Macro Environmental Focus On Coffee Industry In Timor-Leste Sustainable Development Practices*****Valdo dos Santos Bapatista***Master of Business Administration (MBA) Program at University of the East (UE), Manila-Philippines**Email: valdodossantos23@gmail.com***ARTICLE INFO**

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Key word:

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This research investigated the macro environmental impacts of sustainable development practices within Timor-Leste's coffee industry with an emphasis on smallholder coffee farmers in the highland region of Ermera. This study employed a quantitative descriptive research design with a structured and validated self-questionnaire administered to 376 coffee farmers in the region of Ermera. The instrument measured perceived economic-environmental impacts in terms of income stability, market access, production efficiency, and inadequate infrastructure, and measured perceived social-environmental impacts in terms of community empowerment, gender participation, access to training, and life well-being. This study formulated statistical tools such as frequency distribution, weighted mean, Analysis of Variance (ANOVA), and independent sample t-test to apply using SPSS to determine the differences in perception through demographic profiles.



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INTRODUCTION

Timor-Leste's coffee industry has a long-standing history as a small country in Southeast Asia. It is with great pleasure that I state that this country has a historical background in Agriculture, specifically coffee. The coffee Industry has had a strong impact on the nation's economy and life for centuries. The Dutch were the first to introduce coffee to Timor-Leste in the 19th century, and they began its cultivation in the highland regions (Gomes et al., 2024). Coffee cultivation expanded over the years, and by the early 20th century, it was one of the country's main agricultural exports. At that time, the infrastructure and agricultural industry, especially coffee cultivation, were badly damaged during the Indonesian rule from 1975 to 1999. All sectors were neglected, especially most of the coffee industry during that period, and farmers lost access to important resources such as funding, high-quality seeds, and access to export markets. The sector now lacks the basic infrastructure to independently produce and brand its coffee at an internationally competitive level. This reflects both the challenge of industry development in a context of acute post-crisis stress, and also the unlikely prospect that fair-trade arrangements can deliver transformative change for deeply impoverished communities. (Khamis, 2015).

Timor-Leste started nation-building after gaining independence in 2002, and the coffee industry was having a hard time recovering from years of neglect and violence. Each community has a small ownership structure in the coffee sector and is marked by the reality on the specialty that, many farmers use traditional methods to grow coffee on their small plots of land, with enthusiasm to contribute to producing coffee. In the activity of planting and producing, there are advantages and disadvantages to this traditional method arrangement. However, with these shortcomings, it is not an obstacle to minimize the community but rather continues to encourage the involvement of many people in growing coffee because it can lead to increased social justice, although it still limits access to markets and contemporary technology, and large economic scales. Timor-Leste, after independence but still with unresolved political dynamics, must begin to rebuild the coffee industry because it is seen as a vital economic engine for the country; the coffee sector has great capacity to support thousands of small farmers. Various efforts have been made to revive the industry during the post-independence era, with an emphasis on improving Timor-Leste's coffee production methods and global market selling power. Therefore, the government is making every effort to push coffee into the global market as one of the important commodities that the government is pushing for economic growth. According to the World Bank (2024), Timor-Leste's entry into the World Trade Organization (WTO) created new economic opportunities, but also forced the government to comply with

international certification and norms, which created difficulties for regional farmers.

‘The coffee industry in Timor-Leste still faces several challenges despite this progress. Smallholder farmers still produce the majority of coffee, and they often lack access to the equipment and resources needed to improve yields and quality. According to the ADB (2020), farmers find it difficult to improve their growing methods and meet the growing demand for premium coffee due to lack of access to capital, technology, and training. In addition, a major obstacles to increasing the country’s coffee exports and achieving faster economic growth is the continued lack of infrastructure, such as effective roads and processing plants.’

‘The coffee industry development strategy now places a strong emphasis on sustainable development. According to Reindl (2019), international buyers and consumers prioritize sustainability when making purchases. So the Timor-Leste coffee industry has many things to implement ecologically friendly practices and guidelines, such as fair trade or organic. The government is moving to anticipate and find solutions to prioritize sustainability. Agroforestry and climate change adaptation techniques are two projects created by the Timor-Leste government to support sustainable coffee production methods in partnership with international organizations (Gomes et al., 2024). The National Coffee Sector Development Plan (2019-2030) has also been developed by the Ministry of Agriculture and Fisheries (MAF, n.d.). This plan outlines strategic objectives to increase coffee production, improve farmers’ living standards, and ensure environmental sustainability.’

These sustainable development initiatives are closely aligned with the ‘United Nations Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action)’. By promoting environmentally sound farming practices, improving livelihoods, and empowering smallholder farmers through fair trade and inclusive value chains (TraceX Technologies, 2023), Timor-Leste’s coffee industry is making a significant contribution to national development and global sustainability agendas (Asian Development Bank, 2020). The sector’s efforts to balance productivity, social equity, and environmental protection demonstrate its critical role in advancing the SDGs at both local and national levels.

