(Online) ISSN 2712-0554
Heritage and Sustainable Development *Original Research*
Vol. 8, No. 2, 2026, pp.77-90
https://doi.org/10.37868/hsd.v8i2.1718

Green entrepreneurial orientation, competences and sustainability performance of Arabica Gayo coffee farms in Aceh

Alja Yusnadi[1*], Rachmat Pambudy[2], Bayu Krisnamurthi[3], Etriya Etriya[4]
[1] Agricultural Economics Study Program, Department of Resource and Environmental Economics, Faculty of Economics and Management, IPB University, Bogor, Indonesia
[2,3,4] Department of Agribusiness, Faculty of Economics and Management, IPB University, Bogor, Indonesia

*Corresponding author E-mail: aljayusnadi@apps.ipb.ac.id

Received Nov. 6, 2025
Revised Jun. 21, 2026
Accepted Jul. 2, 2026
Online Jul. 17, 2026

Abstract

This study examines Arabica coffee farming in Gayo, Aceh, focusing on the roles of green entrepreneurial orientation and green entrepreneurial competence as key antecedents of sustainability performance. These relationships are analyzed both directly and indirectly through two mediating variables: environmentally oriented innovation and farmer organization participation. The study is based on data collected from 305 Arabica coffee farmers in Central Aceh Regency, selected using purposive sampling. Partial least squares structural equation modelling (PLS-SEM) was employed as the analytical method. The results indicate that green entrepreneurial orientation and green entrepreneurial competence have positive relationships with sustainability performance. These effects become stronger when mediated by green innovation activities and active participation in farmer organizations. The findings also highlight that sustainability in smallholder coffee farming is influenced not only by individual farmer characteristics but also by collective and institutional engagement, as well as the alignment of ecological innovations with production practices. Therefore, fostering an adaptive context for green entrepreneurship that recognizes system-specific characteristics is essential to achieving sustainable Arabica coffee production.

Keywords: Coffee farming, Green entrepreneurial competences, Green entrepreneurial orientation, Sustainability.

1. Introduction

Sustainable entrepreneurship has come of age as an important approach that integrates economic activity with social responsibility and ecological awareness. The core idea behind this perspective is that profits and social impact are not separate outcomes but are closely linked through the creation of value for society. Environmentally oriented entrepreneurial ventures not only generate economic benefits but also address what are often described as “market imperfections” or environmental externalities through innovation and productivity improvements over time [1]. Empirical evidence further suggests that the adoption of sustainable practices can generate multiple benefits across social and economic dimensions.

These developments are particularly relevant in the agricultural sector, where sustainability-oriented practices have been associated with employment generation, environmental conservation, and the expansion of local markets. At the same time, increasing integration into global production systems, especially in energy use, raw materials, and transportation, creates new challenges that require more responsible and adaptive approaches. While some of these benefits emerge gradually through individual initiatives and entrepreneurial activities, they collectively point to the growing importance of sustainability-based capabilities. In this regard, such capabilities should not be viewed merely as aspirations, but as strategic instruments that can enhance both financial resilience and socio-environmental performance [2].

In many developing countries, coffee farming remains a high-value agricultural activity. However, coffee production systems in many developing countries are still characterized by several unsustainable farming practices, including the expansion of cultivation into environmentally sensitive areas, inadequate soil and water conservation measures, and limited adoption of environmentally friendly production technologies. These practices contribute to land degradation, biodiversity loss, increased vulnerability to climate variability, and declining long-term productivity, while farmers often continue to face constraints in accessing productive resources and sustainability-related knowledge [3], [4]. Addressing these challenges requires a transition toward more sustainable management practices that can simultaneously maintain natural capital and improve the long-term stability of farmers' income [5], [6]. In addition, growing demand from domestic markets and the processing industry has led to the expansion of agricultural land, intensifying land-use change and increasing competition among farming communities over limited productive areas [3]. Under these conditions, responsible farming practices become increasingly important, not only for improving farmers' livelihoods but also for strengthening community development and supporting broader public welfare outcomes [5].

Within this context, green entrepreneurial competence (GEC) plays an important role in shaping farmers' capacity to respond to sustainability challenges. GEC reflects a set of knowledge, skills, and attitudes that enable farmers to identify opportunities related to sustainability, adopt environmentally friendly practices, and engage in innovation despite existing risks. These competencies are often reflected in the ability to integrate ecological considerations into production decisions. In parallel, green innovation can be understood as an outcome of such competencies, encompassing the development and adoption of environmentally friendly products, processes, and management practices that minimize negative ecological impacts. The effectiveness of these capabilities is often strengthened by institutional support, including training programs, public policies, and the dissemination of sustainable agricultural systems [4].

Increasing competition and growing sustainability requirements have also encouraged coffee producers to strengthen innovation capacity, improve market linkages, and optimize the use of productive resources [7]. This is particularly relevant in high-value specialty markets such as Gayo Arabica coffee, where sustainability has become an important market criterion. While GEC and green entrepreneurial orientation (GEO) have been widely studied in the context of firms and small and medium enterprises, empirical evidence at the level of smallholder farming systems remains limited.

