“The impact of green finance on the sustainable performance of agri-startups: The mediating role of eco-innovation and the moderating role of climate risk perception”

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THE IMPACT OF GREEN FINANCE ON THE SUSTAINABLE PERFORMANCE OF AGRI-STARTUPS: THE MEDIATING ROLE OF ECO-INNOVATION AND THE MODERATING ROLE OF CLIMATE RISK PERCEPTION

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Abstract

This study investigates the critical drivers of sustainable performance among agricultural startups (agri-startups) in Vietnam, a nation highly vulnerable to climate change. The research uses the Resource-Based View and Institutional Theory to model how green finance – including green credit incentives, green venture capital availability, and institutional support – influences perceived sustainable startup performance through eco-innovation capability. Furthermore, the moderating role of climate change risk perception is explored. Data were collected via an online Google Forms survey conducted from September to December 2025 across Vietnam. The study purposefully sampled 282 founders and senior managers (directors, head/deputy heads of departments) of agri-startups, as these leaders are the primary decision-makers directly responsible for strategic financial acquisitions and green innovation initiatives. Analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) with a Reflective-Formative higher-order construct technique, the quantitative results (n = 282) reveal that green credit incentives, green venture capital, and institutional support are positively associated with eco-innovation capability (R^2 = 23.7%). This capability, in turn, acts as a vital driver of holistic sustainable performance (R^2 = 26.1%). Notably, climate change risk perception significantly moderates the relationship between eco-innovation and performance ($\beta = 0.259$, $p < 0.001$). The findings suggest that ensuring startup survival and sustainable growth highlights the need for policymakers to prioritize accessible green credit and institutional frameworks over generalized support. Concurrently, venture capitalists must evaluate founders' climate risk awareness as a critical metric for funding resilient agricultural ventures.

Keywords green finance, agri-startups, eco-innovation, climate change, risk perception, sustainable performance, PLS-SEM, Vietnam

JEL Classification Q56, G32, O13, O31

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INTRODUCTION

Vietnam is currently ranked among the countries most vulnerable to climate change, posing a severe threat to its agricultural sector – the backbone of the national economy (Anh et al., 2023; World Bank, 2025). In response to this challenge, the transition to sustainable agriculture has become an imperative. Agricultural startups (agri-startups) have emerged as key drivers of this transition, leveraging technology and new business models to promote green practices and ensure food security (Do et al., 2025; Tran et al., 2024). However, unlike traditional enterprises, these green ventures face a profound challenge conceptualized as a "double liability": the liability of newness and the liability of greenness. This dual challenge stems from the requirement of significant initial investments in eco-friendly technologies, which are often accompanied by highly uncertain long-term returns (Bui et al., 2021; Do, 2025).

Despite their transformative potential, a severe lack of adequate financial resources remains a critical bottleneck stifling the growth and survival of sustainable agri-startups. Traditional financial institutions are predominantly hesitant to lend to these firms due to high perceived biological and market risks, a lack of tangible collateral, and profound information asymmetry regarding unproven green technologies (Polzin, 2017). Consequently, "Green Finance" – encompassing targeted instruments such as green credit, specialized green venture capital, and institutional support mechanisms – has been identified as a vital theoretical and practical solution to bridge this funding gap (Fu et al., 2023; Ozili, 2022).

The scientific problem driving this research is the fragmented and ambiguous understanding of how green finance actually translates into tangible sustainable performance within the unique, high-risk context of agri-startups in emerging markets. Currently, the overarching problem in the literature is threefold. First, the specific financial and operational challenges of agri-startups are largely overshadowed by existing studies that predominantly focus on large, listed corporations or analyze the issue strictly from the banking sector's perspective (Chen et al., 2024b; Ighrarah & Khalifa, 2025; Li & Lin, 2024). Second, startup "performance" is frequently reduced to a single financial metric, fundamentally failing to capture the multidimensional nature of sustainability across economic, environmental, and social outcomes (the Triple Bottom Line) (Elkington, 2013; Hartmann, 2020; Rogers & Hudson, 2011). Third, the underlying mechanism of this relationship remains a "black box". Specifically, how external green financial inputs are internalized into dynamic eco-innovation capabilities, and how founders' cognitive perceptions of climate risks influence the deployment of these capabilities, represent critical theoretical gaps. Addressing this multifaceted scientific problem is essential to understand the true efficacy of green finance in vulnerable agricultural ecosystems.

1. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The imperative transition toward sustainable agriculture has underscored the profound challenges faced by entrepreneurial ventures in emerging markets (Brenya et al., 2023; Hoogendoorn et al., 2019; Kademani et al., 2024). Agri-startups, while inherently innovative, grapple with the compounded "double liability" of newness and greenness (Briamonte & Scarpato, 2025; Kademani et al., 2024). Overcoming these liabilities requires a robust theoretical understanding of resource acquisition and deployment. Grounded in the Resource-Based View (RBV) and its extension, the Natural-Resource-Based View (NRBV), an organization's competitive advantage is fundamentally rooted in resources that are valuable, rare, and inimitable (Taher, 2012; Wernerfelt, 1984). Within the environmental context, capabilities that facilitate sustainable economic activity become the primary drivers of strategic superiority (El Nemar et al., 2025; Hart, 1995). Complementing this internal perspective, Institutional Theory emphasizes the profound influence of the external environment, postulating that organizational behavior is intricately shaped by the need to conform to societal norms, regulations, and stakeholder expectations to gain legitimacy (Amenta & Ramsey, 2010; Suddaby & Zakaria, 2026; Zucker, 1987). Together, these theoretical lenses provide a comprehensive framework for analyzing the agricultural startup ecosystem.

