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The Influence of Farmer Collaboration on the Sustainability Performance of Cashew Nut Supply Chains in Tanzania

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Abstract

Supply chains are key in implementing sustainability performance, yet it remains unclear how farmer collaboration can enhance the sustainability performance of Cashew nut supply chains. Cashew nuts are among Tanzania's major cash crops, with export revenues of over US$302 million in 2024. The crop has huge potential to eradicate poverty, reduce price fluctuations, and improve farmers' bargaining power. However, the extent to which cashew supply chains deliver economic, social and environmental sustainability performance is still not well understood in the Tanzanian context. Grounded in Social Exchange Theory, this study examines the influence of farmer collaboration on sustainability performance of Cashew nut supply chains in Tanzania. A quantitative survey was conducted to collect data from 400 farmers in Mtwara, Lindi and Ruvuma regions. A proportionate stratified sampling technique was employed for selecting the sample. For data analysis, structural equation modelling was employed. Results show a significant positive influence of farmer collaboration on all three dimensions of sustainability performance, indicating that when farmers work together, they can gain cost advantages, spread risks and thereby improve their supply chains' sustainability performance. By studying all three dimensions within a single model, practitioners can draw on this knowledge to enhance production efficiencies, community welfare and environmental management. It is recommended that supply chain partners collaborate with policymakers and design programs that strengthen group-based governance structures and build grassroots capabilities for collaborative actions. The article contributes to the operations research literature by operationalising sustainability performance as a multidimensional supply chain problem, providing empirical relationships that prioritise collaboration among farmers to improve economic, social and environmental sustainability performance.

Keywords: Farmer Collaboration, Sustainability Performance, Supply Chain, Cashew Nut

Introduction

Sustainability performance in agriculture has shifted from a secondary option to a central pillar for global agribusiness strategy (Azevedo et al., 2018). It denotes how stakeholders deliver products while treating people fairly and staying financially responsible at all times. Sustainability shift reflects an increase in agriculture's contribution to soil degradation and carbon emissions (Hidayati et al., 2023). Sustainability performance in European countries has been institutionalised through regulations and is understood not only in environmental terms but also in social and economic terms, highlighting its relevance across food supply chains (Dos Santos

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& Ahmad, 2020). Examples of integrative approaches to sustainability performance can be drawn from Brazil, where Cashew farmers combine energy efficiency, cost reduction, and community welfare to improve their supply chain performance (Azevedo et al., 2018). This tactic provides a broader review of sustainability performance while minimising trade-offs among supply chain partners (Dos Santos & Ahmad, 2022). Implementing sustainability performance is limited across developing countries and in African countries, sustainability performance reporting is lacking. This gap is linked to constraints embedded in the African agricultural landscape, including inadequate infrastructure and poor technologies, making it riskier for farmers operating in isolation to perform sustainably (Marquina et al., 2024; Meena et al., 2023). Emerging initiatives in the Southern African region on sustainability performance such as waste recycling, demonstrate the potential to enhance sustainable supply chains. Existing studies show that these initiatives are most effective when multi-stakeholders work together (Kanyoma et al., 2020). In such settings, collaboration is vital to maximise performance.

The literature on supply chains examines collaboration and its influence on sustainability performance (Marquina et al., 2024; Awan et al., 2022). Collaboration is recognised as a strategic approach through which farmers enhance performance of their supply chains (Wu et al., 2014; Chen et al., 2017; Moreno-Miranda & Dries, 2022). Such collaboration can be organised vertically, when actors interact with traders and customers or horizontally when farmers partner with other farmers (Rolfe et al., 2022; Dania et al., 2018). By pooling resources, farmers increase efficiency, improve returns, reduce market uncertainties and enhance overall supply chain performance (Msaddak et al., 2021). However, in smallholder-dominated supply chains, empirical evidence for a direct effect of farmer collaboration on sustainability performance is limited and findings have been inconsistent. Some studies suggest limited farmer collaboration in supply chains (Meena et al., 2023; Kanyoma et al., 2020), while others confirm a significant and positive relationship between collaboration and sustainability performance (Azevedo et al., 2018; Kumari et al., 2018; Marquina et al., 2024). In contexts where farmer collaboration is expected to boost sustainability performance through shared learning and better coordination across supply chains, outcomes still vary across different settings (Meena et al., 2023). These inconsistencies highlight a key empirical gap.

The Tanzanian cashew nut subsector, one of the leading export sectors, has experienced steady growth, driven by supportive policies and rising global demand for organic crops (Aku et al., 2023). In 2024, agricultural exports accounted for about USD 3.22 billion, equivalent to 20% of the country's GDP, with cashew exports alone generating over USD 300 million (TICGL, 2025). These figures suggest the subsector's potential to improve the sustainability of the cashew supply chain. However, farmers operating in isolation face persistent challenges, including limited value-addition capacity, weak environmental protection practices and low bargaining power, which constrain their sustainability performance (Mgonja & Shausi, 2022). In such contexts, farmer collaboration has been promoted as a potential solution to these issues (Dania et al., 2018). However, without the supporting conditions of skills, commitment and institutional backing, such initiatives risk reproducing inefficiencies rather than delivering better rewards for farmers (Krishnan et al., 2021).