‘With an emphasis on strengthening local communities via improved market access, fair trade policies, and sustainable production techniques, the coffee sector has emerged as a key component of Timor-Leste’s rural development plan in recent years. To ensure the long-term economic sustainability of coffee cultivation, it is important to address issues such as unfair trade practices and inadequate income distribution (Lerner et al. 2021). It is essential to continue encouraging the survival and thriving of smallholder farmers in an increasingly competitive global market, so the Timor-Leste coffee industry needs to develop a more inclusive, fair, and competitive market structure.

The study aims to demonstrate how sustainable practices contribute to long-term economic growth by evaluating their environmental effects, including better livelihoods, stronger community empowerment, increased income generation, and improved employment opportunities. To achieve this, the study will investigate how Timor-Leste’s coffee industry can support the country’s larger development goals. Furthermore, this project aims to promote a sustainable, inclusive, and resilient coffee industry in Timor-Leste that improves farmer livelihoods, preserves the environment, and strengthens community development.

THE METHOD

The study was carried out in one of Timor-Leste’s most significant coffee-producing regions, the central highland region of Ermera. The research uses a quantitative design. A structured questionnaire was carefully designed to match the research question based on a Likert Scale in 4-point Likert scale, ranging from 1 (strongly disagree) to 4-(strongly agree). To ensure the validity and reliability of the instrument, this research was carried out with a Pilot test.

Study design

Quantitative, cross-sectional survey conducted in the central highland (Ermera) coffee-producing region of Timor-Leste to measure how macro-environmental factors influence sustainable development practices in the coffee industry. Quantify relationships between macro-environmental domains (political-legal, economic, socio-cultural, technological, environmental/ecological, and possibly legal/regulatory) and firm/farmer sustainable-practice adoption.

Validity procedures

- Content validity: instrument items derived from literature, policy documents, and local stakeholder input; reviewed by subject experts (agronomists, extension officers) and local practitioners for relevance and clarity.
- Face validity: pilot respondents and local extension staff reviewed for comprehensibility and cultural appropriateness.
- Construct validity: planned statistical testing (exploratory factor analysis (EFA) followed by confirmatory factor analysis (CFA) if sample permits) to verify factor structure corresponds to hypothesized constructs.
- Convergent/discriminant evidence: use factor loadings, average variance extracted (AVE), and inter-construct correlations in CFA.

Reliability procedures

- Internal consistency: compute Cronbach’s alpha for each multi-item construct; target $\alpha \geq 0.70$ as acceptable, though exploratory research may accept slightly lower values.
- Item analysis: examine item-total correlations and alpha-if-item-deleted to refine scales.
- Pilot test reliability: pilot administration used to obtain preliminary alpha coefficients and identify problematic items.

Pilot testing

- Purpose: test item clarity, question flow, survey length, response patterns, and preliminary psychometric properties (reliability and factorability).
- Sample: small convenience sample from the target population (recommended 30–50 respondents across strata).
- Procedure: administer full questionnaire under field conditions representative of main study (same interviewers/language); record administration time and respondent feedback.
- Analysis: descriptive statistics for each item (means, SD, skewness), item-total correlations, Cronbach’s alpha, and EFA to detect poorly performing items or unexpected factor structures.
- Instrument revision: remove or reword ambiguous items, collapse or split constructs if necessary, and finalize instrument for main data collection.

Data collection

- Mode: interviewer-administered paper or tablet survey (CAPI) to accommodate varying literacy levels and to ensure consistent application of Likert anchors.
- Enumerator training: standardized training on question wording, neutral probing, informed consent, confidentiality, and handling ambiguous responses.
- Field protocol: consent procedures, privacy safeguards, and logging of refusals/nonresponse.
- Quality control: spot checks, re-interviews on a sub-sample, and daily data checks for missing or implausible responses.

Data preparation and screening

- Data entry/validation: double entry or validation checks for paper surveys; automated consistency checks for electronic capture.
- Missing data treatment: report rates; if low and random, use listwise deletion; if non-trivial, consider multiple imputation or EM methods and report sensitivity.

- Assumption checks: normality, linearity, homoscedasticity for parametric analyses; evaluate multicollinearity (VIF), sampling adequacy (Kaiser-Meyer-Olkin), and sphericity (Bartlett’s test).

Statistical analysis

- Descriptive statistics: frequencies, means, standard deviations for items and constructs; profile respondent/farm characteristics.
- Scale construction: EFA (principal axis factoring or maximum likelihood) with oblique rotation to identify factor structure; retain items with loadings ≥ 0.40 and minimal cross-loadings.
- Reliability testing: Cronbach’s alpha and composite reliability for each scale.

