Research on World Agricultural Economy
https://journals.nasspublishing.com/index.php/rwae

ARTICLE

From Carbon Accounting Quality to Green Investment: Moderated Mediation of Perceived Benefits and Access to Green Finance in Vietnamese Agriculture

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ABSTRACT

While carbon accounting is recognized as a pivotal environmental governance tool, prior literature has not explored in detail the mechanisms through which this informational resource translates into tangible investment decisions. This gap is particularly pronounced in emerging market contexts, which are characterized by multiple barriers regarding managerial cognition and capital availability. To address this knowledge gap, this study investigates the impact of carbon accounting quality within Vietnamese agricultural enterprises. Employing partial least squares structural equation modeling on survey data collected from 235 senior managers, the empirical analysis identifies carbon accounting quality as the main driver that exerts the strongest direct influence (β = 0.496). Beyond this direct pathway, information quality also has an indirect effect (β = 0.185) by enhancing the perceived benefits held by management. A critical and novel contribution of the research is the validation of the positive moderating role of access to green finance (β = 0.250). The availability of such capital functions as a vital catalyst that alleviates resource bottlenecks to significantly amplify the translation of perceived benefits into investment actions. With the model explaining 47.2% of the variance in investment decisions, the findings confirm that sustainable transition

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ARTICLE INFO
Received: 13 October 2025 | Revised: 10 January 2026 | Accepted: 14 January 2026 | Published Online: 31 July 2026
DOI: https://doi.org/10.36956/rwae.v7i3.2826

CITATION
Dao, H.M., Dang, M.P., 2026. From Carbon Accounting Quality to Green Investment: Moderated Mediation of Perceived Benefits and Access to Green Finance in Vietnamese Agriculture. Research on World Agricultural Economy. 7(3): 274–290.
DOI: https://doi.org/10.36956/rwae.v7i3.2826

requires both internal information transparency and a supportive external financial ecosystem to provide a robust quantitative basis for green governance strategies.

Keywords: Resource-Based View; Stakeholder Theory; PLS-SEM (Partial Least Squares-Structural Equation Modeling); Emerging Economy

1. Introduction

Vietnam's commitment to achieve net-zero emissions by 2050 presents the agricultural sector with systemic challenges. As a cornerstone of the national economy, the sector faces a sustainable development paradox: the dual imperative to maintain growth momentum for socio-economic security and to restructure the production models to mitigate adverse ecological impacts. These challenges are compounded by increasingly stringent green technical barriers in export markets. Together with the direct impacts of climate change, they threaten the livelihoods of millions of agricultural workers. This complex landscape mandates that enterprises within the sector strategically reposition their development pathways to address escalating demands from diverse stakeholders [1].

Within this context, green investment decisions (GID), such as adopting circular agriculture, smart irrigation technologies, or renewable energy, are no longer a luxury but have become an existential imperative determining a firm's competitive capacity and sustainable survival [2]. However, executing these decisions faces inherent barriers, including high upfront costs, high risks, and notably, a lack of reliable information for assessing their effectiveness. To navigate this complex environment, carbon accounting has emerged as a strategic tool allowing firms to systematically quantify, analyze, and report their emission flows [3]. Contemporary studies confirm that applying advanced carbon accounting techniques serves as a foundation for fostering sustainable development indices [4] and increasing investment levels in green research and development [5].

According to the Resource-Based View (RBV), a high-quality carbon accounting (CAQ) system is an invaluable informational resource [6]. However, the nature of CAQ in the Net-zero era extends far beyond mere disclosure; it demands accuracy, comparability, and data assurance [7]. Recently, Luo and Pan [8] provided significant empirical evidence showing that the quality and assurance of carbon information help mitigate inefficient investment by improving the information environment and reducing information asymmetry.

Although the role of environmental information is widely acknowledged, a theoretical and practical knowledge gap persists regarding the mechanism through which accounting information translates into concrete investment action within agricultural enterprises. Does high-quality information automatically lead to decisions, or is its effect contingent upon managerial understanding? This study argues that information from CAQ is only truly effective when it shapes the perceived benefits (PB) of managers. Drawing on signaling theory, transparent information helps managers recognize opportunities to attract green investors [9] and access capital at lower costs [10], thereby generating internal motivation for investment decisions.

Furthermore, even the strongest investment intentions may prove futile without sufficient capital, a challenge particularly acute in the agricultural sector. Therefore, this research integrates access to green finance (GF) as a critical moderating factor. Recent evidence from Li et al. [11] and Ma [12] indicates that green finance acts as an essential catalyst, enabling firms with transparent information to overcome liquidity constraints and realize innovation projects. Especially in transition economies, the interaction between green credit policy and firm ownership characteristics is a key factor driving information disclosure and practical action [13].

To elucidate these complex relationships, this study develops and tests a moderated mediation model, analyzing the pathway from CAQ to GID via the mediator of PB and the moderator of GF. This research has three significant contributions. First, it clarifies the internal psychological mechanism, showing that information must be recognized by managers to foster action. Second, it

identifies the external financial boundary condition, emphasizing the indispensable role of a supportive financial ecosystem. Finally, by utilizing empirical data from Vietnam, the study provides specific policy implications to support the green transition of a pivotal economic sector within an emerging market context.

2. Hypotheses and Research Model

2.1. Hypothesis Development

This study draws on stakeholder theory and the RBV to explain how CAQ shapes GID. From an RBV perspective, CAQ is more than just neutral information input; it functions as a strategic capability that underpins sustained competitive advantage when it meets the VRIO criteria of value, rarity, inimitability, and organizational embeddedness[6]. High-CAQ systems provide valuable information useful for decision-making that goes beyond compliance, enabling firms to identify carbon-intensive processes, prioritize abatement opportunities, and uncover complementarities between cost efficiency and environmental performance, which is consistent with the natural RBV of the firm[2].