Eco-innovation is inherently a resource-intensive endeavor characterized by substantial risks and prolonged payback periods, which persistently deters resource-constrained ventures (Appiah-Kubi et al., 2025; Yu et al., 2021). As a vital remedy, "Green Finance" serves as an essential mechanism to bridge the survival and growth gap (Gao et al., 2025; Liu et al., 2024). Specifically, Green Credit Incentives (GCI) alleviate severe financial constraints by offering crucial "financial slack"

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through preferential interest rates and extended loan tenures (Tegethoff et al., 2025). This accessible capital empowers agri-startups to invest in R&D, purchase cleaner technologies, and experiment with unproven sustainable farming models without the immediate, paralyzing pressure of short-term debt repayment (Gao et al., 2025; Liu et al., 2024; Zhang et al., 2022).

Distinct from traditional debt, Green Venture Capital Availability (GVCA) provides highly specialized equity funding alongside "smart money" (Lalita et al., 2025; Louis & Kuriakose, 2025). Venture capitalists operating in the green sector exhibit higher risk tolerance and actively seek high-growth potential driven by radical environmental innovations (Randjelovic et al., 2003). By securing this capital, startups acquire not only funds but also indispensable managerial expertise, technical mentorship, and access to broader green-market networks (Chen et al., 2024a; Li et al., 2025; Ma & Chang, 2023). Furthermore, Institutional Support (IS), manifested through government mandates, subsidies, and certification assistance, acts as a powerful normative and coercive pressure (Achmad et al., 2023; Amenta & Ramsey, 2010; Ishaq et al., 2024). Strong institutional backing drastically reduces external market uncertainties and incentivizes proactive environmental strategies, compelling startups to internalize green practices to maintain operational legitimacy and secure ongoing resources (Achmad et al., 2023; Ball & Kittler, 2019; Eroglu & Rashid, 2022).

The acquisition of external financial and institutional resources, however, is merely foundational. These inputs must be dynamically transformed through Eco-Innovation Capability (EIC). EIC represents a firm's capacity to seamlessly integrate environmentally sustainable practices into product design and operational processes (Ceptureanu et al., 2020; Oduro, 2024; Siddiqi et al., 2025). The deployment of this capability directly dictates Perceived Sustainable Startup Performance (PSSP) (Ceptureanu et al., 2020). Crucially, startup performance within this paradigm must transcend traditional, unidimensional financial metrics. Adopting the Triple Bottom Line framework (Elkington, 2013; Hartmann, 2020; Rogers & Hudson, 2011), comprehensive sustainable performance is manifested simultaneously across economic prosperity, environmental quality, and social justice (Ceptureanu et al., 2020; Oduro, 2024). Economically, eco-innovation enhances operational efficiency and facilitates premium pricing strategies (Ji et al., 2024; Tegethoff et al., 2025). Environmentally, it mitigates carbon footprints, optimizes resource preservation, and reduces chemical waste (Ceptureanu et al., 2020; Oduro, 2024; Siddiqi et al., 2025). Socially, the adoption of green technologies drastically improves community relations, local job creation, and overall corporate reputation (Benović et al., 2025; Esteves et al., 2021). Therefore, EIC acts as the transformative engine bridging green finance and holistic sustainable outcomes (Bailey & Lumpkin, 2023; Demirel & Kesidou, 2019).

Beyond operational capabilities, Upper Echelons Theory dictates that strategic outcomes are profoundly contingent upon the cognitive characteristics of the firm's leadership (Hambrick, 2016; Wang et al., 2016). The efficacy with which EIC translates into tangible performance is inextricably linked to the founder's Climate Change Risk Perception (CCRP) (Bao & Zhang, 2026; Chu & Yin, 2025). Founders harboring high CCRP perceive environmental degradation as an existential threat to business continuity (Wang et al., 2016). Consequently, they are inherently driven to deploy their eco-innovation capabilities more rigorously and strategically as a survival mechanism (Tian et al., 2024). Conversely, founders exhibiting low risk perception may utilize similar innovation capabilities merely as superficial compliance tools, failing to optimize sustainable outcomes (Todaro et al., 2021). Thus, high risk perception acts as a catalyst that strengthens the translation of capability into actual performance (Han et al., 2023; Koch & Menkhoff, 2025).

In summary, while scholarly attention on green finance is expanding, the empirical literature largely isolates financial metrics from multidimensional sustainability, particularly neglecting the vulnerable agri-startup sector (Elkington, 2013; Hartmann, 2020; Rogers & Hudson, 2011). The underlying mechanism detailing how specific financial dimensions are internalized into innovation capabilities, and subsequently moderated by cognitive risk perception, remains an unresolved theoretical puzzle.