RESULT, ANALYSIS, DISCUSSION

Result

Table 15. Challenges Encountered by Coffee Farmers in Adopting Sustainable Development Practices

Indicators	Mean	Descriptive Interpretation
Difficulty affording the initial costs of adopting sustainable farming practices.	3.47	Major Challenge
Limited access to reliable information or training on sustainable farming techniques.	2.98	Moderate Challenge
Challenges in accessing organic or eco-friendly farming inputs.	3.20	Moderate Challenge
Limited support from the government or organizations in adopting sustainable practices.	3.04	Moderate Challenge
Difficulty convincing other farmers in the community to adopt sustainable methods.	3.15	Moderate Challenge
Lack proper tools and equipment needed for sustainable coffee farming.	3.53	Major Challenge
Difficulty accessing markets that value or pay more for sustainably grown coffee.	3.52	Major Challenge
When adopting sustainable farming practices, I sometimes return to traditional farming habits used in my community.	3.24	Moderate Challenge
Lack of confidence in the ability to consistently apply sustainable practices	3.36	Major Challenge
Poor infrastructure, like roads and irrigation, makes it hard for sustainable farming to succeed.	3.78	Major Challenge
WEIGHTED MEAN	3.33	Major Challenge

Table 16. Differences in Perceived Economic and Social Impacts Of Sustainable Development Practicvns in the Timor-Leste Coffee Industry When grouped based on Respondents’s Gender (Independent Sample Test)

Item	Mean Rank		t-test for Equality of Means			Decision	Remarks
	Male	Female	t	df	Sig.(2-tailed)		
Perceived Economic Impacts							
Income Stability	2.95	2.89	1.168	374	.244	Accept <i>H</i> ₀	Not Significant
Access to Local and International Markets	2.52	2.44	1.678	374	.094	Accept <i>H</i> ₀	Not Significant
Production Efficiency	2.58	2.57	.019	374	.985	Accept <i>H</i> ₀	Not Significant
Farm Infrastructure and Logistics	2.15	2.10	.831	374	.407	Accept <i>H</i> ₀	Not Significant
Perceived Social Impacts							
Community Empowerment	2.89	2.90	-.084	374	.933	Accept <i>H</i> ₀	Not Significant
Access to Training and Education Programs	2.84	2.81	.594	374	.553	Accept <i>H</i> ₀	Not Significant
Gender Participation and Equality	2.97	2.97	.121	374	.904	Accept <i>H</i> ₀	Not Significant
Community Well-being	3.06	3.12	-2.180	374	.030	Accept <i>H</i> ₀	Not Significant

Table 17. Differences in Perceived Economic and Social Impacts Of Sustainable Development Practicvns in the Timor-Leste Coffee Industry When grouped based on Respondents’s age

Perceived Economic Impacts	MS		df	F	Sig.	Decision	Remarks
	Between Groups	Within Groups					
Income Stability	3.359	.199	3,372	16.854	.000	Reject <i>H</i> ₀	Significant
Access to local and international markets	1.776	.165	3,372	10.749	.000	Reject <i>H</i> ₀	Significant
Production efficiency	3.569	.273	3,372	13.074	.000	Reject <i>H</i> ₀	Significant
Farm infrastructure and logistics	3.221	.328	3,372	9.811	.000	Reject <i>H</i> ₀	Significant
Perceived Social Impacts							
Community empowerment	3.085	.163	3,372	18.936	.000	Reject <i>H</i> ₀	Significant
Access to training and education Programs	2.932	.182	3,372	16.090	.000	Reject <i>H</i> ₀	Significant
Gender participation and equality	.536	.120	3,372	4.456	.004	Reject <i>H</i> ₀	Significant
Community well-being	.412	.066	3,372	6.223	.000	Reject <i>H</i> ₀	Significant

Table 18. Differences in Perceived Economic and Social Impacts of Sustainable Development Practices in the Timor-Leste Coffee Industry When Grouped Based on Educational Attainment

Perceived Economic Impacts	MS		df	F	Sig.	Decision	Remarks
	Between Groups	Within Groups					
Income Stability	3.216	.192	4,371	16.725	.000	Reject <i>H</i> ₀	Significant
Access to Local and International Markets	2.410	.154	4,371	15.642	.000	Reject <i>H</i> ₀	Significant
Production Efficiency	2.922	.271	4,371	10.780	.000	Reject <i>H</i> ₀	Significant
Farm Infrastructure and Logistics	4.752	.304	4,371	15.632	.000	Reject <i>H</i> ₀	Significant
Perceived Social Impacts							
Community Empowerment	2.481	.162	4,371	15.353	.000	Reject <i>H</i> ₀	Significant
Access to Training and Education Programs	2.631	.178	4,371	14.774	.000	Reject <i>H</i> ₀	Significant
Gender Participation and Equality	.989	.114	4,371	8.653	.000	Reject <i>H</i> ₀	Significant
Community Well-being	.091	.069	4,371	1.330	.258	Accept <i>H</i> ₀	Not Significant

Table 19. Differences in Perceived Economic and Social Impacts of Sustainable Development Practices in the Timor-Leste Coffee Industry, When grouped based on Years of Experience in Coffee Farming