Recent empirical work shows that robust carbon accounting and disclosure systems enhance firm value and green innovation by improving the quality and credibility of emissions data, thereby supporting strategic decision-making and resource allocation for sustainability projects[14]. Moreover, these capabilities are relatively rare because they require the co-evolution of advanced measurement technologies, specialized human capital, and committed leadership, which many agricultural enterprises, particularly in emerging economies, do not yet possess[15]. CAQ's uniqueness comes from its embedding in firm-specific routines, tacit expertise, and historically accumulated data architectures that competitors find difficult to replicate. Recent advances in carbon accounting research further emphasize that developing high-quality CAQ systems requires iterative learning, cross-functional integration, and path-dependent capability-building processes that are inherently socially complex and resistant to imitation[15]. These characteristics are fully consistent with RBV arguments that internal routines, tacit knowledge, and evolving data infrastructures constitute key sources of unique competitive advantage.

Finally, realizing the strategic potential of CAQ depends on organizational structures that enable the integration of carbon data into planning, budgeting, and investment appraisal processes. Studies on carbon accounting and green finance show that when emissions information is systematically incorporated into capital budgeting and risk management, firms are more likely to undertake low-carbon projects and improve their sustainable development indices[4]. In line with the argument by Schaltegger and Csutora[3] that monetized and reliable carbon information can be used to evaluate the business case of environmental investments, we argue that CAQ serves as a strategic interface that transforms raw emissions data into actionable investment insights. Taken together, when CAQ satisfies VRIO conditions, it becomes a core strategic capability that provides a solid informational foundation for firms to commit to green investments. Accordingly, we posit that firms with higher CAQ will pursue greener, more systematic investment portfolios than those with less sophisticated carbon information systems.

Complementing the RBV, stakeholder theory highlights how CAQ becomes a strategic response to an increasingly demanding multi-stakeholder environment. Agricultural enterprises in Vietnam operate within a dense network of stakeholders, including regulators, supply chain partners, investors, local communities, and international standard setters, whose expectations differ in power, legitimacy, and urgency. In line with stakeholder salience theory, firms must prioritize and navigate these diverse pressures simultaneously, making high-quality CAQ an essential tool for managing stakeholder demands[16].

State agencies and government bodies exert coercive and normative pressures when they translate national net-zero commitments and climate pledges into regulations, such as potential carbon pricing schemes, disclosure mandates, and sectoral emission standards[4]. Recent evidence on mandatory carbon disclosure regimes and supply-chain transmission of disclosure requirements shows that regulation and customer demand for emissions data significantly improve emis-

sions performance and strengthen stakeholder monitoring along global value chains [17]. In this context, high-quality CAQ functions both as a risk management and a legitimacy mechanism. It supplies transparent, consistent, and verifiable data that can be used to demonstrate compliance, anticipate policy shifts, and engage with regulators, thereby minimizing regulatory uncertainty and avoiding potential sanctions [18].

Beyond the state, influential supply chain partners, especially international buyers participating in initiatives such as CDP Supply Chain, enforce their own climate targets using stringent information and performance requirements for upstream suppliers, including detailed product carbon footprints and lifecycle emissions [17]. Failure to provide reliable carbon information can lead to exclusion from global supply chains, whereas firms that invest in CAQ can differentiate themselves as trustworthy partners and leverage environmental performance as a source of competitive advantage [19].

The investment community and financial institutions further amplify these pressures. The rapid growth of environmental, social, and governance investment and the proliferation of green financial instruments have increased investors' sensitivity to climate-related risks and their demand for credible emissions data [19]. Prior research on voluntary disclosure indicates that higher-quality environmental and carbon disclosure reduces information asymmetry, lowers the cost of capital, and improves access to external finance [20]. Recent studies specifically focused on carbon information disclosure quality show that high-quality carbon information enhances firm value and stimulates green innovation, in part because it signals superior environmental management to capital providers [14]. At the same time, cutting-edge work on carbon accounting quality demonstrates that external assurance of emissions reports improves CAQ, especially where internal systems are weak, thereby further increasing stakeholder confidence in reported data [21]. In this context, CAQ no longer functions solely as an internal reporting tool. It becomes a key relational resource that supports the negotiation of regulatory expectations, supply chain contracts, and financing terms.

By providing a robust and auditable basis for quantifying carbon costs and efficiencies, CAQ allows managers to justify green projects to stakeholders with short-term financial orientations and to communicate the financial rationale of decarbonization strategies [22]. In short, we expect that firms with higher CAQ will exhibit stronger and more systematic engagement in green investments, driven jointly by the pursuit of competitive advantage and by multi-directional stakeholder pressures. Hence, we propose the following hypothesis:

H1. *CAQ has a positive effect on GID.*

The effect of information quality on organizational action is typically mediated by managerial perception. In this study, we conceptualize PB as the key cognitive mechanism linking CAQ to GID. High-quality carbon information transforms abstract and technical emissions metrics into strategic knowledge about efficiency potentials, regulatory exposure, reputational risks, and new market opportunities. Empirical work revisiting the Porter hypothesis indicates that well-designed environmental regulation and accurate environmental information can stimulate eco-innovation, improve productivity, and enhance competitiveness through innovation offsets rather than merely imposing compliance costs [23, 24]. When firms possess granular and reliable carbon cost information, they can better identify resource and energy efficiency opportunities, redesign processes, and adopt low-carbon technologies that reduce operating costs and vulnerability to future climate policies [25].