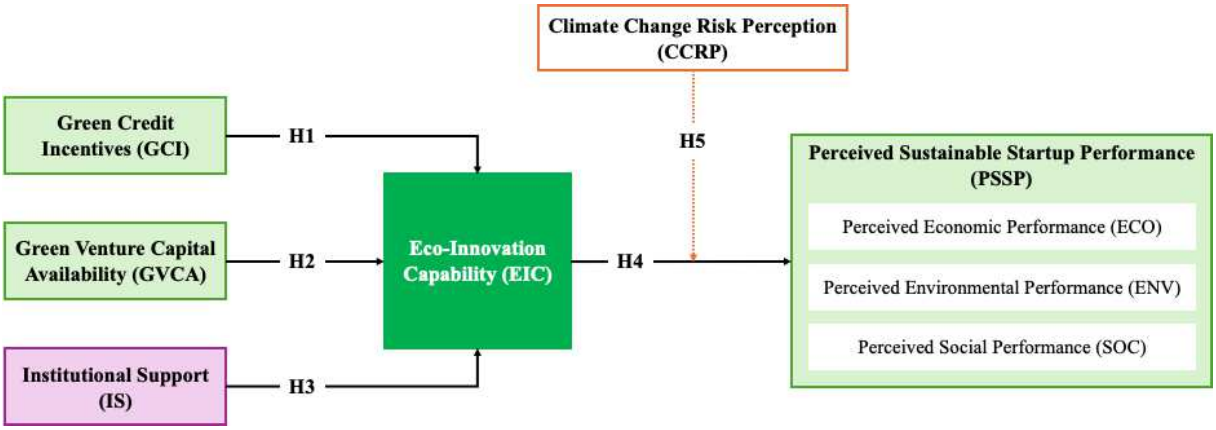

Figure 1. Conceptual model

To systematically address these literature gaps, this study poses the following research question: *How do different dimensions of green finance (green credit incentives, green venture capital availability, and institutional support) influence the sustainable performance of agri-startups in Vietnam?* The primary objective of this study is to develop and empirically test a comprehensive model linking green finance to perceived sustainable startup performance through the mediating effect of eco-innovation capability, whilst evaluating the moderating role of the founder's climate change risk perception. Driven by the synthesized theoretical framework and the stated research objectives, the following hypotheses are proposed:

H1: *Green credit incentives have a significant positive impact on the eco-innovation capability of agri-startups.*

H2: *Green venture capital availability has a significant positive impact on the eco-innovation capability of agri-startups.*

H3: *Institutional support has a significant positive impact on the eco-innovation capability of agri-startups.*

H4: *Eco-innovation capability has a significant positive impact on perceived sustainable startup performance.*

H5: *Climate Change Risk Perception moderates the relationship between eco-innovation capability and perceived sustainable startup performance.*

2. METHODS

2.1. Research procedure and ethical considerations

This study followed a rigorous, sequential research algorithm to ensure empirical validity and ethical compliance. First, the conceptual framework and survey instrument were developed based on an extensive literature review. Second, a pilot study was conducted to refine the instrument. Third, formal data collection was executed via an online survey. Finally, the primary data were analyzed utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM).

Regarding research ethics, human participant involvement was strictly regulated. Prior to accessing the survey, all respondents were provided with a clear explanation of the study's purpose and were required to give informed consent. Impartiality and anonymity were strictly ensured; no personally identifiable information (such as names or exact company addresses) was recorded, allowing respondents to answer objectively without fear of business repercussions. Furthermore, we explicitly confirm that the primary data collected from this recent survey are utilized exclusively for this manuscript and have not been published or used in any other prior or concurrent research.

2.2. Data sampling and respondent profile

The primary data were collected through an online Google Forms survey conducted from September

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to December 2025 across Vietnam. Vietnam was selected as the research setting due to its profound vulnerability to climate change and the rapid, albeit under-resourced, emergence of its green agricultural startup ecosystem, making it an ideal context to study green finance (Anh et al., 2023; World Bank, 2025). The target population was purposively restricted to founders and senior managers of agricultural startups (operating for less than seven years). This specific cohort was chosen because they are the central decision-makers regarding strategic financial acquisitions, sustainable innovations, and long-term business survival.

Given the absence of a comprehensive national database for agri-startups, a convenience and snowball sampling technique was employed (Emerson, 2015). The survey was strategically disseminated through major startup incubators, agricultural associations, and professional networks in Vietnam. Out of 350 initial responses, a rigorous screening process yielded 282 valid responses (an 80.5% effective response rate), which provided sufficient statistical power (0.80) to detect medium effect sizes and satisfied the "10-times rule" for PLS-SEM analysis (Hair et al., 2019). Detailed comprehensive data on the respondents, showcasing a highly relevant and balanced representation across business sectors, firm sizes, and geographic regions, are systematically presented in Table 1.

2.3. Instrument development and questionnaire formulation

The survey questionnaire was meticulously formulated to accurately measure the latent constructs within our conceptual model. We exclusively utilized previously validated English scales from top-tier academic literature to ensure high construct validity, adapting the questions to perfectly fit the context of Vietnamese agri-startups. To prevent respondent fatigue while ensuring comprehensive measurement, the items were strictly limited to those directly testing the proposed hypotheses (resulting in 4-5 items per construct). All constructs were measured using a 7-point Likert scale (ranging from 1 = "Strongly Disagree" to 7 = "Strongly Agree"), a format chosen because it provides optimal variance and reliability for behavioral and perception-based self-administered surveys. The following measurement items are adapted from reliable studies: *Green Credit Incentives (GCI):* Four items were adapted from Yu et al. (2021) and Zhang et al. (2022) to measure the accessibility and preferential terms of bank loans. *Sample item:* "Our startup can access loans with preferential interest rates for green projects." *Green Venture Capital Availability (GVCA):* Four items were adapted from Randjelovic et al. (2003) and Louis and Kuriakose (2025), focusing on the availability of specialized equity funding. *Sample item:* "There are venture capital firms specifically interested in our eco-friendly business model." *Institutional Support (IS):* Four items were developed based on Achmad et al. (2023) and Ishaq et al. (2024) to assess government assistance and legal frameworks. *Sample item:* "Government regulations actively support our transition to sustainable agricultural practices." *Eco-Innovation Capability (EIC):* Five items were adapted from Ceptureanu et al. (2020) and Tegethoff et al. (2025), capturing both product and process eco-innovations. *Sample item:* "We frequently improve our production processes to reduce material usage and waste." *Climate Change Risk Perception (CCRP):* Five items were adapted from Tian et al. (2024) and Todaro et al. (2021) to measure the founders' awareness of environmental threats. *Sample item:* "I believe climate

Table 1. Respondent profile (n = 282)

	Frequency	%		Frequency	%
	Business Sectors			**Experiences**	
Primary Production	39	13,83	Under 1 year	97	34,40
Agri-food Processing	55	19,50	1-3 years	107	37,94
Agri-Tech	84	29,79	3-5 years	42	14,89
Agri-services	104	36,88	over 5 years	36	12,77
	Business Size			**Geographic area**	
Micro-enterprise	158	56,03	North Vietnam	106	37,59
Small enterprise	99	35,11	Central Vietnam	96	34,04
Medium enterprise	25	8,87	Southern Vietnam	80	28,37

change poses a serious threat to the long-term survival of our business." *Perceived Sustainable Startup Performance (PSSP):* This dependent variable was operationalized as a Reflective-Formative second-order construct comprising three first-order dimensions: *Economic Performance (5 items):* e.g., "Our revenue growth meets expectations." *Environmental Performance (5 items):* e.g., "We have significantly reduced our carbon footprint." *Social Performance (5 items):* e.g., "Our business creates stable jobs for the local community." The scales were adapted from the Triple Bottom Line framework by Elkington (2013) and Hartmann (2020). The complete questionnaire is provided in the Appendix of this article for full transparency.