Item	Perceived Economic Impacts	MS		df Between	F	Sig.	Decision	Remarks
		Between Groups	Within Groups					
Income Stability	.587	.222	3	372	2.650	.049	Reject <i>H</i> ₀	Significant
Access to Local and International Markets	.498	.176	3	372	2.836	.038	Reject <i>H</i> ₀	Significant
Production Efficiency	.413	.298	3	372	1.383	.248	Accept <i>H</i> ₀	Not Significant
Farm Infrastructure and Logistics	2.463	.334	3	372	7.367	.000	Reject <i>H</i> ₀	Significant
Perceived Social Impacts								
Community Empowerment	.334	.185	3	372	1.804	.146	Accept <i>H</i> ₀	Not Significant
Access to Training and Education Programs	.713	.200	3	372	3.563	.014	Reject <i>H</i> ₀	Significant
Gender Participation and Equality	.618	.120	3	372	5.162	.002	Reject <i>H</i> ₀	Significant
Community Well-being	.138	.068	3	372	2.016	.111	Accept <i>H</i> ₀	Not Significant

Analysis

Challenges Encountered by Coffee Farmers in Adopting Sustainable Development Practices

The presents the determinants of the challenges encountered by coffee farmers in adopting sustainable development practices. These findings indicated that among determinants, item 10, “Poor infrastructure, like roads and irrigation, makes it hard for sustainable farming to succeed”, with score the highest Mean = 3.78, as “Major Challenges.” This interpreted that inadequate infrastructure significantly impedes the successful adoption of sustainable practices of coffee farming. Item 6 “Lack of proper tools and equipment needed for sustainability coffee farming” with score ($\bar{x}$ = 3.53) as “Major Challenges”, item 7 “Difficulty accessing markets that value or pay more for sustainability grown coffee” with score ($\bar{x}$ = 3.52) as “Major Challenges” item 1 “Difficulty affording the initial cost of adopting sustainable farming practices” with score ($\bar{x}$ = 3.47) as “Major Challenges” and item 9 “Lack of confidancne in the abity to consistently apply sustainable practices” with score ($\bar{x}$ = 3.36) as “Major Challenges”. In contrast, other determinants showing in the item are moderate challenges such as item 2 “Limited access to reliable information or training on sustainable farming techniques with a mean 2.98, in item 3 “Challenges in accessing organic or eco-friendly farming inputs, with score ($\bar{x}$ = 3.20), item 4 “Limited support from government or organizations”, with score ($\bar{x}$ = 3.15), and item 8 “occasional reversion to traditional farming habits with score ($\bar{x}$ = 3.24). In summary, the weighted mean within all determinants is 3.33 for “Major Challenges”. The results of the determinants of challenges supported by findings by Tay et al. (2024), emphasize that the sustainable agricultural adoption in developing countries often faces significant impede due to resource constraints, market limitations, and weak institutional support which mirrors the experience of the coffee farmers in this study.

This result align with research conducted by Gome., et al (2022) the sustainable development practices in coffee farming encompass a broad set of farm and governance responses intended to improve environmental stewardship, livelihood resilience, and long-term productivity. Across the coffee sector, these practices are often linked to climate adaptation, soil and water conservation, and market differentiation through certification or specialty channels. Yet the literature consistently shows that adoption is uneven, partial, and shaped by interacting economic, institutional, and social constraints rather than by farmer awareness alone. This matters because coffee is simultaneously a commercial crop and a livelihood base, so barriers to adoption can directly affect income stability and environmental sustainability.

Differences in Perceived Economic and Social Impacts Of Sustainable Development Practicws in the Timor-Leste Coffee Industry When grouped based on Respondents's Gender (Independent Sample Test)

In Table 16, the findings of the independent sample t-test showing no significant differences between male and female respondents with all indicators examined of the coffee industry in Timor-Leste. In terms of perceived economic impacts, income stability ($t(374) = 1.168$, $p = .244$), access to local and international markets ($t(374) = 1.678$, $p = .094$), production efficiency ($t(374) = .019$, $p = .985$), and farm infrastructure and logistic ($t(374) = .831$, $p = .407$) identified no statistically significant differences between genders. In a similar manner, for perceived social impacts such as community empowerment ($t(374) = -.084$, $p = .933$), access to training and education programs ($t(374) = .594$, $p = .533$), gender participation an equality ($t(374) = .121$, $p = .904$), and community well-being ($t(374) = -2.180$, $p = .030$), demonstared that also no significant differences.

These findings show that male and female respondents of coffee farmers perceived the economic and social impacts of sustainable development practices in the Timor-Leste coffee industry. To rephrase, there are no meaningful differences between genders in how they assess factors such as income stability, market access, production efficiency, farm infrastructure community empowerment, access to training programs, gender participation and equality, community well-being. Consequently, The null hypotheses are accepted for all variables, suggesting that gender does not play a significant role in shaping respondents, perceptions of these sustainable development practices. In general, this consistency suggests that both male and female stakeholders share similar experiences and assessments regarding the benefits and challenges of implementing sustainable development practices of coffee farmers in rural.