Recent micro-level evidence shows that high-quality carbon disclosure and accounting are associated with stronger green innovation and improved sustainable development performance, suggesting that managers internalize both the cost-saving and opportunity-enhancing dimensions of low-carbon investments [14]. Moreover, high-quality carbon disclosures help firms build legitimacy and strengthen their reputation with customers, investors, and other stakeholders, which can lead to better market access and brand differentiation [26]. At the same time, CAQ enables more proactive legal and regulatory risk management by allowing firms to anticipate carbon pricing, disclosure mandates, and supply-chain requirements, thereby lowering the likelihood of sanctions or abrupt compliance costs [17]. As

these economic, strategic, and risk-related benefits are more clearly perceived, they shape managerial attitudes toward green projects, making them appear less arbitrary and more integral to long-term competitiveness.

PB thus functions as a cognitive bridge that converts the informational value of CAQ into a stronger intention to allocate capital to green investments and to prioritize such projects within the firm's investment portfolio. Therefore, we expect that CAQ improves GID primarily through its impact on managers' benefit perceptions. We therefore hypothesize that:

H2. *PB mediates the relationship between CAQ and GID.*

To align with the structural path analysis depicted in the conceptual model, this overall mediating mechanism is decomposed into two constituent sub-hypotheses:

H2a. *CAQ has a positive effect on PB.*

H2b. *PB has a positive effect on GID.*

However, favorable perceptions alone do not guarantee action. Turning intention into actual green investment is contingent on the availability of financial resources, particularly in developing economies where firms often face severe capital constraints and green projects involve high upfront costs and long payback periods. We argue that access to GF plays a critical moderating role in the PB–GID relationship.

The growing literature on green finance highlights its role in directing capital toward environmentally beneficial projects through instruments such as green bonds, green loans, and sustainability-linked credit facilities, and shows that green financing can reduce emissions, support technological upgrading, and enhance firms' sustainable performance [19]. At the firm level, empirical evidence shows that access to dedicated green financial products and favorable lending conditions significantly increase the likelihood and scale of green investment, especially among companies that are already aware of climate risks and mitigation technologies but are constrained by financing frictions [27]. Research on green and sustainable finance in emerging markets similarly suggests that well-designed green finance programs and supportive banking practices help firms convert environmental aspirations into concrete investment actions and improve both financial and non-financial performance [28].

Thus, GF operates as a catalyst that determines whether the perceived attractiveness of green projects, shaped by CAQ and reflected in PB, can be realized in practice. When access to GF is favorable through concessional interest rates, appropriate collateral requirements, credible taxonomies, and transparent procedures, firms with strong perceived benefits can mobilize external capital to cover high upfront costs, scale up projects, and tolerate longer payback horizons [29]. Under such conditions, PB is more likely to translate into actual GID, amplifying the positive PB–GID link.

Conversely, when access to GF is limited or transaction costs are high, even managers who clearly recognize the strategic and financial advantages of green investments may delay, scale back, or cancel projects due to liquidity constraints and risk aversion. Evidence from climate finance and sustainable investment also suggests that firms with better access to external finance are better positioned to exploit the strategic opportunities arising from environmental and social initiatives, whereas financially constrained firms struggle to act on similar perceptions [30]. Accordingly, we expect the marginal effect of PB on GID to be stronger when firms have easier access to GF and weaker when capital constraints are tighter. This leads to the following hypothesis:

H3. *Access to GF positively moderates the relationship between PB and GID, such that the relationship is stronger when access to green finance is higher.*

Finally, consistent with prior research on corporate environmental investment, firm characteristics-especially firm size-are likely to influence GID and must be controlled for to avoid biased estimates of the main effects. Larger firms typically possess more available resources, more sophisticated management systems, and greater exposure to public and regulatory scrutiny, all of which increase both the capacity and the pressure to undertake green investments [27]. Thus, firm size is incorporated as a control variable affecting GID in the empirical model, allowing us to isolate more accurately the effects of CAQ, PB, and GF on green investment behaviour.

2.2. Research Model

Drawing upon the established theoretical foundations and the hypotheses developed, this study proposes a comprehensive moderated mediation model. This model aims to elucidate the complex mechanism through which CAQ influences the GID of enterprises. Specifically, the model posits that CAQ exerts not only a direct effect on GID but also an indirect effect mediated by the variable PB. Furthermore, to reflect real-world barriers, the model incorporates GF as a moderating factor, which is hypothesized to strengthen the relationship between PB and GID.

To enhance the robustness of the findings and account for potential confounding effects, the model also includes firm size (FS) as a control variable. This variable controls for the direct influence of organizational size on the capacity and motivation to undertake green investments. Collectively, this framework permits a simultaneous examination of how (via the mediation of PB), when (contingent upon GF), and under what conditions (after controlling for the influence of size) carbon accounting quality can effectively promote corporate environmental investment activities (**Figure 1**).

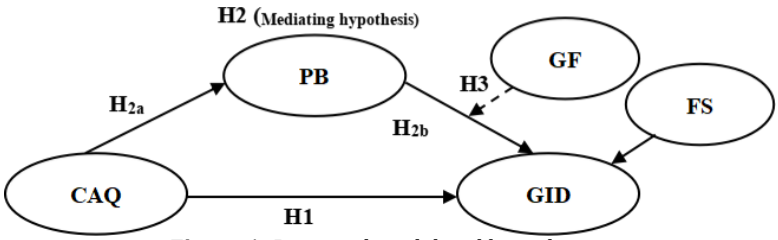

Figure 1. Proposed model and hypotheses.