To ensure cross-cultural equivalence, the back-translation method was employed (Brislin, 1970; Martin et al., 1998). The original English items were translated into Vietnamese by two bilingual researchers, and a professional translator subsequently back-translated them to check for discrepancies (Brislin & Freimanis, 2001; Martin et al., 1998). A pilot test was then conducted with 10 Ph.D. candidates specializing in business and agriculture at the National Economics University (NEU) in Hanoi. Their feedback was incorporated to refine the clarity and phrasing of specific Vietnamese terms related to "green finance" and "eco-innovation" prior to the main survey.

2.4. Data analysis method

This study used PLS-SEM with SmartPLS 4.0 to test the conceptual framework. PLS-SEM was chosen over CB-SEM because it can handle complex models with numerous constructs, moderating effects, and small sample sizes without tight distributional assumptions.

A key feature of this research is the conceptualization of PSSP as a hierarchical component model, specifically a Reflective-Formative second-order construct. This approach allows for a more parsimonious model by integrating three distinct lower-order components (LOCs) – economic, environmental, and social performance – into a single higher-order construct (HOC).

Following the recommendations of Sarstedt et al. (2019), this study adopted the disjoint two-stage approach to estimate the HOC. In the first stage, a model containing only the LOCs was estimated to obtain the latent variable scores. In the second stage, these scores were used as manifest variables (indicators) to represent the HOC in the final structural model. This method is preferred over the repeated indicators approach as it provides more reliable path coefficient estimates for the structural model when HOCs are involved.

The data analysis proceeded in two steps: (1) Measurement model assessment to ensure reliability and validity, and (2) Structural model assessment to test the hypotheses, including path coefficients (p-values), explanatory power (R^2), and effect size (f^2). Finally, the moderating effect of CCRP was analyzed using the product-indicator approach.

3. RESULTS

This section systematically presents the empirical findings derived from the collected data. It encompasses a rigorous evaluation of the measurement model to ensure reliability and validity, and the structural model assessment used for comprehensive hypothesis testing.

3.1. Measurement model assessment

3.1.1. Assessment of lower-order constructs

The lower-order construct measurement model was assessed for internal consistency, convergent validity, and collinearity. Table 2, almost all indicator loadings exceeded the recommended threshold of 0.708, indicating individual item reliability (Hair et al., 2021). The indicator loading for CCRP2 (0.588) is below the recommended threshold; therefore, we exclude this item from the higher-order construct analysis. Internal consistency was evidenced by Cronbach's Alpha and Composite Reliability (CR) values, both of which exceeded the 0.70 cutoff, indicating high reliability across all constructs.

For convergent validity, each construct's Average Variance Extracted (AVE) exceeded 0.50, suggesting that it explained more than half of its indicators' variance (Hair et al., 2019). Furthermore,

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Variance Inflation Factor (VIF) values were also evaluated for lateral collinearity. Each VIF value was below 3.3 (Diamantopoulos & Siguaw, 2006), ensuring that the model has no significant multicollinearity. These results demonstrate the reliability and validity of lower-order constructs, laying the groundwork for higher-order component evaluation.

Discriminant validity was tested to guarantee model constructs are empirically distinct. First, the square root of AVE for each construct was higher than its highest correlation with any other construct, satisfying the Fornell-Larcker criterion for discriminant validity (Fornell & Larcker, 1981).

Additionally, the Heterotrait-Monotrait Ratio (HTMT) was assessed, a more rigorous clinical test in PLS-SEM. Table 3 demonstrates that all HTMT values were below the cautious 0.85 threshold (Henseler et al., 2015), indicating conceptual distinction. The results indicate that the measurement model has sufficient discriminant validity for assessing higher-order constructs.

Table 2. Lower-order constructs: reliability and validity (n = 282)

Construct	Items	Outer loading	Alpha	CR	AVE	VIF
Climate Change Risk Perception (CCRP)	CCRP1	0.795	0.814	0.872	0.579	1.785
	CCRP2*	0.588				1.238
	CCRP3	0.779				1.638
	CCRP4	0.807				1.892
	CCRP5	0.810				1.907
Perceived Economic Performance (ECO)	ECO1	0.928	0.956	0.966	0.851	4.774
	ECO2	0.926				4.665
	ECO3	0.930				4.860
	ECO4	0.913				4.091
	ECO5	0.915				4.143
Eco-Innovation Capability (EIC)	EIC1	0.834	0.889	0.918	0.692	2.213
	EIC2	0.833				2.092
	EIC3	0.817				2.080
	EIC4	0.829				2.153
	EIC5	0.847				2.266
Perceived Environmental Performance (ENV)	ENV1	0.865	0.922	0.941	0.762	2.564
	ENV2	0.878				2.925
	ENV3	0.882				3.095
	ENV4	0.880				3.052
	ENV5	0.859				2.598
Green Credit Incentives (GCI)	GCI1	0.875	0.903	0.932	0.774	2.515
	GCI2	0.873				2.525
	GCI3	0.899				2.872
	GCI4	0.872				2.481
Green Venture Capital Availability (GVCA)	GVCA1	0.858	0.893	0.925	0.756	2.291
	GVCA2	0.867				2.457
	GVCA3	0.875				2.418
	GVCA4	0.877				2.412
Institutional Support (IS)	IS1	0.873	0.890	0.923	0.751	2.365
	IS2	0.849				2.260
	IS3	0.863				2.306
	IS4	0.880				2.462
Perceived Social Performance (SOC)	SOC1	0.867	0.917	0.938	0.750	2.588
	SOC2	0.859				2.439
	SOC3	0.869				2.694
	SOC4	0.859				2.598
	SOC5	0.878				2.895

Note: * Variables are eliminated because of their outer loading < 0.7; AVE: Average Variance Extracted; CR: Composite Reliability; VIF: Variance Inflation Factor.