Differences in Perceived Economic and Social Impacts Of Sustainable Development Practicws in the Timor-Leste Coffee Industry When grouped based on Respondents's age

Based on the ANOVA test showed significant differences between age groups for all variable indicators examined of the coffee industry in Timor-Leste. In terms of perceived economic impacts, income stability ($F(3,372) = 16.854$, $p < .001$), access to local and international markets ($F(3,372) = 10.749$, $p < .001$), production efficiency ($F(3,372) = 13.074$, $p < .001$), and farm infrastructure and logistic ($F(3,372) = 9.811$, $p < .001$) identified no statistically significant differences between genders. In a similar manner, for perceived social impacts such as community empowerment ($F(3,372) = 18.936$, $p < .001$), access to training and education programs ($F(3,372) = 16.090$, $p < .001$), gender participation an equality ($F(3,372) = 4.456$, $p < .004$), and community well-being ($F(3,372) = 6.223$, $p < .001$), demonstared that also revealed significant variations among age groupsno significant differences. Same as research conducted by Lerner, D. G., Saes, M. S. M., Oliveira, G. M., & Pereira, H. M. F. de. (2021) the sustainable practices discussed in the source literature include climate-smart technologies, organic and Fair Trade systems, agroforestry, soil and water conservation, improved irrigation, and broader sustainable farm and environmental practices. Evidence from Vietnam, Ethiopia, Nicaragua, Colombia, Brazil, and Uganda indicates that these practices can support adaptation or improve some farm

outcomes, but they often demand skills, capital, and coordination that many smallholders do not readily possess. As a result, sustainability is not simply a technical package; it is also a matter of access, trust, and institutional design.

These findings show that the age respondents of coffee farmers perceived the economic and social impacts of sustainable development practices in the Timor-Leste coffee industry vary according to age. To rephrase, there are differences that age groups have distinct access factors such as income stability, market access, production efficiency, farm infrastructure community empowerment, access to training programs, gender participation and equality, and community well-being. Consequently, The significant ANOVA results lead to the rejection of the null hypotheses for all variables, suggesting that age is a meaningful factor a significant how respondents perceived the effects of sustainable development practices of coffee farmers. This indicated the importance of considering age-related perspectives when evaluating sustainable practices in the Timor-Leste coffee industry.

Differences in Perceived Economic and Social Impacts of Sustainable Development Practices in the Timor-Leste Coffee Industry When Grouped Based on Educational Attainment

The data analysis showed through the one-way ANOVA test show significant differences respondents educational attainment for most variable indicators examined of the coffee industry in Timor-Leste. In terms of perceived economic impacts, income stability ($F(4,371) = 16.725$, $p < .001$), access to local and international markets ($F(4,371) = 15.642$, $p < .001$), production efficiency ($F(4,371) = 10.780$, $p < .001$), and farm infrastructure and logistic ($F(4,371) = 15.632$, $p < .001$) identified statistically significant differences across different levels of educational attainment. In a similar manner, for perceived social impacts such as community empowerment ($F(4,371) = 15.353$, $p < .001$), access to training and education programs ($F(4,371) = 14.774$, $p < .001$), gender participation an equality ($F(4,371) = 8.653$, $p < .004$), and community well-being ($F(4,371) = 1.330$, $p < .258$), did not also significant differences amon grespondents educational attainment.

These findings show that educational attainment respondents of coffee farmers perceived the economic and social impacts of sustainable development practices in the Timor-Leste coffee industry vary according to respondents level of education attainment. Specifically, respondents with different educational backgrounds have distinct assess evaluation of income stability, market access, production efficiency, farm infrastructure community empowerment, access to training programs, gender participation and equality. In terms of, perceptions of overall community well-being appear to be relative consistent according to educational attainment. The significant ANOVA results lead to the rejection of the null hypotheses for most variables, while the non-significant result of community well-being supports the acceptance of the null hypothesis. Suggesting that educational attainment influences respondents perceptions of several aspects of sustainable development practices of coffee farmer. This indicated the importance of considering educational attainment when related stakeholders experience and expectation in the Timor-Leste coffee industry.

Differences in Perceived Economic and Social Impacts of Sustainable Development Practices in the Timor-Leste Coffee Industry, When grouped based on Years of Experience in Coffee Farming

According to the one-way ANOVA test show significant differences respondents years of experience in coffee farming are associated with significant variations in some, but not all, for the coffee industry in Timor-Leste. In terms of perceived economic impacts, income stability ($F(3,372) = 2.650$, $p = .049$), access to local and international markets ($F(3,372) = 2.836$, $p = .049$), production efficiency ($F(4,371) = 10.780$, $p < .038$), and farm infrastructure and logistic ($F(3,372) = 7.367$, $p < .001$) identified statistically significant differences across different experience groups. In a similar manner, for perceived social impacts such as production efficiency ($F(3,372) = 2.48$, $p = .248$) did not show significant variation.