3. Research Methodology

3.1. Research Design and Data Collection

This study employs a quantitative methodology using a survey to collect primary data. To select the survey participants, we adopted a two-stage non-probability sampling method. In the first stage, a list of potential agricultural enterprises was selected using convenience sampling. This list was compiled by the authors from available sources. These mainly include membership directories of large business associations and the research team's professional networks. This approach was selected for its feasibility and efficiency. It was appropriate due to the lack of a comprehensive and public sampling frame for all agricultural enterprises in Vietnam.

In the second stage, purposive sampling was used to identify specific respondents within each selected enterprise. The core objective was to collect in-depth and reliable information regarding strategic decisions. We therefore targeted only the two positions with the most relevant authority and knowledge: Chief Executive Officers and Chief Accountants. This ensures that the collected data accurately reflects the perspective of the highest management level. It also maximizes the content validity of the research.

The survey was conducted from November 2024 to January 2025. A total of 368 questionnaires were distributed. Following the collection period, 263 responses were collected. The data were then screened to eliminate invalid or incomplete entries. This yielded a final dataset of 235 valid responses for analysis, corresponding to an effective response rate of 63.9%. This response rate is considered quite favorable for a demographic of senior managers. It indicates their interest in the research topic and significantly alleviates concerns about non-response bias. Prior to its official deployment, the questionnaire underwent a rigorous refinement process. This includes in-depth consultations with three academic experts and two industry professionals to ensure all terminology was clear and appropriate for the Vietnamese context.

3.2. Sample Characteristics

The research sample was designed to ensure representativeness and reliability for the data analysis. Regarding job positions, the sample is comprised of 42.6%

CEOs and 57.4% Chief accountants, reflecting the successful outreach to respondents with the authority and expertise required to accurately assess the concepts within the research model. The educational level of the respondents is high, with 45.1% holding a master's degree or higher, which bolsters the quality of the collected responses. Work experience is well-distributed, with the group having 5 to less than 10 years of experience constituting the largest segment (43.4%), indicating that most respondents possessed sufficient practical experience to provide valid assessments. Regarding the firm characteristics, the research sample exhibits a broad geographical distribution, with representation from the northern (46.0%), southern (39.1%), and central (14.9%) regions. The sample is also diverse in scale, comprising large (41.7%), medium-sized (35.3%), and small (23.0%) enterprises. Overall, the sample's characteristics demonstrate its suitability and diversity, providing a solid data foundation for testing the model (**Table 1**).

Table 1. Characteristics of the Survey Sample (N = 235).

Demographics	Frequency	Percent (%)
Job Position		
Chief Executive Officer	100	42.6
Chief Accountant	135	57.4
Educational Level		
Bachelor's Degree	129	54.9
Master's Degree or Higher	106	45.1
Work Experience		
<5 years	52	22.1
5 to <10 years	102	43.4
≥10 years	81	34.5
Region of Operation		
Northern region	108	46.0
Central region	35	14.9
Southern region	92	39.1
Enterprise Size		
Small	54	23.0
Medium	83	35.3
Large	98	41.7

Source: Author synthesis.

3.3. Measurement of Variables

All latent variables in the model were measured using multi-item scales with a 5-point Likert scale, ranging from 1 ("Strongly disagree") to 5 ("Strongly agree"). These scales were carefully adapted from previous studies published in reputable international journals (**Table 2**). Specifically, the CAQ scale consists of four indicators, developed based on the standards of the GHG Protocol [31], drawing upon core concepts from the theoretical framework of Schaltegger and Csutora [3] and illustrated by practical evidence from the case study by Lee [32], Cao et al. [26], and Gipper et al. [21]. The PB scale includes four indicators, adapted from the foundational works of Porter and Linde [25], and further informed by empirical studies from Li et al. [33] and Cao et al. [26]. The GF scale comprises three indicators, based on firm-level investment studies by Kalantzis et al. [27] and Popescu and Popescu [28]. Finally, the GID scale contains four indicators, adapted from the measurement frameworks of Inderst et al. [34] and Kalantzis et al. [27].

3.4. Data Analysis Method

The collected data were analyzed by Partial Least Squares Structural Equation Modeling (PLS-SEM) using the SmartPLS 4.0 software. The selection of PLS-SEM is justified by its distinct advantages in handling complex models, its relaxed requirements regarding data normality, and its specific suitability for prediction-oriented research objectives [35]. To ensure a clear and comprehensive presentation of results, this study adopts a standard two-stage analytical procedure combined with advanced assessment tools.

Table 2. Variables and measurement items.

Variables	Description	Sources
	Carbon Accounting Quality (CAQ)	
CAQ1	My company provides a full and transparent presentation of its GHG emissions (Scope 1, 2, and, where applicable, Scope 3), including methodologies and assumptions.	Adapted from: Schaltegger and Csutora [3]; Gipper et al. [21]; Cao et al. [26]; GHG Protocol [31]; Lee [32].
CAQ2	My company provides multi-year emissions data to allow for the comparison of trends over time.	
CAQ3	My company's carbon emissions data is verified by an independent third party or is subject to a rigorous internal quality assurance process.	
CAQ4	Carbon accounting information is highly integrated into the management reporting system to support investment and operational decisions.	
	Perceived Benefits (PB)	
PB1	Our leadership believes that green investments will help reduce long-term operational costs (e.g., energy savings, raw materials, waste treatment costs).	Adapted from: Porter and Linde [25]; Cao et al. [26]; Li et al. [33].
PB2	Green investment is a strategic opportunity to improve our company's reputation, brand image, and competitive advantage.	
PB3	Proactive green investment helps our company better meet requirements from the supply chain/customers and opens up new market opportunities.	
PB4	Green initiatives help our company mitigate risks related to legal and increasingly stringent environmental regulations.	
	Access to Green Finance (GF)	
GF1	Our company perceives that there are numerous green capital/credit sources available in the market for investment projects.	Adapted from: Kalantzis et al. [27]; Popescu and Popescu [28].
GF2	The financial institutions we work with offer preferential conditions (e.g., interest rates, loan terms) for green investment projects.	
GF3	The procedures and requirements for accessing green finance sources are clear and feasible for our company.	
	Green Investment Decisions (GID)	
GID1	In the past three years, my company has made significant investments in upgrading machinery and equipment to save energy.	Adapted from: Kalantzis et al. [27]; Inderst et al. [34].
GID2	My company has invested in cleaner production technologies to reduce emissions directly at the source (e.g., emission treatment, water recycling).	
GID3	Our leadership plans to increase the budget allocation for green projects in our upcoming investment strategy.	
GID4	When approving a new investment project, environmental criteria (e.g., CO_2 reduction levels) are considered an important factor in the decision-making process.	