Table 3. Discriminant validity

Fornell-Larcker criterion	CCRP	ECO	EIC	ENV	GCI	GVCA	IS	SOC
CCRP	0.761							
ECO	–0.157	0.923						
EIC	–0.014	0.372	0.832					
ENV	–0.219	0.382	0.216	0.873				
GCI	–0.164	0.422	0.402	0.237	0.880			
GVCA	–0.166	0.307	0.315	0.339	0.357	0.869		
IS	–0.270	0.451	0.394	0.358	0.418	0.403	0.866	
SOC	–0.455	0.488	0.194	0.530	0.300	0.354	0.538	0.866
HTMT ratio	**CCRP**	**ECO**	**EIC**	**ENV**	**GCI**	**GVCA**	**IS**	**SOC**
CCRP								
ECO	0.179							
EIC	0.071	0.401						
ENV	0.252	0.406	0.237					
GCI	0.192	0.454	0.448	0.260				
GVCA	0.191	0.332	0.352	0.372	0.398			
IS	0.312	0.487	0.441	0.396	0.465	0.453		
SOC	0.523	0.520	0.215	0.577	0.331	0.391	0.594	

3.1.2. Assessment of higher-order construct

Following the measurement of lower-order constructs, this study evaluated the higher-order construct (HOC). PSSP was conceptualized as a Reflective-Formative Type II model. Utilizing the disjoint two-stage approach, the latent variable scores (LV scores) of the three lower-order components – Economic (ECO), Environmental (ENV), and Social (SOC) performance – were used as formative indicators for the HOC in the second stage (Hair Jr et al., 2021).

Unlike reflective constructs, the evaluation of formative HOCs relies on the assessment of collinearity and the significance of indicator weights. As presented in Table 4, lateral collinearity was assessed using the Variance Inflation Factor (VIF). The VIF values for ECO (1.350), ENV (1.430), and SOC (1.605) were well below the stringent threshold of 3.3, confirming the absence of critical collinearity issues (Hair Jr et al., 2021).

Furthermore, the significance and relevance of the formative indicators were evaluated. The outer weights for ECO (0.389), ENV (0.336), and SOC (0.510) were all positive and highly significant ($p < 0.001$), with t-values of 7.153, 8.359, and 9.875, respectively. Additionally, the 95% confidence intervals for all dimensions did not contain zero, solidifying their empirical contribution to PSSP (Hair Jr et al., 2021). These findings validate the formative hierarchical structure of PSSP, allowing it to be treated as a single, parsimonious construct in the subsequent structural model analysis.

3.2. Structural model assessment

3.2.1. Explanatory power and model fit

The coefficient of determination (R^2) assessed model explanatory power. Table 5, the values for EIC and PSSP were 0.237 and 0.261, respectively. These results indicate that the exogenous constructs (GCI, GVCA, and IS) explain 23.7% of the variance in EIC, while the overall model explains

Table 4. Assessment of reflective-formative higher-order constructs

HOC	LOC	Collinearity (VIF)	Outer Weight	*t*-value	*p*-value	97.5% CI	
						(2.5%)	(97.5%)
Perceived Sustainable Startup Performance (PSSP)	LV scores – ECO	1.350	0.389	7.153	0.000	0.272	0.483
	LV scores – ENV	1.430	0.336	8.359	0.000	0.255	0.414
	LV scores – SOC	1.605	0.510	9.875	0.000	0.421	0.622

Note: CI: Confidence Interval.

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Table 5. Model fit and R^2 results

R^2 results	R^2	R^2 adjusted	Model fit	Saturated model	Estimated model
EIC	0.237	0.229	SRMR	0.053	0.088
PSSP	0.261	0.253	d_ULS	0.839	2.310
			d_G	0.297	0.373
			χ^2	497.826	593.354
			NFI	0.872	0.847

26.1% of the variance in PSSP. In the context of emerging markets and early-stage startups, these values represent a substantial level of explanatory power (Hair et al., 2019).

Regarding the model fit, several indices were examined as presented in Table 5. The Standardized Root Mean Square Residual (SRMR) for the estimated model was 0.088. Although slightly above the most conservative threshold of 0.08, it remains within the acceptable range for complex models in social sciences, suggesting an adequate fit between the proposed model and the empirical data (Hu & Bentler, 1999). Additionally, the Normed Fit Index (NFI) reached 0.847, further supporting the model's overall parsimony and structural integrity.

3.2.2. Predictive relevance and effect size

To further validate the model, Stone-Geisser's Q^2 value was calculated using the blindfolding procedure. As shown in Table 6, the values for all endogenous constructs, particularly for EIC (0.531) and PSSP (0.299), are substantially greater than zero.