The literature on cashew nut supply chains indicates limited empirical evidence on how farmer collaboration translates into sustainability performance (Azevedo et al., 2018). Prior studies have emphasised efficiency and overall sustainability performance in developed economies (Ali et al., 2017; Marquina et al., 2024), overlooking the challenges of implementing sustainability performance in emerging economies. This is evident in Tanzania, where cashew supply chains are fragmented and farmers face persistent challenges in production and marketing (Mihyo et al., 2019). Findings on the relationship between farmer collaboration and sustainability performance have often been inconsistent (Kumari et al., 2021; Azevedo et al., 2018; Dania et al., 2018). Some studies indicate that limited collaboration between farmers constrains sustainability performance (Meena et al., 2023; Huo et al., 2022; Kanyoma et al., 2020), while others report that farmer collaboration improves better resource use and environmental management (Dania et al., 2018; Azevedo et al., 2018; Marquina et al., 2024). The limited Tanzania-specific focus indicates a need for further empirical investigation to address the knowledge gap. This study utilises social exchange theory to examine collaboration among farmers in Tanzanian cashew nut supply chains. It focuses on shared activities, resources, communication, knowledge sharing and information exchange. In doing so, it aims to provide valuable theoretical, practical and empirical insights into the influence of farmer collaboration on production economic sustainability performance, social sustainability performance and environmental sustainability performance.

Theoretical Perspective

The study adopts Social Exchange Theory (SET), pioneered by Homans (1958), to understand why farmers collaborate. SET examines the social structure underpinning collaboration. The theory assumes that social behaviour is grounded in the exchange of rewards and costs. In this study, SET frames collaboration as an exchange relationship in which farmers participate because they expect sustainability performance as rewards (Blau, 1968). Through collaboration, these farmers exchange local knowledge, production inputs, or market information in return for improved performance across their supply chains (Marquina et al., 2024). From the SET perspective, Tanzanian farmers can achieve better outcomes by engaging in joint activities that reduce production costs (Paavilainen et al., 2021). As long as these exchanges remain mutually rewarding, collaboration persists; when they cease to be beneficial, relationships weaken (Blau, 1968). SET is particularly relevant to farmer collaborations, where the efficiency of production, processing and marketing activities depends on reciprocal flows of economic and social rewards that define sustainability performance (Marquina et al., 2024; Badraoiu et al., 2020). These aspects align with SET, where peer learning, shared enforcement of good agricultural practices and access to training would lead to environmental sustainability performance rewards. Thus, SET guides the analysis by treating farmer collaboration as a social exchange relationship and sustainability performance as a reward that can improve when such an exchange remains mutually beneficial. When farmers communicate regularly, share resources and information and believe their relationships are significant, collaboration becomes more likely to improve sustainability performance in cashew supply chains.

Empirical Literature and Hypotheses Development

Farmer Collaboration and Economic Sustainability Performance of a Supply Chain

Empirical studies have examined the influence of collaboration on economic performance across a wide range of settings, including various forms of cooperatives, supply chain arrangements and farmer organisations in diverse countries and entities. The first dimension of sustainability performance in this study is Economic Sustainability Performance (ECOP), defined as a measure that emphasises cost savings and economic gains derived from resource use and collaboration, which are more relevant to explaining sustainability performance in agricultural terms (Jennings, 2013). Evidence from food supply chains in Germany shows that interaction mechanisms such as the sharing of information and knowledge can secure fair pricing, reduce costs and strengthen community engagement (Stoeva et al., 2024), while digital platforms reduce transaction costs, improve coordination efficiency and reinforce collaborative ties among actors (Zhou et al., 2024). A second line of studies points to cooperatives as institutionalised systems of collaboration that spread fixed costs and strengthen members' bargaining power (Dos Santos et al., 2020). Farmer commitment is associated with improvements in outputs and revenues (Donkor & Hejkrlik, 2021). Cooperative farming models also enhance rural economic development by increasing incomes and lowering costs (Kareska, 2025). They promote resource sharing, social capital and environmental practices (Zhu & Wang, 2024). Other scholars suggest specific cost-related mechanisms that can reduce transaction expenses and increase access to information, knowledge and key resources (Dos Santos et al., 2020), and that farmer–farmer collaboration is associated with higher profits (Khong, 2022). Hence, farmer collaboration appears to improve economic sustainability performance by spreading risks and increasing cost efficiency. The study hypothesises the following:

H1: Farmer collaboration positively influences the economic sustainability performance of the supply chain

Farmer Collaboration and Social Sustainability Performance of a Supply Chain

Social sustainability performance in this study is defined as promoting social equity, community well-being, and fair labour practices, ensuring that agricultural practices benefit all stakeholders, including farmers (Marquina et al., 2024). According to Sudusinghe and Seuring (2022), frequent information sharing helps ensure that stakeholders are well informed and can participate in timely decision-making processes. This emphasis on participation and information symmetry is reinforced by Hidayati et al. (2023), who found that joint farming practices are significant enablers of sustainable agricultural value chains. These studies suggest that farmer collaboration is a core element of social equity and is essential to delivering social sustainability performance. Other scholars have shown how farmer collaboration builds community well-being and social support networks. In their study, Ariadi et al. (2024) found that activity sharing influences collaboration. Connecting this to wider social challenges, Dania et al. (2018) pointed out the need for farmers to collaborate to minimise challenges affecting supply chains. Zhang et al. (2021) demonstrated that participation in agricultural cooperatives ensures food safety. Fontana and Pisalyaput's (2023) results show that sustainability practices raise household incomes. Kareska (2025) analysed cooperative farming models in Europe using case studies and demonstrated how social sustainability performance fosters social cohesion and community support for development initiatives. Together, these studies reveal the power of social sustainability performance in terms of income, protection and community welfare. Therefore, the research hypothesises:

H2: Farmer collaboration positively influences the social sustainability performance of the supply chain

Farmer Collaboration and Environmental Sustainability Performance of a Supply Chain

Environmental Sustainability Performance (EP) in agriculture involves adopting practices that reduce ecological footprints while enhancing productivity (Azevedo et al., 2018). Globally, food supply chains generate solid waste, greenhouse gas (GHG) emissions and soil degradation (Morone et al., 2019). Arcuri and Giolli (2022) explored the relationship between vertical integration and environmental sustainability, finding that higher levels of integration were associated with positive outcomes. Sudusinghe and Seuring (2022) identified practices that foster collaboration in food chains, with product recovery playing a crucial role in enhancing sustainability performance. Liu et al. (2025) found that agricultural cooperatives strengthen agri-food value chains by providing technical and financial support for environmental management. Barbosa and Cansino (2024) demonstrated that environmental collaboration in supply chains enhances performance in managing carbon emissions, energy waste and water footprints. Milliet et al. (2024) found that training farmers in good environmental practices positively affected their pro-environmental behaviours, underscoring the importance of group-based collaboration. Thus, based on the previous results, it is hypothesised that:

H3: Farmer collaboration positively influences the environmental sustainability performance of the supply chain

Conceptual Model

The conceptual model for this research (Figure 1) is based on a theoretical and empirical review of the literature. Farmer Collaboration is modelled as a single independent variable because it reflects a single underlying exchange relationship among farmers, captured through behaviours such as frequent information sharing, communication, and joint decision-making. From a SET lens (Homans, 1958), that same exchange relationship can generate multiple rewards at once reciprocal support and coordinated actions accumulate through collaboration.

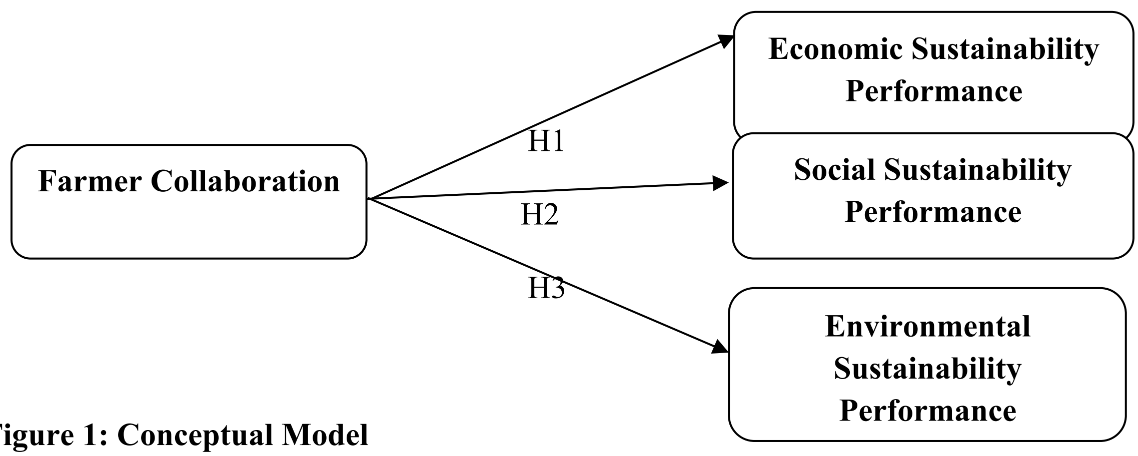

Figure 1: Conceptual Model
Source: Literature Review (2025)

Methodology and Approaches

This study used an explanatory research design and employed quantitative methods. An explanatory cross-sectional design was useful for investigating causal relationships among variables (Sarstedt et al., 2019; Gamage, 2025). A positivist philosophy and a deductive approach were used in hypothesis testing. This study targeted cashew nut farmers drawn from a finite population of 4,896 members. These members were from the Tanzania Cashew Nut Growers Association, organised into 143 farmer groups. Of these, 2680 group members were from Mtwara, 1,506 from Lindi and 800 from Ruvuma. These regions were purposively selected because they contribute approximately 75% of Tanzania's GDP from the cashew industry (Dimoso et al., 2021). The study applied the finite population approach proposed by Krejcie and Morgan (1970). The approach uses population size, an assumed population proportion and the desired precision level to determine the sample size.

Krejcie and Morgan's formula was applied across each study site using the equation $N_o/N \times n = n_o$. N_o represents the population of a given stratum; N is the overall population; n is the sample size; and n_o is the calculated sample size for each stratum, yielding a sample size of 357. However, the sample was slightly adjusted to 400 respondents based on Hair et al. (2022) recommendation that a larger sample size enhances stability of the estimates and eliminates the non-response challenge, ensuring adequate sample representation. Since the research covered three regions, 400 respondents were allocated using proportionate stratified sampling so that each region contributed respondents in line with its share of the overall population. Accordingly, regional samples were 194 farmers from Mtwara, 126 from Lindi and 80 from Ruvuma. These farmers were selected from farmer group membership lists using simple random sampling with random numbers generated in Excel spreadsheets. Eligibility was restricted to farmers with at least three years of farming experience to ensure they had sufficient familiarity with supply chain practices to provide the required data.