Given that data were collected from a single source at a single point in time, potential common method bias (CMB) was addressed in a preliminary step. This was achieved through a full collinearity assessment by examining variance inflation factor (VIF) values, following the recommendations of Kock [36].

Upon confirming that CMB was not a significant concern, the first stage focused on evaluating the measurement model to verify reliability and validity. Specifically, internal consistency reliability was assessed via Cronbach's alpha and composite reliability. Convergent validity was evaluated using the average variance extracted (AVE), while discriminant validity was tested using the heterotrait-monotrait ratio (HTMT) criterion, which reflects the established standard practice [37].

In the second stage, the structural model was ana-

lyzed to test the proposed hypotheses. The statistical significance of path coefficients was determined through a bootstrapping procedure employing 5,000 subsamples. Notably, to elucidate the magnitude of effects and the model's predictive power for a robust presentation of findings, the analysis extends beyond the coefficient of determination (R^2). It incorporates the predictive relevance (Q^2) metric via the PLSpredict procedure. This multidimensional approach ensures that the drawn conclusions possess not only statistical significance but also high practical value.

4. Research Results

4.1. Common Method Bias Control

To ensure the accuracy of the model estimations, testing for multicollinearity is an indispensable step. This issue occurs when independent variables in a model are highly correlated, leading to unstable and difficult-to-interpret coefficient estimates. In this study, we used the VIF to assess the level of multicollinearity. According to the criteria proposed by Hair et al.[35], VIF values for latent variables (Inner VIF) and indicators (Outer VIF) below 3.0 or 5.0 are considered acceptable, indicating no serious multicollinearity issues. The results of the full collinearity VIFs analysis are presented in **Table 3**. As shown, the range of outer VIF values for the indicators of the research constructs is between 1.454 and 2.162, all of which are well below the 3.0 threshold. Notably, the inner VIF values for the relationships between constructs in the endogenous model are also very low, with the highest value being 1.239. These results provide convincing evidence that the research model is not affected by multicollinearity, thus ensuring the reliability of the subsequent analyses and interpretations[36].

Table 3. Full collinearity VIFs analysis.

Latent Construct (Indicators)	Outer VIF Range	Inner VIF
CAQ (CAQ1–CAQ4)	1.662–1.882	1.239
FS (Firm Size)	1.000	1.010
GF (GF1–GF3)	1.587–1.684	1.015
GID (GID1–GID4)	1.454–1.622	–
PB (PB1–PB4)	1.913–2.162	1.239
GF x PB	1.000	1.007

Source: Authors' calculation using SmartPLS 4.

4.2. Measurement Model Assessment

The reliability of the scales was evaluated using Cronbach's alpha, composite reliability (Rho_a, Rho_c). The findings indicated that all constructs were reliable. Specifically, the values for Cronbach's alpha (ranging from 0.774 to 0.860), composite reliability (Rho_c, from 0.855 to 0.905), and, notably, the more conservative estimate of Rho_a (from 0.774 to 0.866), all surpassed the recommended threshold of 0.70, thereby confirming the high internal consistency of the measurement scales[35]. Convergent validity was assessed using the AVE. All constructs had AVE values greater than 0.5 (ranging from 0.595 to 0.703), confirming that the indicators for each construct converge well and effectively represent the concepts they measure[38].

To test for discriminant validity, the study used the HTMT ratio of correlations. According to Henseler et al.[37], the HTMT value between two constructs should be less than 0.85 (or 0.90 for models with similar concepts). The analysis revealed that the highest HTMT value in the model was 0.649 (between PB and GID). As all HTMT values were significantly below the most stringent threshold, it can be concluded that the scales achieved good discriminant validity. This provides strong evidence for the distinctiveness of the constructs in the model, affirming that each one is unique and measures a different phenomenon. Overall, the analysis confirms that the study's measurement model is robust, reliable, and valid, providing a dependable foundation for the evaluation of the structural model (**Table 4**).

Table 4. Results of Measurement Model Reliability and Validity Assessment.

Construct	Cronbach's Alpha	CR (Rho_c)	CR (Rho_a)	AVE	Highest HTMT Result
CAQ	0.832	0.888	0.833	0.666	0.592 (with GID)
GF	0.783	0.872	0.804	0.695	0.205 (with GID)
GID	0.774	0.855	0.774	0.595	0.649 (with PB)
PB	0.860	0.905	0.866	0.703	0.649 (with GID)

Source: Authors' calculation using SmartPLS 4.

4.3. Structural Model Assessment and Hypothesis Testing

After the measurement model was confirmed to be reliable and valid, the next step was to assess the structural model to test the research hypotheses. The results of the PLS-SEM structural equation model analysis are presented in **Figure 2**.