Table 6. Q^2 and f^2 results

Q^2 results	SSO	SSE	*Q^2* (=1 – SSE/SSO)	*f^2* results	*f^2*
CCRP	1128.000	647.418	0.426	CCRP → PSSP	0.212
EIC	1410.000	660.899	0.531	EIC → PSSP	0.128
GCI	1128.000	443.221	0.607	GCI → EIC	0.069
GVCA	1128.000	476.038	0.578	GVCA → EIC	0.017
IS	1128.000	483.085	0.572	IS → EIC	0.054
PSSP	846.000	592.834	0.299	CCRP x EIC → PSSP	0.051

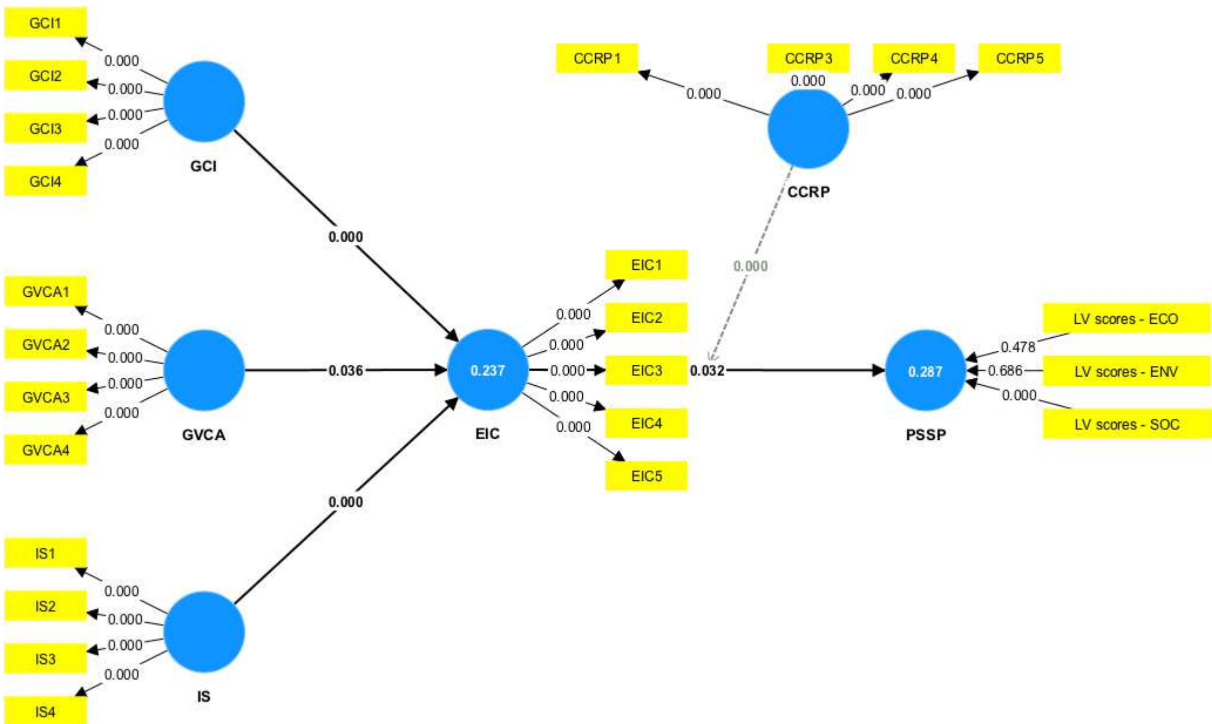

Figure 2. Conceptual model result

These results provide strong evidence of the model's predictive relevance (Hair et al., 2021), suggesting that the structural model can accurately predict the data points of the latent variables.

In addition to the explanatory power, the effect size (f^2) was examined to determine the relative impact of each exogenous construct on the endogenous variables. Based on the results in Table 6, the impact of CCRP on PSSP ($f^2 = 0.212$) is considered a medium effect. EIC exerts a small-to-medium effect on PSSP ($f^2 = 0.128$). Regarding the antecedents of EIC, GCI ($f^2 = 0.069$) and IS ($f^2 = 0.054$) show small effects, while GVCA ($f^2 = 0.017$) has a relatively weak effect.

These values, while varying in magnitude, indicate that all proposed drivers contribute to the development of eco-innovation and sustainable performance within the model.

3.2.3. Hypothesis testing results (direct effect)

The empirical results provide strong support for the direct relationships. Specifically, GCI ($\beta = 0.259$, $t = 4.025$, $p < 0.001$), GVCA ($\beta = 0.127$, $t = 2.099$, $p < 0.05$), and IS ($\beta = 0.235$, $t = 4.123$, $p < 0.001$) all have significant positive impacts on EIC, thus supporting H1, H2, and H3. Furthermore, EIC is found to significantly enhance PSSP ($\beta = 0.241$, $t = 2.144$, $p < 0.05$), confirming H4.

3.2.4. Mediation analysis (indirect effects)

To empirically validate the mediating role of EIC between the dimensions of green finance and perceived sustainable startup performance, a bootstrapping procedure was conducted. Table 7 presents the specific indirect effects, their corresponding t-values, p-values, and 95% confidence intervals.

The results robustly confirm that EIC acts as a significant mediator across all three theoretically proposed pathways. Specifically, the indirect effect of GCI on PSSP through EIC is positive and significant (β = 0.078, t = 2.877, p = 0.004), with a confidence interval of [0.030; 0.133]. Similarly, Institutional Support (IS) indirectly influences PSSP via EIC (β = 0.070, t = 2.834, p = 0.005, CI = [0.026; 0.122]). Finally, GVCA also demonstrates a significant indirect effect on PSSP through EIC (β = 0.038, t = 1.905, p = 0.047, CI = [0.002; 0.080]). Because none of the 95% confidence intervals cross zero, the mediating mechanism of eco-innovation capability within the conceptual model is empirically demonstrated, effectively addressing the "black box" of how external financial inputs translate into holistic sustainable outcomes.