More specifically, limited attention has been given to sustainable or green entrepreneurship in smallholder coffee farming systems, particularly in the context of Gayo Arabica coffee production. Existing studies on coffee farming have predominantly focused on farm performance, market access, certification, and institutional support mechanisms [8], [9], while the entrepreneurial dimensions that enable farmers to respond proactively to sustainability challenges remain underexplored [10]. As a result, there is still insufficient empirical evidence regarding how green entrepreneurial orientation (GEO) and green entrepreneurial competence (GEC) influence sustainability outcomes among Gayo coffee farmers. Furthermore, although previous studies have demonstrated the importance of green innovation as a mechanism linking entrepreneurial orientation to performance [11] and have highlighted the role of farmer organizations in improving access to resources, knowledge exchange, and sustainable development [12], these relationships have not been adequately examined in an integrated framework within smallholder coffee farming systems. Addressing this gap is important because coffee

producers operate in an increasingly competitive market environment where environmental standards, certification requirements, and long-term resource sustainability have become critical determinants of competitiveness and sustainable performance [4]. Existing studies in environmental entrepreneurship within agriculture have largely focused on performance outcomes at the farm or agribusiness level. Research adopting the GEC perspective highlights the importance of entrepreneurial competencies as key determinants of agricultural performance [13]. Similarly, studies on GEO consistently report a positive relationship between entrepreneurial orientation and performance in agribusiness contexts [14]. In addition to individual-level characteristics, collective mechanisms such as farmer organizations and sustainability certification have been recognized as important institutional factors that support access to resources, knowledge exchange, and market participation [8].

However, despite these developments, the literature still provides limited empirical insight into how entrepreneurial orientation and competence interact with innovation processes and collective institutional engagement in shaping sustainability performance, particularly in smallholder agricultural settings. This gap is especially relevant in the context of Gayo Arabica coffee production, where sustainability pressures from global markets require not only individual capability but also coordinated collective action. Understanding these relationships is important for designing policies and institutional arrangements that support sustainable agricultural development and enhance competitiveness in global value chains.

In this regard, the role of mediating mechanisms becomes critical. Innovation-oriented practices and farmer organization participation may serve as key channels through which entrepreneurial capabilities are translated into sustainability outcomes. These mechanisms facilitate knowledge exchange, improve access to markets, and support the adoption of environmentally adaptive production systems. Collective action among farmers, combined with appropriate technological adaptation and long-term partnerships with market actors, can strengthen the resilience of smallholder farming systems in responding to environmental and economic challenges [15].

Conceptually, this study contributes to a better understanding of how entrepreneurial competence and strategic orientation are linked to sustainability performance through these mediating processes. By emphasizing the roles of green innovation and farmer participation in collective institutions, this research seeks to clarify how environmental entrepreneurship operates in smallholder agricultural contexts.

Therefore, this study examines the relationship between green entrepreneurial orientation, green entrepreneurial competence, and sustainability performance in Gayo Arabica coffee farming. It also investigates the mediating roles of green innovation and farmer organization participation. In doing so, this research aims to provide both theoretical and practical insights into how sustainability-oriented entrepreneurship can be effectively developed in agricultural systems.

2. Literature review

The academic discussion around sustainable entrepreneurship has primarily focused on manufacturing and small and medium-sized enterprises, while primary production systems have been relatively neglected. Agricultural contexts are different in many ways because they are highly dependent on natural cycles, the limited availability of local resources, and uncertain environmental conditions; all these factors influence how sustainability-oriented entrepreneurial actions emerge and persist. Within agricultural systems, sustainability-driven entrepreneurship arises mainly from production decisions aimed at balancing economic continuity with ecological conservation and social welfare. Empirical evidence from Aliabadi et al. emphasizes the significance of environmental, economic, and institutional dimensions in the development of a sustainable entrepreneurial ecosystem [10]. Through cross-impact analysis, their research demonstrates a mutually reinforcing network of factors contributing to system-level sustainability, including job creation; ownership structure and business scale; income security; flexibility in adapting administrative rules and regulations; access to information; the involvement of civil society organizations (CSOs); and perceptions of operational risk.

Business development is often necessary because persistent structural conditions and uneven factor endowments act as barriers to scaling entrepreneurial efforts in smallholder agriculture. Insecure land tenure, limited access to land and inputs, and restricted access to credit are usually the primary issues involved [16]. On the other hand, the degree of entrepreneurial behavior varies across individuals. Ntow et al. found that exposure to pesticidal water was associated with an instance (degree TBD) [17]. For example, rice farmers were found to exhibit moderate to high levels of risk propensity, openness to innovation, future orientation, self-efficacy, and decision-making ability. All of these have a bearing on market channel decisions. Addressing these factors is potentially important. The above issues highlight the need to broaden our understanding of entrepreneurship in rural areas, especially where individual agency is intertwined with institutional and physical infrastructure.

In most of the references reviewed in this article, green entrepreneurial orientation is defined as an environmentally oriented strategic outlook. In other words, it refers to the stage at which opportunities to go green are recognized and systematically pursued over time, while foreseeable threats are rationally assessed [11]. From a conceptual perspective, this active behavior can be considered a dynamic capability embedded in a set of interrelated processes that encompass environmental fitness, innovation, future anticipation, and risk aversion [18]. By integrating environmental targets into strategic choices, such an orientation can lead to persistent adaptive behavior and sustainable outcomes [19]. In this way, GEO positions green entrepreneurship as an integral part of a company's strategy, in which improvements in environmental quality are associated with economic sustainability and broader social responsibility [14].

Green innovation (GI), which is directly linked to GEO, has also received considerable attention as a strategy for responding to increasing global sustainability pressures. In corporate management, GI can be observed in practices such as modifying production processes to reduce energy consumption and generate additional environmental benefits, investing in end-of-pipe pollution-control equipment, recycling, and adopting production processes that minimize waste. These practices can simultaneously increase system efficiency, product performance, and organizational capabilities while reducing environmental costs and resource inputs [20]. This form of innovation is often operationally classified into product innovation and process innovation. Empirical evidence also indicates that environmental concern and perceived technical and economic feasibility are key factors determining the adoption of such practices [21]. Behavioral intention is an important pathway that mediates between awareness and practice. Other research has also shown that environmentally oriented innovation strategies might strengthen the relationship between environmental performance and economic returns [22]. Moreover, past research also shows that green innovation is a significant mediating variable that connects entrepreneurial self-efficacy for environmental goals with GEO. Thus, it accelerates the translation of strategic commitments to sustainable business activities into specific environmental benefits [23].