Data were collected using a 7-point Likert-scale structured questionnaire that included demographic characteristics and measurement items capturing the study constructs. This scale was selected to enhance scale sensitivity as suggested by Taherdoost (2019). The questionnaire was translated into Swahili to ensure all farmers understand the questions in a local language. Measurement items reflecting farmer collaboration, economic, social and environmental sustainability performance were adopted from Ali et al. (2017) and Azevedo et al. (2018). Before the main survey, the questionnaire was reviewed for clarity and content coverage and then pilot tested to confirm that respondents understood the question as intended, an approach commonly recommended to improve instrument quality and reduce avoidable measurement errors (Gamage, 2025). After fieldwork, the dataset was screened before modelling. Data cleaning focused on missing data, for example, patterns suggesting inattentive responding. These checks are consistent with suggestions by Hair et al. (2022) in applied PLS-SEM reporting which encourage researchers to examine missing data, outliers and suspicious response patterns before estimating the model. During this process, 23 questionnaires were excluded due to substantial incompleteness problems, leaving 377 clean questionnaires. This corresponds to a 94.25% response rate. The hypotheses were tested using PLS-SEM which allows the simultaneous assessment of measurement model and structural model assessments.

Results

Demographics Data

The data in Table 1 show that the majority of respondents, 290 (76.9%), are farm owner-managers, whereas 87 (23.1%) are farm managers. A higher representation of farm owner-managers may indicate that most farms are self-owned, reflecting a strong entrepreneurial and independent farming culture in Tanzania. This could drive long-term investment initiatives, such as good agricultural practices, including organic farming. Regarding cashew nut production experience, the majority of respondents, that is 174 (46.2%), have 16 years or more of experience in cashew production. This finding indicates that cashew farming is a well-established production activity in the country, sustained through intergenerational knowledge transfer. Findings on experience collaborating with other farmers reveal that 138 (36.6%) of respondents have 16 years or more of collaboration with others, and 120 (31.8%) have experience collaborating between 11 and 15 years. These results imply that collaboration in cashew nut production is deep-rooted, with lasting engagement by farmers in regions where it is grown. Educational qualifications reveal valuable insights into farmers' backgrounds. A substantial 255 (67.5%) of respondents have completed primary school. 58 (equivalent to 15.4%) have progressed to secondary school, demonstrating their commitment to furthering their education, and 32 (8.5%) have achieved advanced secondary or university-level qualifications. This diversity in educational attainment in this study indicates opportunities for targeted programmes that could encourage continued learning and skill development among respondents.

Table 1: Descriptive Statistics

Profile	Items	Frequency	Percentage
Title of respondents	Owners-managers	290	76.9
	Managers	87	23.1
Experiences in Cashew Nut Production	3 - 5 years	23	6.1
	6 -10 years	56	14.9
	11 - 15 years	124	32.9
	16 years and above	174	46.2
Experience in collaborating with other farmers	3 - 5 years	43	11.4
	6 - 10 years	76	20.2
	11- 15 years	120	31.8
	16 years and above	138	36.6
Educational Qualifications	Primary School	255	67.6
	Secondary School	58	15.4
	Advanced Secondary School	32	8.5
	Degree and Above	32	8.5
Total		**377**	**100**

Source: Survey Data (2024)

Measurement Model Results

Indicator Reliability Results

When assessing reflective measurement models, it is essential to consider construct and indicator reliability scores (Becker et al. 2023). According to Hair et al. (2022), indicator reliability shows how well an indicator measures its respective construct in a measurement model and the acceptable threshold is 0.7 and above. Such a threshold is suggested because it indicates that a particular construct accounts for more than 50% of the variance in the indicators (Hair et al., 2022). Smart PLS 4.0 was deployed to perform structural equation modelling. Results in Figure 2 show that items ECOP1 to ECOP8 measure Economic Sustainability Performance, and the indicator loadings ranged from 0.791 to 0.854, indicating a robust link between the measurement items and the ECOP construct. SP1 to SP10 measured Social Sustainability Performance, with indicator loadings between 0.800 and 0.871, indicating strong measurement of Social Sustainability Performance. EP1 to EP8 measured Environmental sustainability performance construct where the outer loadings value of items ranged from 0.724 to 0.892, which are all relatively high, implying a stronger relationship between items and the EP construct. FC1 to FC5 measured Farmer Collaboration, with loadings ranging from 0.864 to 0.897. These higher loadings suggest that the items are good indicators of farmer collaboration. Since overall high loading values across constructs indicate good convergent validity, it implies that each set of items effectively captures its respective construct.