For the perceived social impacts, access to training and education programs ($F(3,372) = 3.563, p < .014$), gender participation an equality ($F(3,372) = 5.162, p = .002$), demonstrated significant differences based on years of experience of coffee farmer. However, for community empowerment ($F(3,372) = 1.804, p = .146$), and community well-being ($F(3,372) = 2.016, p = .111$), did not also vary significant among experience groups.

These findings show that years of experience of coffee farmin perceived the economic and social impacts of sustainable development practices in the Timor-Leste coffee industry influence their perceptions of certain economic and social impacts. Specifically, income stability, market access, farm infrastructure, access to training programs, and gender participation and equality. But, experience dos not appear to affect perceptions of production efficiency, community empowerment and community well-being. The results indicate partial rejection of the null hypotheses, suggesting that practical experience contributes to differences in some perceptions of sustainable development practices. Overall, these findings highlight the importance of considering farmers' experience when evaluating initiatives to promote sustainable development practices in the Timor-Leste coffee sector.

Discussion

Adoption of sustainable development practices in Timor-Leste's coffee sector occurs within a complex mix of biophysical strengths, entrenched smallholder structures, market uncertainties, and varied socio-cultural contexts. The discussion that follows synthesizes observed challenges and interprets differences in perceptions of economic and social impacts across gender, age, and educational attainment. Where appropriate, illustrative vignettes and comparative reasoning are used to clarify how structural factors and lived experience shape attitudes and behaviors toward sustainability interventions. The aim is to move from description to explanation and to identify implications for policy, program design, and future research.

Alignment with Prior Studies and Interpretation of the Findings

The present findings align closely with prior research showing that coffee sustainability challenges arise from the convergence of resource constraints, governance deficits, and behavioral inertia. Across regions, studies report that adoption is not blocked by a single factor but by the interaction of market incentives, institutional support, and local capability. This convergence is important because it explains why interventions focused narrowly on certification or training often yield partial results. The literature therefore supports a multidimensional interpretation of adoption barriers.

A further implication is that physical infrastructure and farm-level access conditions shape whether sustainability is even operationally feasible, since irrigation, transport, and input availability are repeatedly identified as enabling or constraining adoption in coffee systems. Evidence from coffee-barrier typologies also shows that adoption setbacks cluster around cost, knowledge, access, and organizational support, which helps explain why farmers may recognize sustainability benefits yet still fail to implement them consistently. In this sense, the present findings fit a broader pattern in which adoption depends on both material capacity and the surrounding institutional ecosystem. Comparative studies also suggest that perceived sustainability gains translate into adoption only when farmers can offset transition risks through better prices, dependable buyers, or certification-linked rewards. Where those incentives are weak, farmers tend to remain exposed to price volatility and continue relying on familiar production routines, even when they acknowledge environmental benefits. This helps explain why confidence, market access, and institutional backing emerge as decisive constraints rather than secondary concerns. Infrastructure and input bottlenecks further narrow the space for adoption, because irrigation, transport, and farm-level equipment shape whether sustainability measures can be maintained beyond the pilot stage. Studies of coffee agroecosystems

likewise show that technical adoption is more durable when extension, finance, and producer organizations reduce the transaction costs of change. This is especially important for smallholders, for whom implementation barriers often accumulate across multiple practice domains rather than appearing as a single constraint. These layered barriers also help explain why adoption often remains partial: farmers may implement one practice while postponing others that require more capital, labor coordination, or access to specialized inputs. In several coffee systems, sustainability uptake is strongest when market incentives are matched by practical support for training, organization, and farm infrastructure, rather than information alone.

As a result, improving enabling conditions can matter as much as promoting the practices themselves. Comparable constraints are reported in coffee studies from Vietnam and Nicaragua, where farmers' willingness to adopt sustainable practices depends not only on awareness but also on whether market conditions and institutional arrangements make the shift economically feasible. Evidence from Colombia and Costa Rica further shows that adoption is more likely when producer incentives, certification support, and broader sustainability governance align with farm-level capacities. Taken together, these findings suggest that the main bottleneck is not interest in sustainability, but the ability to convert that interest into routine practice under resource-poor conditions.

This interpretation is also consistent with barrier typologies that separate financial constraints, infrastructure gaps, input shortages, and weak extension support as distinct obstacles to sustainable coffee adoption. Studies of smallholder coffee systems similarly show that producers are more likely to adopt when access to tools, advisory services, and collective organization reduces the transaction costs of changing farm routines. Where those supports are absent, farmers may recognize the benefits of sustainability but still struggle to sustain implementation over time. Infrastructure-related constraints may be especially consequential because coffee sustainability depends on reliable water access, transport, and postharvest handling, all of which shape whether improved practices can be used consistently at farm level.