Path coefficients (β), *t*-statistics (*t*-values), and confidence intervals were estimated using a bootstrapping procedure with 5,000 resamples, a robust method for assessing statistical significance without requiring assumptions of normal data distribution [35]. The results of the main hypothesis tests are summarized in **Table 5**.

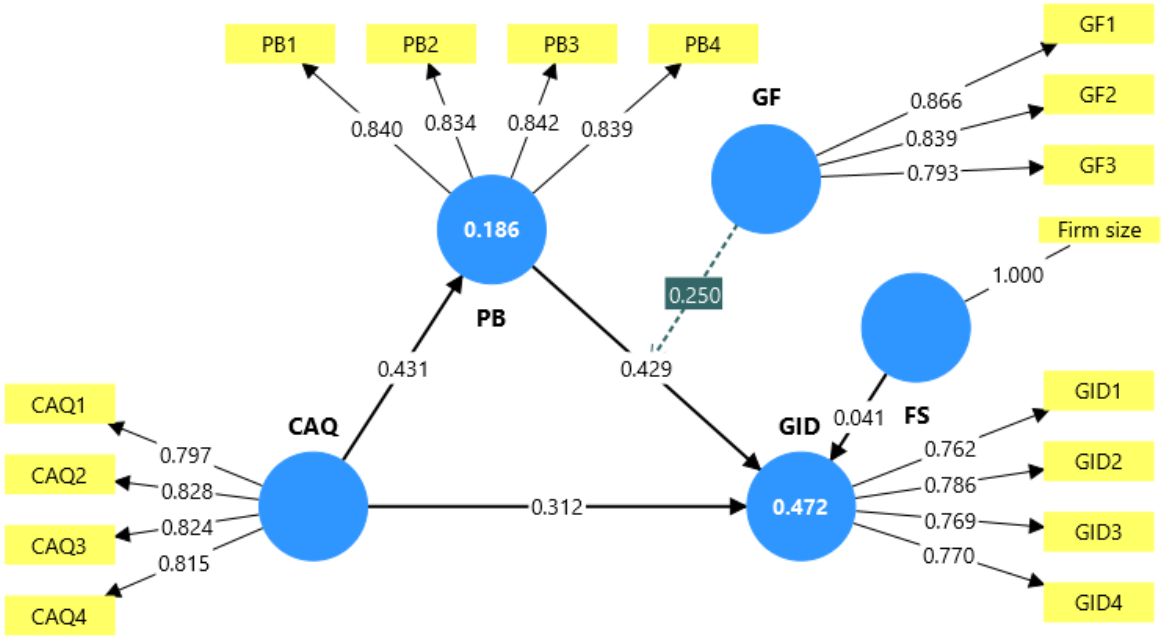

Figure 2. The results of the PLS-SEM structural equation model analysis.

Table 5. Hypothesis Testing Results.

Hypothesis	Relationship	Path Type	Path Coefficient (β)	*t*-Statistic	*p*-Value	Conclusion
H1	CAQ -> GID	Direct Effect	0.312	5.319	0.000	Supported
H2	CAQ -> PB -> GID	Indirect Effect	0.185	5.621	0.000	Supported
H3	GF x PB -> GID	Interaction Effect	0.250	4.392	0.000	Supported
Control	FS -> GID	Direct Effect	0.041	0.826	0.409	Not Supported

Source: Authors' calculation using SmartPLS 4.

The analysis indicates that all direct relationships in the model are statistically significant at the $p < 0.001$ level. Specifically, the results strongly support hypothesis H1, showing that CAQ has a significant and strong positive effect on GID (β = 0.312, $t = 5.319$). This finding reinforces the key argument that a high-quality carbon information system, providing reliable and timely data, is a core foundation for management to confidently make

investment decisions in green technologies and projects, thereby realizing the "win-win" opportunities proposed by Porter and Linde [25].

The results also confirm hypothesis H2 regarding the indirect effect (CAQ -> PB -> GID), with a significant indirect coefficient of 0.185 (t = 5.621). This confirms the partial mediating role of PB in the relationship between CAQ and GID, as a significant direct effect of CAQ on GID still exists. In other words, high-quality information has both a direct impact on action and an indirect impact through shaping and reinforcing perceptions of benefits, thus promoting green investment comprehensively.

Hypothesis H3, which pertains to the moderating effect of Green Finance (GF), also receives strong support from the data. The interaction term (GF x PB -> GID) is positive and statistically significant (β = 0.250, t = 4.392). This finding shows that GF serves as a critical catalyst, positively moderating the relationship between PB and GID. Specifically, in an environment where green financial resources (such as concessional loans or green bonds) are easily accessible under transparent conditions [27], the impact of PB on GID becomes significantly stronger. Conversely, barriers to capital access can substantially weaken this link, even when perceptions of benefits are high. This highlights the multifaceted nature of the green investment decision-making process, where internal drivers (perceptions) need to be supported by favorable external conditions (finance).

The control variable, Firm Size (FS), was not found to have a statistically significant effect on GID (β = 0.041, t = 0.826, p = 0.409). This implies that, within the context of this study's sample, the impetus for green investment may be driven more by strategic and cognitive factors than by the absolute size of the enterprise.

Regarding the model's explanatory power, the R^2 value for the main dependent variable, GID, is 0.472, indicating that the model explains 47.2% of the variance in GID. For the mediating variable, PB, the R^2 is 0.186 (**Table 6**). These values are considered moderate to substantial in social science research, confirming that the model has good predictive and explanatory power for the phenomenon under investigation [35].

Table 6. Model Explanatory Power.

Construct	R^2	R^2 Adjusted
GID (Green Investment Decision)	0.472	0.460
PB (Perceived Benefits)	0.186	0.182

Source: Authors' calculation using SmartPLS 4.