Convergence Validity and Common Method Bias Results

Convergent validity was analysed to determine how consistently multiple indicators measure the same underlying construct using indicator loadings and Average Variance Extracted (AVE) following Hair et al. (2022). It assessed common method bias for collinearity through Variance Inflation Factor (VIF). VIF measured collinearity among latent variables to indicate how much the variance of a latent variable's coefficient is inflated due to correlations with other variables. The tests ensure the accurate measurement of constructs and the meaningfulness of relationships among variables. Findings presented in Table 2 and Figure 2 show that all factor loadings exceeded 0.70 and AVE values are above 0.50, confirming satisfactory convergent validity as recommended by Ringle et al. (2024). Both inner and outer VIF values fall below 3.0 threshold indicating that common method bias was not a concern. These findings confirm measurement's model internal consistence and accuracy in capturing the constructs related to farmer collaboration and sustainability performance.

Table 2: Indicator Loadings, AVE and VIF values

Construct (s)	Items' Code	Indicator items	Factor Loading	AVE values	VIF values
Farmer collaboration	FC1	We frequently participate in group activities with other farmers	0.897	0.790	1.594
	FC2	We have joint resource mobilisation programs with other farmers	0.896		2.821
	FC3	We frequently communicate with other farmers	0.897		2.420
	FC4	We share information frequently with other farmers	0.889		2.247
	FC5	We are actively involved in joint decision-making with other farmers	0.864		2.795
Economic sustainability performance	ECOP1	Purchasing cost of production materials has been reduced	0.787	.673	2.306
	ECOP2	Overall cost savings have been increased through recycling of cashew waste materials	0.831		2.793
	ECOP3	Energy usage costs have been reduced	0.832		2.687
	ECOP4	The cost of water use has been reduced	0.852		2.986
	ECOP5	The cost of cashew's waste disposal has been reduced	0.838		2.888
	ECOP6	Transportation costs have been reduced	0.846		2.873
	ECOP7	Savings on labor costs at our plants have been increased	0.821		2.436
	ECOP8	The costs of developing new cashew products have been reduced	0.755		2.306
Social sustainab	SP1	We are satisfied with cashew nut production activities	0.844	0.718	2.248

ility performa nce	SP2	Customer satisfaction has been improved	0.801		2.131
	SP3	The health and safety training in production has been improved	0.850		2.437
	SP4	The production reputation of cashew nuts to our stakeholders has been improved	0.869		2.835
	SP5	Locally sourced production materials have been increased	0.837		2.303
	SP6	Relationships with our key stakeholders have been improved	0.883		1.879
	SP7	Community welfare services have been improved	0.833		1.659
	SP8	The value chain's working environment has been improved	0.871		2.248
	SP9	The socially responsible practices have been improved	0.812		2.131
	SP10	Our employees' welfare facilities have been improved	0.869		2.437
Environ mental sustainab ility performa nce	EP 1	The generation of waste from cashew products has been reduced	0.727	0.710	1.739
	EP2	Recycling practices of cashew waste products have been increased	0.834		2.684
	EP3	Raw materials usage has been reduced	0.840		1.001
	EP4	Carbon dioxide emissions have been reduced	0.887		1.842
	EP5	The use of hazardous materials in production has been reduced	0.864		2.193
	EP6	Water usage in production has been reduced	0.847		2.123
	EP7	Energy usage has been reduced	0.892		2.011
	EP8	Designing recyclable packages has increased	0.841		2.657

Source: Survey Data (2024)

Discriminant Validity Results

The study further conducted discriminant validity tests to measure how empirically distinct are the constructs from one another. Discriminant validity was checked using HTMT ratio, with the rule of thumb that coefficient values should be below 0.85, and with Fornell-Larcker criterion, which requires the square root of AVE to exceed that of inter-construct correlations (Hair et al., 2022; Ringle et al., 2024). In this study, discriminant validity enhanced the elimination of overlapping constructs. The study findings (Table 3) indicate that all HTMT values are below 0.85 threshold, and the square roots of AVE for each construct exceed their inter-construct correlations, confirming presence of discriminant validity. In Table 4, all values load higher on themselves for each construct, confirming discriminant validity through the Fornell-Larcker criterion.

Table 3: Results for Discriminant Validity using HTMT Criterion

Constructs	EP	FC	ECOP	SP
EP				
FC	0.746			
ECOP	0.647	0.803		
SP	0.801	0.835	0.840	

Source: Survey Data (2024)

Table 4: Results for Discriminant Validity using Fornell - Larcker Criterion

Constructs	EP	FC	ECOP	SP
EP	0.843			
FC	0.704	0.889		
ECOP	0.611	0.749	0.821	
SP	0.763	0.789	0.793	0.847

Source: Survey Data (2024)

Reliability Results

The study tested reliability using Cronbach's alpha and composite reliability, with values equal to or above 0.70 considered acceptable as recommended by Ringle et al. (2024) and Hair et al. (2022). All constructs (Table 5) met the required threshold of 0.70, indicating that the measurement model is consistent and accurate in measuring the intended variables throughout the study.