Building on the work of previous scholars, this study emphasizes the mediating role of farmer organizations in translating farmers' green entrepreneurial orientation (GEO) into sustainability outcomes in Gayo Arabica coffee production. Farmer organizations, particularly cooperatives, have played a vital role in the overall development of agriculture as supportive institutional actors. Ortmann [24] emphasizes the ability of cooperatives to minimize transaction-related inefficiencies and facilitate the integration of small-scale farmers into broader market channels. Consistent with this perspective, Zhong et al. [25] describe cooperatives as central information providers that offer support during the production and marketing stages, generate higher returns for members, and improve access to input suppliers and output markets. These functions indicate that farmer organizations not only reduce costs but also stabilize income and enhance farmers' adaptive capacity, thereby strengthening the sustainability effects of environmentally focused entrepreneurial strategies at the farm level.

Previous studies have increasingly recognized the relevance of green entrepreneurship in agricultural systems. Sher et al. [7] argue that environmentally oriented entrepreneurial behavior can support the transition toward more sustainable farming practices by encouraging resource efficiency, ecological stewardship, and innovation adoption. Empirical evidence from the agribusiness sector further demonstrates that green entrepreneurial orientation (GEO) positively influences sustainable performance, both directly and indirectly through green

innovation mechanisms [14]. Likewise, studies on entrepreneurial competence emphasize that farmers' knowledge, skills, and opportunity-recognition capabilities are important determinants of farm performance and business development [26], [27]. However, existing research has largely examined these factors separately and has predominantly focused on agribusiness firms, agricultural enterprises, or general farming systems. Limited attention has been given to understanding how green entrepreneurial competence (GEC) and GEO jointly influence sustainability performance through green innovation and farmer organization participation in smallholder coffee farming. Furthermore, empirical evidence from specialty coffee production systems, such as Gayo Arabica coffee, remains scarce. Therefore, this study contributes to literature by integrating entrepreneurial orientation, entrepreneurial competence, green innovation, and farmer organization participation into a single analytical framework to explain sustainability performance in a smallholder coffee-farming context.

3. Research method

This research was conducted in the Jagong Jeget and Pegasing subdistricts of Central Aceh Regency, which are major centers of Gayo Arabica coffee production, a flagship agricultural commodity of the region. These areas were selected based on their strategic importance to coffee production and their representation of the local agricultural environment. The field survey ensured that empirical data was collected through face-to-face interviews. This data collection approach was intended to ensure that the information and insights were reliable and contextually relevant, reflecting the socioeconomic and production characteristics of the target farming population.

The study targeted small-scale Gayo Arabica coffee producers who were affiliated with cooperatives in the study area and operated farms of less than two hectares. Field data were collected over a period of two months, in April and May 2025.

This sampling technique was adopted to identify eligible respondents, as only a portion of the farming community met the study's inclusion criteria. Participation was limited to coffee farmers who practiced natural farming methods and could provide information based on firsthand experience. Strict adherence to these criteria ensured that the information provided was relevant and grounded in firsthand experience, thereby supporting the quality of the research data. The study's research model incorporates green entrepreneurial orientation (GEO), green entrepreneurial competence (GEC), farmer organization participation, green innovation, and sustainability performance. The relationships among these constructs were tested using partial least squares structural equation modeling (PLS-SEM). The analytical framework is presented in Figure 1.

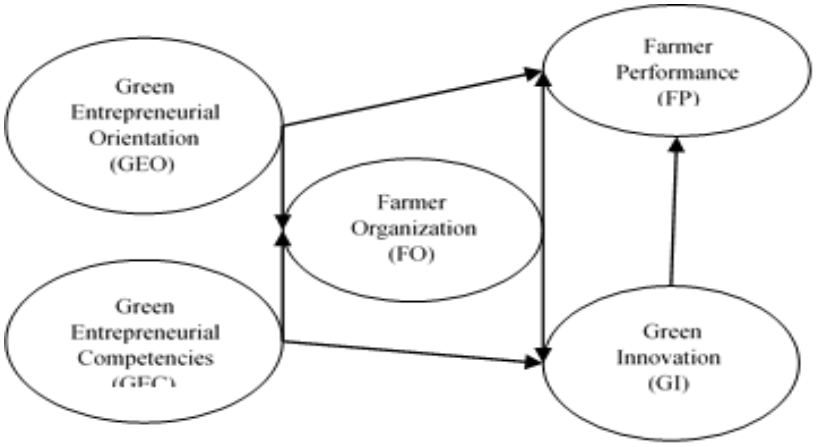

Figure 1. Research framework

Based on the model presented above, this study develops the following research hypotheses:

H1: Green entrepreneurial orientation positively and significantly affects farmer organization participation and farmer performance.

Farmers with a stronger green entrepreneurial orientation are more likely to take the initiative in adopting sustainable practices and participating in collective institutional arrangements [9]. In the context of this study, green entrepreneurial orientation (GEO) is positioned as a strategic driver that promotes cooperation, innovation, and shared learning within farmer organizations. These processes help build farmers' adaptive capacity, thereby improving outcomes at both the individual and collective levels [30]. Therefore, GEO is expected to play a significant role in improving farmer organization participation and farmer performance, thereby strengthening the long-term resilience of smallholder agricultural systems.

H2: Green entrepreneurial competence positively and significantly affects farmer organization participation and green innovation.