Moderating Effect: H5 predicted that CCRP moderates the relationship between EIC and PSSP (see Table 8). The results show a significant interaction

Table 7. Indirect effect path

Indirect effect path	β	CI* on .05 level		*t*-values	*p*-values	Results
		(2.5%)	(97.5%)			
IS → EIC → PSSP	0.070	0.026	0.122	2.834	0.005	EIC acts as an intermediary between IS and PSSP
GCI → EIC → PSSP	0.078	0.030	0.133	2.877	0.004	EIC acts as an intermediary between GCI and PSSP
GVCA → EIC → PSSP	0.038	0.002	0.080	1.905	0.047	EIC acts as an intermediary between GVCA and PSSP

Note: CI: Confidence Interval.

Table 8. Path coefficients of hypotheses

Hypothesis	Path	β	CI* on .05 level		*t*-values	*p*-values	Results
			(2.5%)	(97.5%)			
H1	GCI → EIC	0.259	0.130	0.381	4.025	0.000	Supported
H2	GVCA → EIC	0.127	0.008	0.244	2.099	0.036	Supported
H3	IS → EIC	0.235	0.131	0.350	4.123	0.000	Supported
H4	EIC → PSSP	0.241	0.015	0.146	2.144	0.032	Supported
H5	CCRP x EIC → PSSP	0.259	0.127	0.369	4.121	0.000	Supported
	CCRP → PSSP	–0.419	–0.527	–0.285	6.847	0.000	Control path

Note: CI: Confidence Interval. CCRP is included as a control variable; no hypothesis is formulated for this path

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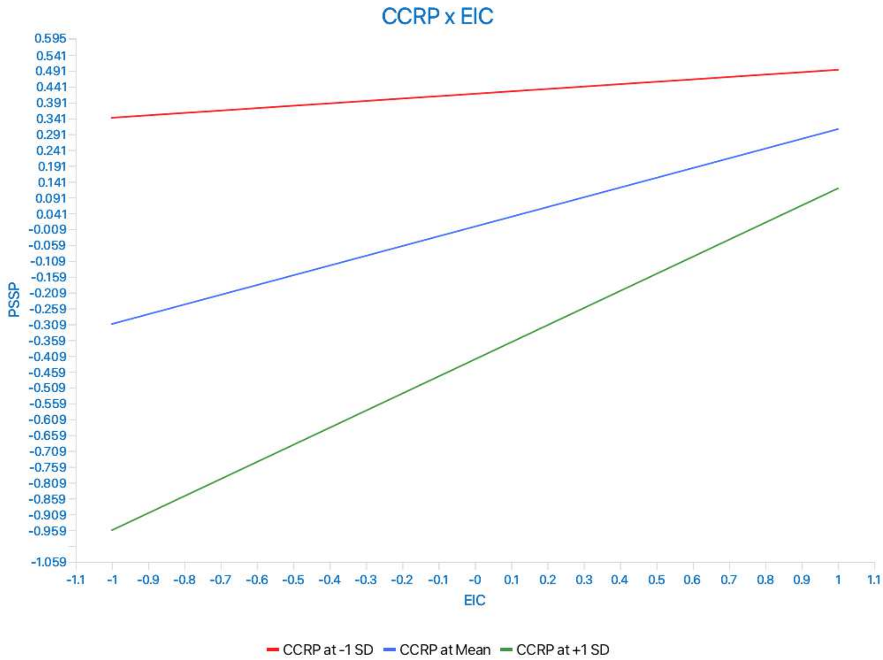

Figure 3. Interaction Plot CCRP × EIC → PSSP

effect ($\beta = 0.259$, $t = 4.121$, $p < 0.001$), thus supporting H5. The interaction plot reveals that startups with high CCRP achieve consistently higher levels of sustainable performance across all levels of EIC compared to those with low CCRP (see Figure 3)

4. DISCUSSION & IMPLICATIONS

This section provides a detailed interpretation of the empirical results, situating them within the existing body of literature. By comparing our findings with previous studies, we highlight the unique mechanisms driving sustainable performance in the context of emerging market agri-startups and outline the subsequent theoretical and managerial implications.

4.1. Discussion of findings

Firstly, the significant positive impact of EIC on PSSP (*H4*) reinforces the notion that innovation is the primary vehicle for sustainability. This finding strongly aligns with the conclusions of Ceptureanu et al. (2020) and Oduro (2024), who posited that eco-innovation is a primary driver of SME sustainable performance. However, while previous studies primarily focused on general SMEs in developed economies, our study extends this confirmation to the highly vulnerable agri-startup sector in an emerging market. It empirically validates the Resource-Based View (RBV), demonstrating that EIC acts as a strategic capability capable of transforming external resources into multidimensional competitive advantages.

Secondly, the study highlights the critical role of external financial catalysts. GCI (*H1*) and IS (*H3*) emerged as the strongest predictors of EIC. This corroborates the findings of Zhang et al. (2022) regarding green credit and Achmad et al. (2023) regarding institutional frameworks, emphasizing that government-backed mechanisms are vital for overcoming the "double liability" of newness and greenness. Interestingly, in contrast to Liu et al. (2024), who found venture capital to be the dominant driver for clean energy technology adoption, our context reveals that GVCA (*H2*), while significant, exerts a smaller effect size. This discrepancy logically reflects the nascent and risk-averse nature of the venture capital market for green agriculture in Vietnam, where investors remain cautious about long-term biological risks.

Crucially, the mediation analysis systematically unpacks the theoretical 'black box' between external green finance and sustainable performance. The significant indirect effects confirm that green credit, venture capital, and institutional support do not spontaneously generate sustainable outcomes. Rather, their strategic value is fully realized only when these financial and institutional resources are actively internalized and transformed into robust eco-innovation capabilities. This empirical evidence significantly enriches the Resource-Based View by demonstrating that acquiring external green resources is insufficient on its own; they must be dynamically coupled with internal innovation capacities (EIC) to successfully achieve multidimensional Triple Bottom Line objectives in the vulnerable agricultural sector.