Table 5: Reliability Results

Construct(s)	Cronbach Alpha (α)	Composite Reliability (Rho_A)	Composite Reliability (Rho_C)
FC	0.833	0.834	0.849
ECOP	0.830	0.831	0.843
EP	0.741	0.742	0.751
SP	0.816	0.827	0.832

Source: Survey Data (2024)

Structural Model Results

Model's Explanatory Power and Predictive Relevance

The coefficient of determination (R^2) and predictive relevance (Q^2) were used to evaluate the structural model in this study. The study also used Root Mean Square Error (RMSE), Mean Absolute Error (MAE) and effect size (f^2) as recommended by Hair et al. (2022). Assessing these metrics was essential for evaluating the model's predictive relevance, explanatory power, predictive accuracy and significance of path coefficients. The model's predictive relevance and accuracy were measured using Q^2 values, which integrate aspects of both in-sample and out-of-sample models' predictive analyses (Shmueli & Koppius, 2011). Q^2 values greater than 0 specify the predictive accuracy of the structural model, while the values between 0, 0.25 and 0.50 indicate small, medium, and large predictive relevance of the model, respectively. Results in Table 6 show that the Q^2 value for EP, ECOP and SP are 0.557, 0.621, and 0.493, respectively. Since all values are positive and the Q^2 value (>0), the model has predictive relevance and accuracy, meaning that it performs better than a baseline model.

The lower RMSE and MAE values in Table 6 indicate better predictive accuracy. Since the Q^2 predict value is greater than 0 and RMSE and MAE are small, it is suggested that the model has strong predictive relevance and accuracy for SP, ECOP, and EP. Regarding the effect size, which assesses the contribution of each independent variable to the explained variance in outcome variable, findings reveal varying magnitudes of influence. The results in Table 6 show that EP constructs, $R^2 = 0.497$ and Adjusted $R^2 = 0.495$. This means the model explains approximately 49.7% of the variation in EP and the adjusted R2 is close to the R2, indicating that the predictors used likely contribute to the model's explanatory power. ECOP constructs ($R^2 = 0.561$, Adjusted $R^2 = 0.560$, means that the model explains about 56.1% of the variation in ECOP, while there is a small difference between R^2 and adjusted $R^{2,}$ implying a well-fitting model with minimal irrelevant predictors. SP constructs have (R-square = 0.624, R-square Adjusted = 0.623). This means that the model explains around 62.4% of the variance in SP, suggesting a strong fit as the adjusted R^2 is close to R^2, which implies that the predictors contribute meaningfully to the model. All three models (EP, ECOP and SP) have relatively high R^2 values and adjusted R^2 values, with the highest being for SP, followed by ECOP and lastly EP. This indicates that the FC in each model explains a significant portion of the variation in their respective outcome variables by showing strongest relationships among variables.

Table 6: Explanatory Power and Predictive Relevance Results

	Coefficient of Determination		LV prediction summary		
Construct	**R^2**	**Adjusted R^2**	**Q^2 values**	**RMSE**	**MAE**
EP	0.497	0.495	0.557	0.677	0.489
ECOP	0.561	0.560	0.621	0.625	0.443
SP	0.624	0.623	0.493	0.717	0.517

Source: Survey Data (2024)

Model's Effect Size Results

The effect size, f-square (f^2), was used in this study to assess the effect of farmer collaboration on the dependent variables (ECOP, SP and EP) in the model. According to Cohen (1988), f-square values quantify the extent to which each independent variable contributes to explaining the variance of the outcome variable after accounting for other predictors. The rule of thumb for f-square (f^2) effect size holds that a value of 0.02 is a small effect, a value of 0.15 is a medium effect, and a value of 0.30 is a large effect (Cohen, 1988). The study results in Table 7 show that the f^2 value for FC -> SP is 0.369, indicating that farmer collaboration has a large effect on SP, making FC a strong predictor for this outcome. The f^2 value for FC -> EP is 0.236, and for FC -> ECOP it is 0.234, implying that farmer collaboration (FC) has a medium influence on EP and ECOP, accounting for a moderate portion of their variance.

Table 7: Effect Size Results

Construct Relationships	**Effect size (f^2)**
FC -> EP	0.236
FC-> ECOP	0.234
FC -> SP	0.369

Source: Survey Data (2024)

Hypotheses Tests Results

Given that all hypotheses were directional (i.e., positing that Farmer Collaboration positively influences each dimension of sustainability performance), this study used a one-tailed test at the 5% significance level. Accordingly, a critical t-value of 1.96 was used to determine significance, and path coefficients with p-values below 0.05 were considered statistically significant (Hair et al., 2022). This study has tested three (3) hypotheses for the direct relationship which are: H1- Farmer collaboration positively influences the economic sustainability performance of cashew nuts supply chains, H2- Farmer collaboration positively influences social sustainability performance of cashew nuts supply chains, and H3- Farmer collaboration positively influences environmental sustainability performance of cashew nuts supply chains. The findings are presented in Table 8 and Figure 2. Hypothesis H1, which tested the direct effect of FC -> ECOP, has a path coefficient of $\beta = 0.749$, a t-value of 9.855, and a p-value of 0.000 ($p < 0.05$) at the confidence interval (0.600, 0.898). This provides strong evidence that farmer collaboration positively and significantly influences economic sustainability performance. Hypothesis H2, which tested the effect of farmer collaboration on the social sustainability performance of cashew nut supply chains (FC -> SP), has a path coefficient of $\beta = 0.790$ and a t-value of 10.82, with a p-value of 0.000 ($p < 0.05$, which is statistically significant) at the confidence interval (0.647, 0.933). This provides strong evidence that farmer collaboration positively and significantly influences social sustainability performance. Hypothesis H3 tested the influence of farmer collaboration on the environmental sustainability performance of cashew nut supply chains (FC -> EP) and found a path coefficient of $\beta = 0.705$, a t-value of 10.681 (greater than 1.96), and a p-value of 0.000 ($p < 0.05$, which is statistically significant) at the confidence interval (0.576, 0.834). This provides strong evidence that farmer collaboration positively and significantly influences environmental sustainability performance. All hypotheses H1–H3 were supported, indicating that farmer collaboration has a significant and positive influence on the sustainability performance of cashew nut supply chains.