Farmers with higher levels of entrepreneurial competence possess not only broader knowledge but also the practical skills and environmental awareness needed to adopt more sustainable farming practices [31]. These capabilities facilitate effective teamwork within farmer organizations and encourage the implementation of more sustainable production methods [12]. Therefore, green entrepreneurial competence (GEC) is considered a key factor in improving organizational capacity and supporting farmers' continued adoption of environmentally friendly products, technologies, and practices.

H3: Green innovation positively and significantly affects farmer performance.

In addition, such technologies can be introduced to farmers in village communities to help control costs. In this way, integrating green technology into agricultural systems used to produce agricultural products, such as fruits and vegetables, makes this type of advanced equipment necessary. The fruit market relies primarily on low-capacity refrigerated transportation powered by diesel to distribute fresh products to cities at premium prices. By eliminating middlemen in long-distance sales, farmers can establish direct contact with customers who would otherwise be reached only through intermediaries, thereby improving their economic position. The machinery has already been fully developed and requires only further effort from farmers to popularize it. Bringing environmentally friendly technology together with sustainable production systems has changed the way farmers carry out their work and has given them not only better products that are more suited to market preferences but also a stronger bargaining position on both the demand and supply sides [32]. The introduction of modern techniques into farming can help farmers manage costs more effectively and offset any negative environmental impacts that may be caused by their activities. It is also a way of ensuring stability in production over time [33]. In this context, green innovation is expected to be a major facilitator of both economic development and environmental rehabilitation for communities that rely on agriculture.

H4: Farmer organization participation mediates the relationships between GEO, GEC, and farmer performance.

Functional farmer organizations provide an institutional setting for knowledge sharing, collective action, and access to productive resources, potentially strengthening the effects of green entrepreneurial orientation (GEO) and green entrepreneurial competence (GEC) on performance-related outcomes. Continuous interaction and collaboration within these organizational structures help farmers internalize and implement sustainable and innovative practices more consistently [34]. Therefore, farmer organization participation is expected to act as a mediating mechanism through which green entrepreneurial orientation and green entrepreneurial competence influence farmer performance and broader sustainability outcomes.

Data analysis in this study was conducted using Microsoft Excel and partial least squares structural equation modeling (PLS-SEM). The advantage of this approach is that both measurement components and structural relationships can be estimated simultaneously, making it possible to examine both direct and mediated relationships among the constructs. A more comprehensive analytical approach is provided by structural equation modeling (SEM), which integrates regression, factor analysis, and path analysis within a single modeling framework [28]. This integrated framework is therefore well suited to examining the complex relationships proposed in this study.

The selection of PLS-based structural equation modeling in this study was based on its methodological advantages. According to Abdillah and Hartono [29], this method has been widely adopted for studying complex conceptual domains because it can partially address potential multicollinearity and maintain model robustness in the presence of extreme values or missing data. Furthermore, its ability to accommodate different measurement scales and relatively small sample sizes makes it appropriate for empirical applications in agricultural and social sciences.

The hypothesized relationships were tested using a bootstrap resampling procedure, a nonparametric technique that produces empirical t-statistics to test the significance of the estimated paths. The analytical model was validated in two stages. In the first stage, the adequacy of the measurement model and the validity of each construct were examined by focusing on convergent and discriminant validity. Convergent validity was assessed using the average variance extracted (AVE), with a value of 0.50 or higher considered acceptable. The structural model was then assessed by examining the coefficient of determination (R^2) as a measure of explanatory power. R^2 values of 0.75, 0.50, and 0.25 were interpreted as indicating substantial, moderate, and weak explanatory power, respectively.

4. Results and discussion

This section discusses the empirical findings from PLS-based structural analysis and explains how entrepreneurial capacity is converted into better performance at the farm level. The findings provide evidence that individual skills and strategic outlook produce performance benefits when supported by innovation-based practices and collective farmer participation. Attention is focused on the processes through which individual entrepreneurial characteristics are transformed into sustainability-oriented outcomes in coffee farming systems, thus identifying the underlying mechanisms linking entrepreneurship and long-term performance improvement.

Table 1 presents the results of the discriminant validity assessment based on the Fornell–Larcker criterion. The purpose of this assessment is to ascertain whether the individual latent constructs in the structural model are empirically distinct from one another, thereby providing evidence that the variables reflect unique and non-overlapping conceptual dimensions.

Table 1. Discriminant validity results

Variable	GEC	GEO	GI	FP	FO
GEC	0.853				
GEO	0.702	0.763			
GI	0.722	0.753	0.790		
FP	0.616	0.672	0.735	0.805	
FO	0.640	0.748	0.650	0.515	0.786

The results indicate that the square roots of the AVEs for GEC (0.853), GEO (0.763), GI (0.790), FP (0.805), and FO (0.786) are consistently higher than the correlations between these latent variables and the other constructs. This finding shows that the empirical distinctiveness of each latent construct is sufficiently strong to establish discriminant validity. Accordingly, the constructs represent different conceptual dimensions and can be included in further structural model testing. It is also evident from the results presented in Table 2 that all five constructs including GEC, GEO, GI, FP, and FO have composite reliability values above the threshold of 0.70. This finding indicates a high level of internal consistency among the measurement items. The indicators used in this study can therefore be considered reliable measures of their intended conceptual dimensions, supporting their use in further analysis.

Table 2. Reliability analysis

Variable	Composite reliability
GEC	0.842
GEO	0.874

Variable	Composite reliability
GI	0.869
FP	1.000
FO	0.867

The results of the direct antecedent assessment using a PLS-SEM-based structural model are reported in Table 3. The findings indicate that green entrepreneurial competence (GEC) has a statistically significant positive effect on both green innovation (GI) ($\beta = 0.519$; $t = 10.776$; $p < 0.001$) and farmer organization (FO) participation ($\beta = 0.223$; $t = 3.926$; $p < 0.001$). These results suggest that higher levels of environmentally oriented competence among farmers are associated with a greater tendency to adopt innovations and become more involved in collective organizational settings, such as cooperatives.