4.4. Model Predictive Power and Assessment

The results of the predictive power assessment presented in the table demonstrate that the research model possesses substantial predictive value. The $Q^2_{predict}$ indices for both dependent variables yielded positive values, specifically 0.245 for green investment decisions and 0.174 for perceived benefits. In accordance with the criteria established by Shmueli et al. [39], $Q^2_{predict}$ value greater than zero indicates that the model holds superior predictive capability relative to the naive mean-based benchmark. This finding confirms that the theoretical framework not only effectively explains the relationships between carbon accounting quality and the outcome variables but also holds practical utility in forecasting investment behavioral trends within agricultural enterprises. Such predictive capability is particularly salient for managers seeking to anticipate the efficacy of green finance strategies. The prediction error metrics provide further substantiation of the model's accuracy. The RMSE and MAE values for both dependent variables remain within acceptable and relatively balanced ranges. Specifically, the root mean square error for green investment decisions is 0.875 while it is 0.917 for perceived benefits, with corresponding mean absolute error values of 0.706 and 0.791, respectively. The stability observed in the magnitude of error metrics across the two variables suggests consistency in the predictive capacity of the model. Accurate predictive capability enhances the reliability of the research recommendations and enables managers to utilize the model for evaluating compliance prospects and formulating investment decisions grounded in transparent data (**Table 7**).

Table 7. Model Predictive Power Assessment Results.

Dependent Variable	$Q^2_{predict}$	RMSE	MAE
GID	0.245	0.875	0.706
PB	0.174	0.917	0.791

Source: Authors' calculation using SmartPLS 4.

5. Discussion of Research Results

The empirical findings of this study offer a multidimensional and profound insight into the mechanism driving green investment within the Vietnamese agricultural sector, signifying a paradigm shift from a compliance-based view to a strategic resource-based perspective. The confirmation of the direct impact of CAQ on GID reinforces the core premise of the RBV in the digital era. Consistent with contemporary scholars such as Huang et al.[14], Luo and Pan[8], and Glenk[15], our results indicate that high-quality carbon information has evolved into a strategic intangible asset in the race toward net-zero. By satisfying the VRIO criteria through accuracy and auditability, CAQ mitigates the inherent opacity of agricultural operations. This transparency serves not only for regulatory reporting but also functions as a risk mitigation mechanism, empowering managers to identify inefficiencies and allocate capital confidently to green technologies. This finding refutes the conventional view of environmental accounting as a cost burden, instead asserting it as a prerequisite for resolving under-investment issues caused by information asymmetry. This strongly supports the foundational arguments of Porter and Linde[25] and Schaltegger and Csutora[3], while being bolstered by the recent analyses of Gipper et al.[21].

Delving deeper into the transformation mechanism, the study elucidates the psychological dimension through the mediating role of PB. The validation of this pathway underscores that informational resources do not automatically lead to strategic action but must overcome a perception barrier. Reliable carbon data reshapes managerial cognition, converting abstract environmental pressures into tangible business equations, such as energy cost savings or premium market positioning. This result resonates with the meta-analytical perspectives of Zhang et al.[23], demonstrating that accurate information stimulates innovation by altering the risk-return calculus of leadership. Furthermore, aligning with Cao et al.[26] and Feng and Huang[9] within the framework of signaling theory, transparent information serves as a signal of legitimacy. This creates a psychological impetus for leaders to commit to green investments to safeguard corporate reputation, attract green investors, and reduce the cost of capital. Consequently, managers perceiving that their accounting system broadcasts positive signals regarding ESG performance experience a significantly heightened internal motivation to commit to investment. Thus, CAQ acts as the evidence, while PB functions as the conviction necessary for decision-making.

Notably, the research highlights the boundary conditions of these relationships through the moderating role of GF. The acceptance of this interaction effect reveals the catalytic nature of capital markets in emerging economies. While internal information and cognitive motivation are necessary conditions, they remain insufficient to surmount the barriers of substantial initial costs and long payback periods characteristic of agricultural projects. The findings demonstrate that favorable access to green capital, such as concessional credit or green bonds, significantly amplifies the translation of managerial intent into execution. This reflects the conclusions of Ahmad et al.[19], Kalantzis et al.[27], as well as Li et al.[11] and Ma[12], confirming that the synergy between internal transparency capabilities and an external supportive financial ecosystem is a key factor in unlocking capital flows for green transition. Specifically in Vietnam, where the capital market is developing, green finance operates as a bridge resolving the liquidity constraints that often stifle innovation in the private sector.

Finally, the finding that the firm size control variable lacks statistical significance offers a profound implication regarding the institutional context of export-oriented agriculture. Contrasting with traditional theories that favor large enterprises, this result suggests

an equalization of competitive status driven by global supply chain pressures. As analyzed by Deng et al.[17], institutional isomorphism compels Small and Medium-sized Enterprises (SMEs) to adopt rigorous sustainability standards similar to those of large conglomerates to maintain their position in the global value chain, particularly when exporting to the EU or the US. Consequently, for these SMEs, green investment is driven less by economies of scale and more by the existential necessity of maintaining organizational legitimacy and rights to access international markets.

6. Implications of the Study

6.1. Theoretical Implications

The findings of this study offer significant contributions to the existing literature by synthesizing Stakeholder Theory and the RBV into a coherent framework for explaining green investment behaviors. Unlike prior studies that predominantly focused on direct relationships, this research elucidates the complex mechanism wherein perceived benefits mediate the impact of carbon accounting quality on investment decisions. Furthermore, by situating the model within an emerging economy context, the study provides empirical evidence for the boundary conditions of these relationships, specifically highlighting the catalytic role of access to green finance. This validates the argument that in transitional markets, internal capabilities must be coupled with favorable external financial conditions to translate strategic intent into actualized investment.