Table 8: Hypothesis Testing Results for the Direct Effects

Hypotheses and Path models					Confidence Intervals (95%)		
	β-coefficient	Standard deviation (STDEV)	t-values	p-values	Lower bound	Upper bound	Decision
H1: FC -> ECOP	0.749	0.076	9.855	0.000	0.600	0.898	Supported
H2: FC -> SP	0.790	0.073	10.821	0.000	0.647	0.933	Supported
H3: FC -> EP	0.705	0.066	10.681	0.000	0.576	0.834	Supported

Source: Survey Data (2024)

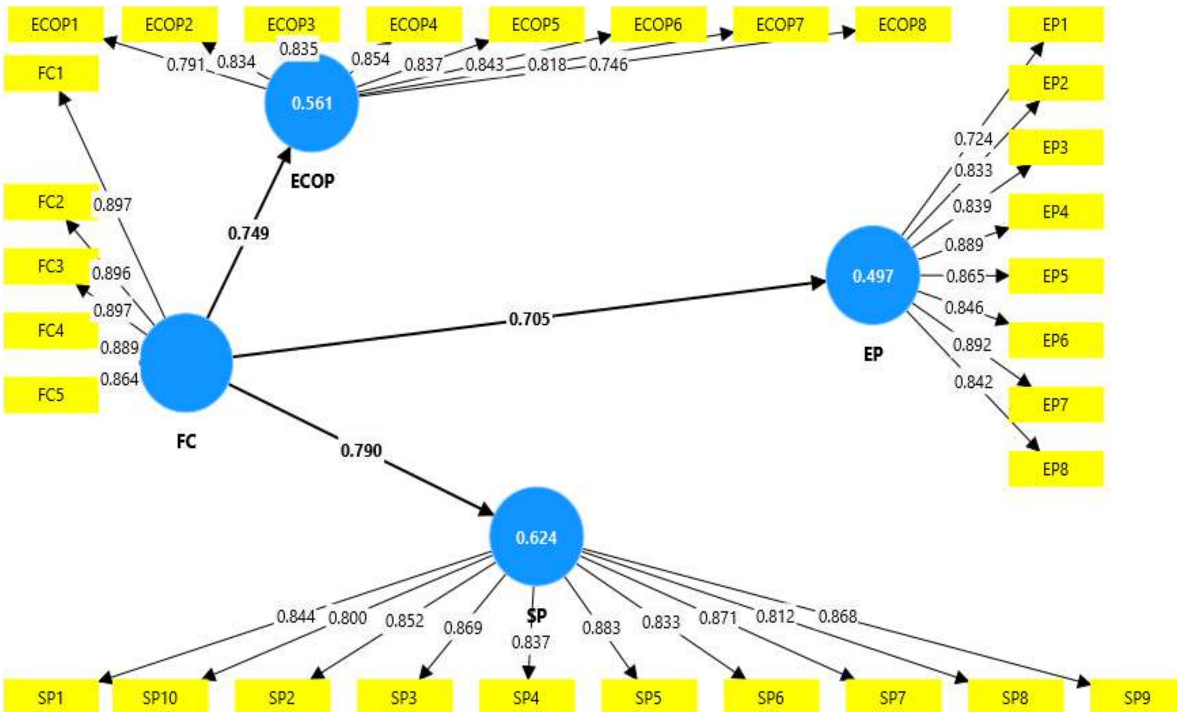

Figure 2: Structural Model Result for the Direct Effects
Source: Survey Data (2024)

Discussion of Findings

The results revealed that farmer collaboration has a positive and significant influence on economic sustainability performance. This demonstrates that when farmers work together through shared information, knowledge and resources, they can reduce operational expenses and improve production efficiency. The finding is supported by Dossou and Akdemir (2020), who argued that farmers working toward a common goal are better situated to overcome structural problems and enhance their incomes. In Tanzanian cashew sub-sector, such an example is evident in farmer groups that let members aggregate products, secure shared transportation leading to reduced expenditures. This result aligns with Stoeva et al. (2024), who demonstrated that collaboration reduces costs through better pricing and with Zhou et al. (2024), who demonstrated that collaboration increases cost efficiency. Donkor and Hejkrlik (2021) in Zambia showed that cooperative membership led to higher yields and better margins, indicating that collaboration is a cost-saving mechanism in African smallholder contexts. From a theoretical perspective, these empirical studies support present study by showing that cost efficiency is an outcome of reciprocal exchanges, helping farmers mitigate their dependence on buyers and intermediaries by pooling resources. Findings confirm theory of Social Exchange which recommends that people are motivated to collaborate in order to generate reciprocal benefits and share costs. For Tanzanian farmers, collaboration is evident as a practical strategy to address market volatility and high input costs, ultimately improving economic sustainability performance.