In line with the previous findings, green entrepreneurial orientation (GEO) has a positive and significant influence on farmer organization participation ($\beta = 0.591$; $t = 11.293$; $p < 0.001$), indicating that a forward-looking and sustainability-oriented entrepreneurial orientation contributes to greater farmer participation in collective arrangements and institutional cooperation. In contrast, the direct association between GEO and farmer performance (FP) is not empirically supported ($\beta = 0.024$; $t = 0.246$; $p = 0.806$). This result implies that GEO does not directly affect performance outcomes; rather, its effect is more likely to be indirect and operate through other pathways, such as innovation activities and engagement in organizational structures.

Consistent with the findings, neither green innovation (GI) ($\beta = -0.047$; $t = 0.582$; $p = 0.561$) nor farmer organization (FO) participation ($\beta = -0.067$; $t = 0.780$; $p = 0.436$) is directly and significantly related to farmer performance. This finding suggests that the relationships between innovation-oriented activities, organizational participation, and performance are unlikely to be linear. Rather, these factors may operate within more complex processes that influence performance indirectly instead of through first-order direct effects.

In particular, the results support a positive and highly significant relationship between farmer performance and innovation-based behavior ($\beta = 0.316$; $t = 6.263$; $p < 0.001$). This result suggests a cumulative process in which improvements at the farm level enhance farmers' capacity and motivation to invest in environmentally friendly innovations. Rather than being an end in itself, performance and productivity appear to act as enabling conditions that support further innovative behavior. Taken together, the empirical evidence suggests that entrepreneurial capabilities and orientations are critical drivers that trigger innovation processes and increase collective institutional involvement. At the same time, improvements in performance are not achieved through linear progression. Instead, through a combination of indirect mechanisms and recursive interactions, higher performance levels feed back into and improve the conditions that enable sustained innovation and organizational learning in smallholder coffee systems.

Table 3. Results of direct hypothesis testing

Hypothesis testing	Path coefficient (β)	Standard deviation (STDEV)	t-value	P-Values
GEC -> GI	0.519***	0.048	10.813	0.000
GEC -> FO	0.223***	0.057	3.912	0.000
GEO -> FP	0.024	0.097	0.247	0.806
GEO -> FO	0.591***	0.052	11.365	0.000
GI -> FP	-0.047	0.081	0.580	0.561
FP -> GI	0.316	0.050	6.320	0.000
FO -> FP	-0.067	0.087	0.770	0.436

Notes: Statictical significance is denoted as *** $p < 0.001$, ** $p < 0.01$, and * $p < 0.05$

Table 4 reports the results of the indirect effects tested using a PLS-based structural model and indicates the pathways through which individual-level entrepreneurial antecedents are translated into performance-related

outcomes. As is evident from the results, organizational engagement serves as a key mechanism for converting entrepreneurial capabilities into environmentally oriented innovation practices. This is consistent with the empirical evidence, which suggests that both competence- and orientation-based entrepreneurial attributes have significant indirect effects on innovation outcomes through collective institutional engagement. In particular, organizational involvement has a significant and positive mediating effect on the relationship between entrepreneurial competence and innovativeness ($\beta = 0.071$; $p = 0.001$). The indirect effect is stronger in the orientation-driven pathway, indicating that a proactive and sustainability-oriented mindset facilitates innovation outcomes by increasing involvement in farmer organizations ($\beta = 0.187$; $p < 0.001$). These results underscore the role of organizational embeddedness as a facilitating process through which individual-level entrepreneurial potential is translated into actual innovative behavior.

This suggests that group institutions act as a significant mediating factor through which individuals' entrepreneurial potential is translated into responsive innovation. Entrepreneurial competencies and orientations do not directly produce innovative outcomes; rather, their effects are more significant when farmers are embedded in formalized group structures. Involvement in such institutions facilitates coordination and the exchange of tacit knowledge while reducing experimentation costs at the farm level, thereby accelerating the adoption of green innovations.

Table 4. Results of indirect hypothesis testing

Hypothesis testing	Indirect path coefficient (β)	Standard deviation (STDEV)	t-value	P Values
EC -> FO -> GI	0.071***	0.020	3.550	0.001
GEO -> FO -> GI	0.187***	0.038	4.921	0.000
GEC -> GI -> FP	-0.025	0.043	0.581	0.563
GEC -> FO -> GI -> FP	-0.003	0.006	0.500	0.577
FO -> GI -> FP	-0.015	0.027	0.556	0.573
GEO -> FO -> GI -> FP	-0.009	0.016	0.563	0.582
GEC -> FO -> FP	-0.015	0.020	0.750	0.442
GEO -> FO -> FP	-0.040	0.052	0.769	0.445

Notes: Statistical significance is denoted as *** $p < 0.001$, ** $p < 0.01$, and * $p < 0.05$.

Farmer collectives are generally effective channels for translating individual entrepreneurial efforts into innovative farming activities; however, the indirect pathways through which these effects are transmitted to farmer performance are not statistically significant. In particular, the mediating pathways from entrepreneurial competence through innovation to performance, as well as the longer chains involving farmer organization participation and innovation, are not statistically significant. The same applies to indirect effects operating only through farmer organization participation, which produce non-zero but statistically insignificant effects on performance. These results indicate that collective structures and environment-related innovation can contribute to farmers' adaptation and learning, but this does not necessarily lead to direct performance gains. Instead, participation in farmer organizations, organizational engagement, and innovation activities appear to operate indirectly by enabling innovation-oriented processes and strengthening long-term capabilities for sustainable development rather than directly improving current performance.