Reviews of coffee value chains also show that sustainability gains are limited when problems in logistics, processing, and market coordination persist beyond the plot boundary. In this sense, farmer behavior is only one part of the transition; the surrounding enabling environment can determine whether adoption remains partial or becomes durable. Empirical studies also indicate that market incentives and price premia matter because farmers are more willing to maintain sustainable methods when certification or specialty channels improve returns relative to conventional coffee. At the same time, adoption is often uneven across households, with access to information, farm resources, and social networks shaping whether practices move from trial use to routine management. These findings suggest that the main barrier is not simply awareness, but the combination of financial risk, weak market rewards, and limited institutional backing that constrains sustained uptake.

Comparison with Evidence from Coffee-Producing Regions

The pattern observed here is reinforced by evidence from Vietnam, Ethiopia, Nicaragua, Colombia, Uganda, Brazil, Peru, Costa Rica, and the Philippines. Farmers' intentions are shaped by social norms and perceived control in Vietnam while education, extension, and radio ownership matter in Ethiopia. Cooperative membership raises adoption in Nicaragua and bundled practice uptake in Ethiopia depends on literacy, training, labor, and certification. In Uganda, standards do not fully eliminate trade-offs between socioeconomic and environmental outcomes and in Vietnam certification does not automatically improve water efficiency. Collectively, these findings support the present conclusion that sustainability adoption requires more than awareness.

The results indicate an absence of significant gender differences across measured indicators, and pronounced, statistically significant variation across age groups. The interpretation below attends first to the gender findings, then to the age-related differences, before synthesizing implications for policy, practice, and future research. Each section connects empirical results to broader theoretical and empirical literatures, proposes plausible mechanisms, and advances concrete recommendations for stakeholders policymakers, development practitioners, cooperatives, producer organizations, and researchers. The discussion also integrates illustrative vignettes that animate the lived realities these statistics reflect, and highlights methodological limitations that temper generalization. Ultimately, this analysis argues that the observed pattern gender parity in perceptions paired with significant age heterogeneity speaks to contextual social dynamics in Timor-Leste and to the evolving nature of sustainable agricultural practices: implementation and impact are shaped more by life-stage, experience, and exposure than by binary gender alone, though gendered structures remain crucial background conditions.

The independent sample t-tests reveal no statistically significant differences between male and female respondents across all economic and social impact indicators examined: income stability, access to local and international markets, production efficiency, farm infrastructure and logistics, community empowerment, access to training and education, gender participation and equality, and community well-being. The null hypotheses for gender were accepted in each case.

At face value, these findings indicate that male and female coffee farmers and stakeholders in the sampled population of Timor-Leste report comparable assessments of how sustainable development practices affect their livelihoods and communities. This parity suggests that both genders experience and perceive the benefits and challenges associated with sustainability interventions in similar ways.

Timor-Leste's socio-cultural context is patriarchal, with traditional norms influencing decision-making roles, resource control, and labor divisions. Women often have domestic responsibilities and may be less visible in formal economic domains; yet women in many rural coffee-producing communities frequently contribute substantively to farming activities including harvesting, processing, and post-harvest handling.

The lack of significant gender differences in perceptions must therefore be interpreted against this backdrop: parity in reported perceptions need not equate to parity in opportunity, control of resources, or decision-making power. Rather, it indicates similarity in subjective assessment of certain impacts. In a patriarchal setting, this could arise when women's indirect or unpaid contributions translate into similar assessments of outcomes as men, or when interventions explicitly target inclusiveness, ensuring women receive tangible benefits.

Empirical studies present mixed evidence on gendered perceptions of agricultural interventions. Some studies observe markedly different assessments between men and women due to differential access to resources, information, and markets; others document minimal perceptual differences where interventions have achieved inclusive outreach or where community-level benefits are salient.

The Timor-Leste finding aligns with evidence suggesting that when sustainable practices generate visible, collective gains (e.g., improved local infrastructure or higher community incomes), men and women may perceive benefits similarly. Conversely, when benefits are contingent on individual asset ownership or control (e.g., access to credit tied to land ownership), gendered differences are more pronounced. Thus, the pattern observed here

suggests that the sustainable development practices in the studied coffee communities likely produce effects that are salient at the level of households and communities, rather than exclusively accruing to individual resource owners.

ANOVA results show statistically significant differences across age groups on all economic and social indicators examined: income stability, access to local and international markets, production efficiency, farm infrastructure and logistics, community empowerment, access to training and education programs, gender participation and equality, and community well-being. These outcomes indicate that perceptions of the impacts of sustainable development practices vary meaningfully by respondent age.

The empirical pattern observed in Timor-Leste offers broader theoretical implications. It highlights the necessity of treating demographic variables as multifaceted and interactive determinants of perception and behavior. Gender, while a central axis of inequality, does not always manifest in perceptual divergence; other axes such as age may be equally or more influential depending on context.

The evidence from the Timor-Leste coffee industry reveals a nuanced picture: men and women report similar perceptions about the economic and social impacts of sustainable development practices, yet age significantly differentiates these perceptions. This pattern implies that while gender-based outreach may be achieving surface-level inclusivity, generational experiences and resources fundamentally shape stakeholders' assessments and capacities to benefit.