The findings revealed that farmer collaboration positively influences social sustainability performance. This means that Tanzanian cashew farmers not only minimise costs when collaborating with other farmers but also build stronger social ties and enhance community well-being. Mutonyi (2019) observed that resource mobilisation through collaboration supports equitable resource use, thereby enhancing community stability. Sudusinghe and Seuring (2022) emphasised that frequent communication and joint decision-making increase members' commitment, which mirrors the situation in cashew farming groups where trust and participation drive performance. Hidayati et al. (2023) argued that collective farming is one of the most significant enablers of sustainable agri-food value chains, showing that social outcomes depend on farmer cooperation. Ariadi et al. (2024) provided related evidence in Bali, where joint efforts and shared activities enhanced collaboration and improved social outcomes for farmer groups. These findings support Social Exchange Theory by indicating that trust-based relationships encourage farmers to support one another. For farmers in Tanzania, this means that collaboration can strengthen social structures, improve equity and ensure equal benefit sharing among community members, making cashew nut production an activity that can improve incomes and living standards for the most vulnerable groups of smallholders such as youth and women, who are resource-poor and operate individually and are not integrated into agri-food supply chains.

Results show a statistically significant and positive influence of farmer collaboration on environmental sustainability performance. These results are in line with Ali et al. (2017) whose results demonstrated positive association between supplier collaboration and environmental practices in achieving sustainability performance. Sudusinghe & Seuring (2022) expand further the discussion by positing collaboration as a key governance instrument in sustainable food systems. Practices such as the conversion of organic residuals (composts) into fertilizes and the use of integrated pest management systems are more likely to be realized when farmers jointly coordinate their production and food waste management systems. These actions reflect strategic resource efficiencies which are key in the agricultural contexts marked by high crop wastes (Rolfe et al., 2022). Liu et al. (2025) found that cooperatives strengthened green agri-food value chains by supporting technical training and infrastructure. Barbosa and Cansino (2024) also demonstrated that environmental collaboration helped to reduce emissions, improve energy use and strengthen water management in agri-food supply chains. The positive influence identified in these studies supports the relevance of Social Exchange Theory in the current research, showing that collaboration fosters mutual responsibility and encourages farmers to support one another in adopting environmentally friendly agricultural practices.

Conclusion

This study integrated Social Exchange Theory (SET) to analyse how farmers collaborate to shape sustainability performance in Tanzania's cashew nut supply chains. The findings reveal that collaboration is sustained and becomes performance-enhancing when farmers perceive reciprocal benefits of collaborating and are willing to share both rewards and costs of such actions. By analysing sustainability performance across Tanzania's Cashew nut supply chains, this study demonstrates that farmer collaboration can work in low and middle-income agri-food supply chain contexts where smallholder farmers face persistent resource and coordination constraints. For these farmers, leveraging collaboration becomes a practical mechanism for improving performance of their food chains through collective problem-solving, resource sharing, information sharing and stronger communication ties across their supply chains. From the results, farmer collaboration is not only a social coping strategy but a viable pathway to strengthening sustainability performance in Tanzania's Cashew nut supply chains.

Theoretical Implications

The results contribute to SET within the context of a developing country's agricultural economy. The results specify key "attributes" of exchange including information sharing, communication quality and joint decision-making which build trust and coordination and in turn, produce visible sustainability performance gains for the farmer groups including cost reduction in production activities. The use of SET (Homans, 1958) in this study demonstrates its relevance beyond traditional resource-sharing settings, suggesting that farmer collaboration can enhance economic, social, and environmental sustainability performance. Also, the study explains why joint activities such as processing of raw cashew nuts and regular group meetings contributes to efficient utilization of resources, knowledge transfer and effective communication among members hence expanding the social exchange theory's explanatory power that assist the most vulnerable groups of societies such as smallholder farmers in developing agricultural supply chains that work for the benefits of both parties to the social exchange.

Practical Implications

For stakeholders working to improve agricultural supply chains in Tanzania and similar contexts, the study recommends a strong focus on fostering farmer collaboration as a foundation for sustainability performance. The findings show that when farmers collaborate, they are better placed to adopt environmentally responsible practices, reduce production inefficiencies and improve social outcomes, including community engagement. To support these outcomes, development partners should strengthen group-based governance structures and build grassroots capabilities for joint action. This includes practical interventions such as participatory training in sustainable farming techniques and facilitation of access to technologies that support joint activities. For practitioners and policy-makers, the study suggests that farmer groups be supported by appropriate systems such as extension services and training programs. Such systems should use farmer groups as the delivery channel for health and safety training, welfare-related initiatives and environmental management programs because collaboration has been shown to have strong potential to improve sustainability performance. Hence, these results are useful for stakeholders such as the Tanzania Cashew Nuts Board, Agricultural Marketing Cooperatives, farmer networks and private actors who work with farmers. Strengthening collaboration structures can help accelerate improvements in cost reductions, community welfare and environmental management through coordinated activities within farmer groups. Streamlining these practices can help sustain participation in food chains while reducing conflicts of interest among collaborating parties. Such interventions will ensure collaboration remains beneficial to all cashew nut farmers in Tanzania. In addition, the study focused only on collaboration among farmers. This scope omits the broader spectrum of interactions with other actors upstream and downstream in the supply chains. Future studies should examine other actors across supply chains, as the nexus between farmer collaboration and sustainability performance is important in other agricultural sub-sectors.

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