The revised estimates provide clear empirical evidence of the importance of entrepreneurial push and pull factors and an orientation towards a green paradigm in channeling collective action and innovation processes in smallholder farming. The results show that competence-related factors affect both the extent of institutional engagement and the adoption of green practices. This suggests that, among farmers who are better equipped with ecological knowledge and entrepreneurial skills, the potential to activate innovation processes and consolidate collective approaches is greater. Similarly, a forward-looking and sustainability-oriented entrepreneurial mindset increases levels of engagement, as more proactive farmers are more willing to participate in joint-action platforms and invest in collaborative business models, governance, and organizational processes. Such orientations are conducive to the coordination and mutual accountability required to build

institutions in fragmented farming landscapes. Overall, these results are consistent with previous empirical observations regarding the importance of environmentally embedded entrepreneurial characteristics as determinants of innovation diffusion and institutional transformation in rural contexts, particularly those shaped by sustainability constraints and market pressures [14], [35].

In contrast, the empirical analysis does not reveal a direct causal link between particular entrepreneurial attributes and farm-level performance indicators. Neither competence-based nor orientation-based entrepreneurial characteristics show a statistically significant direct association with the performance variables. In addition, neither collective institutional engagement nor environmentally oriented innovation alone produces short-term performance outcomes. This configuration implies that improved performance in smallholder agriculture does not automatically result from either engagement or innovation adoption but instead emerges from repeated processes that accumulate learning, enhance capabilities, and support the realignment of production systems [36]. Further insights into these relationships are provided by mediation analysis. Only the indirect effects of entrepreneurial attributes on environmentally oriented innovation, mediated through collective organizational engagement, are statistically significant, which is consistent with the role of farmer organizations as key intermediaries. These organizations appear to provide a mechanism for converting individual-level potential into collective strength that can support innovation processes. In contrast, all pathways ending in performance outcomes, whether operating only through collective organizational engagement or through multistep sequences linking organization and innovation, are statistically non-significant. This finding suggests that collective arrangements primarily influence the likelihood of developing innovations but do not generate changes in performance in the short term.

Taken together, these results suggest that environmentally related entrepreneurial system characteristics are primarily translated into positive on-farm outcomes through innovation-led institutional capacity building rather than through direct or linear performance effects [33]. In this context, performance improvements appear to be a downstream effect of reorganizing actors to facilitate learning, coordination, and the diffusion of new practices. From a policy and development perspective, these findings suggest that strategies aimed at promoting sustainability in smallholder coffee systems should focus on strengthening farmer organizations as key intermediaries of innovation. Solutions that focus solely on developing individual capabilities are likely to fail without supportive market and collective institutions. Developing policy, institutional, and market settings that support the maturation of innovative activities and their economic adoption at the farm level is therefore important for creating meaningful and sustained change.

5. Conclusion

This research shows that the impact of entrepreneurial orientation on the sustainability performance of Gayo Arabica coffee farming does not occur through direct effects. In other words, entrepreneurial traits, particularly environmental orientation and entrepreneurial competence, primarily support the development of collective institutions and environmentally driven innovations, which act as important intermediaries in transforming smallholder coffee farming into more sustainable production systems. Environmental orientation and entrepreneurial competence are associated with greater participation in collective activities and greater openness to adopting new practices, both of which help balance production goals with environmental considerations.

However, the direct effects of environmental orientation and entrepreneurial competence on short-term performance are not significant, suggesting that these capabilities do not immediately translate into measurable outcomes. Instead, their influence tends to emerge over time as farmers' skills and capacities develop through experience, organizational learning, and evolving institutional arrangements. These findings indicate that sustainability-driven entrepreneurship in agriculture is more likely to generate long-term impacts through gradual structural changes, in which innovation and collective action precede observable improvements in performance.

The mediation analysis further highlights the role of farmer organizations as key institutional intermediaries through which entrepreneurial orientation and competence are translated into green innovation practices. At the same time, the results suggest that strong innovation capacity and organizational involvement alone do not automatically lead to immediate performance gains. Rather, improvements at the farm level tend to materialize with a time lag, reflecting the cumulative effects of incremental innovation, shared learning, and broader system transformation.

From a practical perspective, these findings emphasize the importance of farmer organizations as strategic platforms for facilitating collective learning, promoting the adoption of environmentally friendly technologies, and improving access to markets. Accordingly, development programs and public policies should focus on strengthening green entrepreneurship ecosystems that enable individual competencies to be translated into sustained performance outcomes. Such efforts require integrated support, including organizational development, innovation facilitation, and improved market access.

Future research may benefit from adopting longitudinal and mixed-method approaches to better capture the dynamic processes through which green entrepreneurial orientation (GEO) and green entrepreneurial competence (GEC) influence sustainability performance over time. The findings of this study indicate that, while GEO and GEC are associated with green innovation and farmer organization participation, several direct and indirect relationships with sustainability performance were not statistically significant. This suggests that additional contextual and institutional factors may shape the effectiveness of green entrepreneurial initiatives in smallholder farming systems. Future studies could therefore examine the moderating or mediating roles of variables such as institutional support, sustainability certification, market access, value chain collaboration, environmental awareness, and farmers' adaptive capacity. Furthermore, comparative studies across different coffee-producing regions and agricultural commodities would provide deeper insights into how green entrepreneurship contributes to sustainable development under varying socioeconomic and ecological conditions.

Declaration of competing interest

The authors declare no conflict of interest.

Funding information

This research was funded by the Indonesian Education Scholarship (Beasiswa Pendidikan Indonesia) Balai Pembiayaan Pendidikan Tinggi (BPPT).

Acknowledgements

The authors would like to express their sincere gratitude to the Arabica coffee farmers in Central Aceh Regency who generously participated in this study. The authors also acknowledge the valuable insights provided by key informants during the data collection process. Appreciation is extended to the academic environment of IPB University for supporting this research.