Consider the village of Lautem (composite example reflecting common patterns): Here, a cooperative introduced agroforestry training, improved drying beds, and facilitated a link to an international buyer. Men and women gathered for the opening workshop; both applauded the potential for improved incomes. Yet the young returned to urban training, set up an online ordering calendar, and pushed for an investment in mechanized pulping. Mid-career farmers reinvested premiums into processing, seeing steady income gains. Elders watched improvements but worried about the sustainability of a market that demanded uniform beans and precise post-harvest handling. The cooperative leaders realized that to sustain inclusive growth they needed not only to maintain gender-balanced participation in meetings but also to create mentoring programs pairing youth with experienced farmers, and flexible financing that recognized elders' capital constraints. Over time, these efforts produced a more resilient value chain in which both genders saw benefits and generations cooperated.

That vignette encapsulates the practical imperative: achieving sustainable, equitable development in agricultural sectors requires policies attentive to multiple social axes. Gender inclusion is an essential baseline, but age-differentiated strategies that harness the strengths of each cohort youthful innovation, mid-life investment capacity, and elders' knowledge will systematically enhance the effectiveness and fairness of interventions.

In closing, the equilibrium of perceptions between men and women in Timor-Leste's coffee communities offers a promising foundation for scaling sustainable practices. However, the divergent lenses through which different age cohorts view these practices must be purposefully integrated into program design. By doing so, stakeholders can convert perceptual convergence into sustained, equitable material gains that strengthen livelihoods across generations.

Findings

The findings of the research indicate the critical role of coffee farming in the socio-economic stability of rural communities in Timor-Leste. The study

identified the challenges; such as inadequate infrastructure, high financial cost for sustainable adoption, limited access to the market, difficulty access to certification, and unsupported institutional, are present serious barriers to minimizing the potential of sustainable development practices of coffee farming. Statistical evidence also suggest regarding while gender differences are negligible, younger and more educated coffee farmers are more welcoming to sustainable innovation, show opportunity for renerational renewal and knowledge transfer in the coffee farmer. For the most part, the sustainability of the coffee industry in Timor-Leste aligns with the convergence of tradition and innovation.

The overall weighted mean across all evaluated challenges is 3.33, classifying them collectively as "Major Challenges." The barriers are split into major and moderate hurdles, aligning with global findings (e.g., Tay et al., 2024) that resource constraints and weak institutional support hinder sustainable agricultural adoption in developing nations.

To successfully scale sustainable coffee farming in Timor-Leste, institutional programs must address structural bottlenecks (infrastructure, tool deficits, and premium market access) as a priority. Furthermore, while outreach programs do not need to be structurally customized by gender, they must be tailored carefully to accommodate variations in age, formal education levels, and practical farming experience.

CONCLUSION

Adoption of sustainable development practices in Timor-Leste's coffee sector is constrained by interlocking economic, institutional, demographic, and socio-cultural factors. Differences in perceived economic and social impacts by gender, age, and education reflect underlying disparities in asset access, labor allocation, risk preferences, and information networks. Addressing these requires integrated strategies: strengthening collective institutions, aligning financial instruments with adoption timelines, investing in inclusive capacity building, and developing market structures that reliably reward quality and sustainability. By designing gender and age-sensitive interventions, simplifying certification pathways, and fostering local value addition, policymakers and development partners can convert Timor-Leste's biophysical advantages and traditional agroforestry practices into sustainable livelihoods and resilient coffee economies.

RECOMMENDATION

The collaboration government with development partners, should prioritize investments in farm to the markets road, post harvest equipment, and storage system of farming. Also improve infrastructure will helped to reducing post harvest losses, enhance product quality, and expand access to local and international markets.

Government policymakers should provide subsidies, access to credit, or offer low interest loans to support coffee farmers in adopting sustainable farming techniques and certifications. This wil helped to reduce the financial burden of transitioning to environmentally sound practices.

Agricultural and NGOs should expand training programs focused on sustainable coffee farming, quality improvement training, and entrepreneurial skills. Training is crucial that must be tailored to coffee farmers educational backgrounds.

Institutional support should ensure that, women and younger coffee farmers are must include in leadership roles, and in decision making process within cooperatives, and farming association in communities. This will help promote intergenerational knowledge transfer, inclusivity, and greater innovation in the coffee farming sector.

For coffee cooperatives should be empowered to negotiate better prices, establish direct trade partnerships, and pursue certifications like organic, fair trade to promote stronger markets linkages to enhance profitability, and global competitiveness.

The central government should formulating policies on agriculture, trade, and rural development to helping environment for coffee sustainability, also create stronger collaboration among ministers relevant, cooperatives, and private stakeholders are needed to avoid fragmented intervention.

Studies should examine the long term economic-environmental impacts of sustainable development farming on household income and future wealth, as well as the role of climate change in shaping coffee farmer productivity in Timor-Leste. For the future research may also compare the effectiveness of traditional practices adoption versus modern techniques practices adoption to guide based policymakers.

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