6.2. Practical Recommendations

Based on the empirical results, this study proposes specific recommendations targeted at three key stakeholder groups: corporate managers in the agricultural sector, policymakers, and financial institutions.

For corporate managers and practitioners, the confirmation of the mediating role of perceived benefits suggests that the value of carbon accounting quality extends beyond regulatory compliance. Managers should rethink the role of carbon accounting from a mere administrative obligation to a strategic asset that drives competitive advantage. To operationalize this, agricultural enterprises are recommended to invest in advanced environmental management information systems that ensure data reliability and transparency. More importantly, leadership must actively utilize this data to communicate the economic and reputational benefits of green initiatives to internal stakeholders. By integrating carbon reduction targets into departmental key performance indicators, managers can align the cognitive perceptions of the workforce with the firm's strategic green objectives, thereby facilitating smoother approval and implementation of green projects.

For policymakers and regulators, the proven moderating effect of access to green finance underscores the necessity of a supportive financial ecosystem. The results indicate that even with high internal motivation, firms may hesitate to invest without sufficient capital support. Therefore, recommendations for this group focus on removing financial barriers rather than solely imposing reporting mandates. Policymakers should prioritize the development of a comprehensive green taxonomy and legal framework for green bonds and credits. Specific interventions should include establishing credit guarantee funds for agricultural projects and offering preferential interest rate mechanisms for verified green investments. These measures will reduce the cost of capital and mitigate the risks associated with long-term environmental projects, effectively unlocking private sector participation in the national net-zero agenda.

For financial institutions and investors, the study highlights the relevance of carbon accounting quality as a critical screening criterion. Banks and investment funds are recommended to incorporate the maturity of a firm's carbon accounting system into their credit appraisal processes. A high-quality reporting system should be viewed as a signal of lower transition risk and better governance. Consequently, financial institutions should design specific green financial products that reward firms possessing transparent emissions data with streamlined approval processes or lower lending rates. This approach not only safeguards the financial sector's portfolio against climate risks but also incentivizes agricultural firms to upgrade their information disclosure practices to access capital more easily.

7. Limitations and Future Research

Although this study has provided important results, it is not without certain limitations that need to be acknowledged. First, the study uses a two-stage non-probability sampling method, combining convenience and purposive techniques. While this method was appropriate for targeting the correct experts, it inherently limits the statistical generalizability of the findings. The results may not apply to the entire population of Vietnamese agricultural enterprises. Future research could therefore use random sampling methods to enhance external validity. Second, the use of cross-sectional data only allows for testing correlations at a specific point in time. It cannot definitively establish causal relationships between the variables. Future studies should use panel data or conduct longitudinal surveys. This would track changes in variables over time and provide stronger causal evidence. Third, the research relies on perceptual data collected from managers. Although the scales were validated for reliability and validity, using objective secondary data would enhance the results. This could include actual investment costs from financial statements or audited emissions data. Fourth, regarding the classification of agricultural operations, the current survey design did not stratify enterprises into specific sub-sectors such as crop production, livestock, aquaculture, or forestry. Consequently, the analysis could not disaggregate the sample to examine potential heterogeneity in investment behaviors across these distinct categories. Future research should incorporate this classification to assess whether the impact of carbon accounting varies among different agricultural sub-sectors. Finally, the research context may limit the generalizability of the findings beyond Vietnam. The role of green finance can differ significantly between countries with varying levels of financial market development. Therefore, cross-national comparative studies would be a promising avenue for future research.

8. Conclusions

In the context of Vietnam's agricultural sector facing an urgent need for sustainable transformation, this study was conducted to unravel the complex mechanisms through which carbon information quality impacts green investment decisions. By successfully developing and testing a moderated mediation model, the research has provided clear empirical evidence of these impact pathways. The results confirm that CAQ influences GID directly. It also operates indirectly by enhancing managers' perception of benefits (PB). This finding highlights the dual role of CAQ as both a technical, informational resource and a tool for shaping strategic cognition. Critically, the study underscores the indispensable catalytic role of GF. It acts as a decisive factor in converting perception and intention into tangible investment action.

Theoretical contributions: Theoretically, this study makes several important contributions to the relevant academic literature. First, it enriches the resource-based view by demonstrating that the value of an informational resource is not automatically realized. It requires an internal cognitive process through which the resource is transformed into a true capability. Second, the research extends stakeholder theory by showing that meeting external demands can generate internal benefits. This allows firms to shift from passive compliance to proactive opportunity-seeking. Finally, for the field of sustainable finance, the study provides firm-level empirical evidence of the enabling role of green finance. It confirms that green finance is not just a source of capital but also a strategic catalyst.

Practical implications: Practically, these findings offer critical guidance for both enterprises and policymakers. For managers, the research sends a powerful message. They should view investment in carbon accounting systems not as a compliance cost, but as a strategic investment in decision-making capability. They need to proactively use this data to shape perceptions throughout the organization. For policymakers, the results emphasize that information transparency regulations will not be fully effective without strong financial support. In summary, the synergy between high-quality information, positive managerial cognition, and a supportive financial environment is the key. This synergy is essential to accelerating the transition to a greener and more sustainable economy.

Author Contributions

Conceptualization, H.M.D. and M.P.D.; methodology, M.P.D.; software, H.M.D.; validation, H.M.D. and M.P.D.; formal analysis, H.M.D.; data curation, H.M.D.; writing—original draft preparation, H.M.D.; writing—review and editing, H.M.D. and M.P.D.; supervision, M.P.D. Both authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Data requirement should contact: daomanhhuy@gmail.com.

Conflicts of Interest

The authors declare no conflict of interest.

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