Author contribution

The contribution to the paper is as follows: Alja Yusnadi: conceptualization, methodology, data collection, formal analysis, and writing the original draft; Rachmat Pambudy, Bayu Krisnamurthi, Etriya Etriya: reviewing, editing, and supervising the research. All authors approved the final version of the manuscript.

References

[1] R. Watson, K. R. Nielsen, H. N. Wilson, E. K. Macdonald, C. Mera, and L. Reisch, "Policy for sustainable entrepreneurship: A crowdsourced framework," J. Clean. Prod., vol. 383, Art. no. 135234, 2023. https://doi.org/10.1016/j.jclepro.2022.135234.

[2] A. Prayudi, H. Kurniawati, D. W. Pitaloka, and Z. Roihah, "Analisis kewirausahaan berkelanjutan dalam penjualan brownies di Kampung Kebon Cinangka," Jurnal Pendidikan Sosial dan Humaniora, vol. 2, no. 3, 2023.

[3] J. Haggar, B. Medina, R. M. Aguilar, and C. Muñoz, "Land use change on coffee farms in southern Guatemala and its environmental consequences," Environ. Manage., vol. 51, no. 4, pp. 811–823, 2013. https://doi.org/10.1007/s00267-013-0019-7

[4] A. Sher, S. Mazhar, F. Zulfiqar, D. Wang, and X. Li, "Green entrepreneurial farming: A dream or reality?," J. Clean. Prod., vol. 220, pp. 1131–1142, 2019. https://doi.org/10.1016/j.jclepro.2019.02.198

[5] Y. Kamakaula, "Sustainable agriculture practices: Economic, ecological, and social approaches to enhance farmer welfare and environmental sustainability," West Sci. Nat. Technol., vol. 2, no. 2, pp. 47–54, 2024. https://doi.org/10.58812/wsnt.v2i02.964

[6] A. T. Rosário, R. J. Raimundo, and S. P. Cruz, "Sustainable entrepreneurship: A literature review," Sustainability, vol. 14, no. 9, Art. no. 5556, 2022. https://doi.org/10.3390/su14095556

[7] S. Yonaldi, M. Noer, Y. H. Yeni, and Nofialdi, "Technosociopreneurship model in local economic institutions for agricultural commodity business development," Res. World Agric. Econ., vol. 6, no. 2, pp. 585–604, 2025. https://doi.org/10.36956/rwae.v6i2.1687

[8] H. Dong and Q. Liang, "Agro-food quality certification, agricultural organizations, and farm performance: Evidence from vegetable farmers in China," Int. J. Agric. Sustain., vol. 21, no. 1, Art. no. 2205772, 2023. https://doi.org/10.1080/14735903.2023.2205772

[9] Y. Widiastuti, "The effect of entrepreneurship orientation on coffee farming performance in Banyuwangi Regency (case study in Glagah District)," in Proc. Int. Conf. Manage., Bus., Technol. (ICOMBEST 2021), 2021, pp. 152–157. https://doi.org/10.2991/aebmr.k.211117.022

[10] V. Aliabadi, P. Ataei, and S. Gholamrezai, "Identification of the relationships among the indicators of sustainable entrepreneurial ecosystems in agricultural startups," J. Innov. Knowl., vol. 7, no. 4, Art. no. 100245, 2022. https://doi.org/10.1016/j.jik.2022.100245

[11] Y. Guo, L. Wang, and Y. Chen, "Green entrepreneurial orientation and green innovation: The mediating effect of supply chain learning," SAGE Open, vol. 10, no. 1, Art. no. 2158244019898798, 2020. https://doi.org/10.1177/2158244019898798

[12] W. Ma, M. A. Marini, and D. B. Rahut, "Farmers' organizations and sustainable development: An introduction," Ann. Public Coop. Econ., vol. 94, no. 3, pp. 683–700, 2023. https://doi.org/10.1111/apce.12449

[13] Yusmarni, A. Putri, and C. Paloma, "Entrepreneurial competencies and farm management performance of potato farmers in Solok Regency," IOP Conf. Ser.: Earth Environ. Sci., vol. 1160, no. 1, Art. no. 012058, 2023. https://doi.org/10.1088/1755-1315/1160/1/012058

[14] X. Zhang, X.-E. Zhang, and L. Yang, "Does green entrepreneurial orientation improve the sustainable performance of agribusiness? Evidence from China," SAGE Open, vol. 14, no. 3, Art. no. 21582440241271110, 2024. https://doi.org/10.1177/21582440241271110

[15] D. K. Kangogo, "Farm resilience to climate change: The role of farmer entrepreneurship, farmer organizations and value chain collaboration," Ph.D. dissertation, Wageningen Univ., Wageningen, The Netherlands, 2022. https://doi.org/10.18174/558578

[16] E. Wale, U. Chipfupa, and N. Hadebe, "Towards identifying enablers and inhibitors to on-farm entrepreneurship: Evidence from smallholders in KwaZulu-Natal, South Africa," Heliyon, vol. 7, no. 1, Art. no. e05660, 2021. https://doi.org/10.1016/j.heliyon.2020.e05660

[17] T. K. Ntow, C. A. Wongnaa, R. Nyadu-Addo, M. Addison, D. Awunyo-Vitor, and E. Abokyi, "Effects of entrepreneurial behaviour on market outlets choice: Evidence from rice producers in Ashanti Region, Ghana," Sustain. Technol. Entrep., vol. 2, no. 2, Art. no. 100037, 2023. https://doi.org/10.1016/j.stae.2023.100037

[18] W. Jiang, H. Chai, J. Shao, and T. Feng, "Green entrepreneurial orientation for enhancing firm

performance: A dynamic capability perspective," J. Clean. Prod., vol. 198, pp. 1311–1323, 2018. https://doi.org/10.1016/j.jclepro.2018.07.104

[19] T. F. Musfar, "Green entrepreneurial orientation for achieving sustainable business performance: A conceptual paper," in Proc. Int. Conf. Innovations Social Sciences Education Engineering, vol. 3, Art. no. 049, 2023

[20] M. Mariyamah and S. Handayani, "Pengaruh green innovation terhadap economic performance dengan environmental management accounting sebagai variabel moderasi," J. Akuntansi dan Auditing, vol. 16, no. 2, pp. 105–123, 2020

[21] M. R. H. Polas, A. I. Kabir, A. A. Jahanshahi, A. S. M. Sohel-Uz-Zaman, R. Karim, and M. I. Tabash, "Rural entrepreneurs behaviors towards green innovation: Empirical evidence from Bangladesh," J. Open Innov. Technol. Mark. Complex., vol. 9, no. 1, Art. no. 100020, 2023. https://doi.org/10.1016/j.joitmc.2023.100020

[22] M. Sarfraz, I. Ozturk, S. Yoo, M. A. Raza, and H. Han, "Toward a new understanding of environmental and financial performance through corporate social responsibility, green innovation, and sustainable development," Humanit. Soc. Sci. Commun., vol. 10, no. 1, Art. no. 297, 2023. https://doi.org/10.1057/s41599-023-01799-4

[23] A. S. Alshebami, "Green innovation, self-efficacy, entrepreneurial orientation and economic performance: Interactions among Saudi small enterprises," Sustainability, vol. 15, no. 3, Art. no. 1961, 2023. https://doi.org/10.3390/su15031961

[24] G. F. Ortmann and R. P. King, "Agricultural cooperatives I: History, theory and problems," Agrekon, vol. 46, no. 1, pp. 40–68, 2007. https://doi.org/10.1080/03031853.2007.9523760

[25] Z. Zhong, C. Zhang, F. Jia, and J. Bijman, "Vertical coordination and cooperative member benefits: Case studies of four dairy farmers' cooperatives in China," J. Clean. Prod., vol. 172, pp. 2266–2277, 2018. https://doi.org/10.1016/j.jclepro.2017.11.184

[26] Yusmarni, A. Putri, and C. Paloma, "Entrepreneurial competencies and farm management performance of potato farmers in Solok Regency," IOP Conf. Ser.: Earth Environ. Sci., vol. 1160, no. 1, Art. no. 012058, 2023. https://doi.org/10.1088/1755-1315/1160/1/012058

[27] S. Yang, S. Yu, and L. Li, "Resource acquisition, entrepreneurial competence, and entrepreneurial growth performance of new farmers," Front. Sustain. Food Syst., vol. 9, Art. no. 1545721, 2025. https://doi.org/10.3389/fsufs.2025.1545721

[28] C. M. Stein, N. J. Morris, and N. L. Nock, "Structural equation modeling," in Statistical Human Genetics: Methods and Protocols, R. C. Elston, J. M. Satagopan, and S. Sun, Eds. Totowa, NJ, USA: Humana Press, 2012, vol. 850, pp. 495–512. https://doi.org/10.1007/978-1-61779-555-8_27

[29] W. Abdillah and J. Hartono, Partial Least Square (PLS): Alternatif Structural Equation Modeling (SEM) dalam Penelitian Bisnis. Yogyakarta, Indonesia: Andi, 2015.

[30] C. D. Osei and J. Zhuang, "The effects of institutional supports on farm entrepreneurial performance: Exploring the mediating role of entrepreneurial orientation," SAGE Open, vol. 14, no. 1, Art. no. 21582440241227713, 2024. https://doi.org/10.1177/21582440241227713

[31] S. Nieuwoudt, J. I. F. Henning, and H. Jordaan, "Entrepreneurial competencies and financial performance of farmers in South Africa," S. Afr. J. Econ. Manag. Sci., vol. 20, no. 1, Art. no. a1640, 2017. https://doi.org/10.4102/sajems.v20i1.1640

[32] S. Hutabarat, M. Slingerland, P. Rietberg, and L. Dries, "Costs and benefits of certification of independent oil palm smallholders in Indonesia," Int. Food Agribus. Manag. Rev., vol. 21, no. 6, pp. 681–700, 2018. https://doi.org/10.22434/IFAMR2016.0162

[33] F. Orlando, S. Alali, V. Vaglia, E. Pagliarino, J. Bacenetti, and S. Bocchi, "Participatory approach for developing knowledge on organic rice farming: Management strategies and productive performance," Agric. Syst., vol. 178, Art. no. 102739, 2020. https://doi.org/10.1016/j.agsy.2019.102739

[34] H. R. M. P. Abeyrathne and L. N. A. C. Jayawardena, "Impact of group interactions on farmers'

entrepreneurial behaviour," E&M Econ. Manag., vol. 17, no. 4, pp. 46–57, 2014. https://doi.org/10.15240/tul/001/2014-4-004

[35] T. Perdana, H. M. Arari, H. F. Rahayu, T. Ginanjar, and N. P. A. Sesy, "Development of collaboration in sustainable agribusiness cluster," MATEC Web Conf., vol. 159, Art. no. 01045, 2018. https://doi.org/10.1051/matecconf/201815901045

[36] A. C. Segnon, E. G. Achigan-Dako, O. G. Gaoue, and A. Ahanchédé, "Farmer's knowledge and perception of diversified farming systems in sub-humid and semi-arid areas in Benin," Sustainability, vol. 7, no. 6, pp. 6573–6592, 2015. https://doi.org/10.3390/su7066573