A particularly noteworthy finding is the moderating role of CCRP (*H5*). The significant interaction effect confirms that the "innovation-performance" linkage is not uniform across all firms. This insight extends the works of Tian et al. (2024) and Todaro et al. (2021), who previously identified climate awareness primarily as a precursor to adopting green strategies. By comparing our results with their studies, we demonstrate that CCRP does not merely initiate green actions; it actively magnifies their effectiveness. The positive interaction coefficient and slope analysis reveal that founders who are acutely aware of climate risks (e.g., saltwater intrusion in the Mekong Delta) achieve a higher baseline of sustainable performance. For these proactive leaders, sustainability is driven by an existential necessity, ensuring that eco-innovations are deployed rigorously rather than as superficial compliance tools.

4.2. Implications

4.2.1. Theoretical implications

This study contributes to the literature on green finance and sustainable entrepreneurship in several ways. First, it advances the Resource-Based View and Institutional Theory by integrating them into a single framework that explains how external financial resources and institutional pressures are internalized into an organization's EIC. Second, methodologically, this research validates PSSP as a robust Reflective-Formative second-order construct. By successfully employing the disjoint two-stage approach in PLS-SEM, the study provides a more holistic and parsimonious way to measure the "Triple Bottom Line" in the context of early-stage ventures. Finally, the findings extend Upper Echelons Theory (Hambrick, 2016) by demonstrating that the cognitive factor of CCRP acts as a critical boundary condition, determining how effectively innovation capabilities are translated into sustainable outcomes

4.2.2. Managerial implications

For Policy Makers: The government should prioritize GCI and IS (such as technical training and green certifications) over general subsidies, as these factors are the primary drivers of eco-innovation in startups.

For Investors and Venture Capitalists: Specialized green funds should look beyond financial metrics and evaluate a founder's CCRP as a predictor of a startup's resilience and long-term sustainability potential.

For Startup Founders and CEOs: Agri-startup leaders must realize that possessing technology is not enough; they need to cultivate a deep awareness of environmental threats within their management teams. This cognitive alignment ensures that innovation efforts are not merely for compliance but are strategically deployed to mitigate risks and enhance social and environmental value

CONCLUSION, LIMITATIONS, AND FUTURE RESEARCH

The primary purpose of this study was to investigate how different dimensions of green finance (green credit incentives, green venture capital availability, and institutional support) influence the sustainable performance of agri-startups in Vietnam, taking into account the mediating role of eco-innovation capability and the moderating effect of the founder's climate change risk perception.

The empirical analysis demonstrated that all three dimensions of green finance positively and significantly drive eco-innovation capabilities. Consequently, this innovation capacity acts as a vital transformative engine, seamlessly translating financial inputs into holistic sustainable performance across economic, environmental, and social metrics. Furthermore, the findings revealed that founders with a

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high perception of climate change risks effectively catalyze this process, achieving superior sustainable outcomes compared to their less aware peers.

From these results, it can be concluded that unlocking green finance in emerging markets is not simply a matter of increasing capital liquidity. To ensure the survival and resilient growth of agricultural ventures, financial support mechanisms – particularly accessible green credit and robust institutional frameworks – must be strategically coupled with environmental risk education at the leadership level.

While this study offers robust insights, certain limitations present opportunities to determine further prospects for research. First, the use of convenience sampling within specific regions of Vietnam may limit broad generalizability; future scholars are encouraged to employ longitudinal designs to track the long-term effectiveness of green financial instruments across diverse ecological zones. Second, while perceived performance metrics are suitable for early-stage startups, future studies could integrate objective, verified environmental data (e.g., carbon footprint audits) for a more rigorous assessment. Finally, exploring additional moderating variables, such as the digital transformation maturity of these startups, will further refine the theoretical understanding of the green finance-performance nexus.

AUTHOR CONTRIBUTIONS

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Formal analysis: Tat Cuong Do, Thi Ngoc Anh Ngo.
Funding acquisition: Tat Cuong Do, Thi Ngoc Anh Ngo.
Investigation: Tat Cuong Do, Thi Ngoc Anh Ngo.
Methodology: Tat Cuong Do, Thi Ngoc Anh Ngo.
Project administration: Tat Cuong Do, Thi Ngoc Anh Ngo.
Resources: Tat Cuong Do, Thi Ngoc Anh Ngo.
Software: Tat Cuong Do, Thi Ngoc Anh Ngo.
Supervision: Tat Cuong Do, Thi Ngoc Anh Ngo.
Validation: Tat Cuong Do, Thi Ngoc Anh Ngo.
Visualization: Tat Cuong Do, Thi Ngoc Anh Ngo.
Writing – original draft: Tat Cuong Do, Thi Ngoc Anh Ngo.
Writing – review & editing: Tat Cuong Do, Thi Ngoc Anh Ngo.

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CONFLICT OF INTEREST

All authors declare no conflicts of interest.

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APPENDIX A

Table A1. Measurement items used in the study

Code	Items
	Green Credit Incentives: Developed based on Yu et al. (2021) and Zhang et al. (2022)
GCI1	Businesses can easily access preferential loan packages specifically for green agricultural projects
GCI2	Interest rates for loans for sustainable production activities are significantly lower than those for conventional business loans
GCI3	The process and procedures for demonstrating the "green" nature of a project to disburse funds are clearly designed and not overly complicated
GCI4	Credit institutions offer flexible loan terms that suit the long-term investment cycle for green technology in agriculture
	Green Venture Capital Availability: Developed based on Randjelovic et al. (2003) and Louis and Kuriakose (2025)
GVCA1	There are many specialized venture capital funds interested in sustainable agriculture
GVCA2	Investors are willing to provide seed capital for startup ideas that have the potential to reduce emissions or save resources
GVCA3	Businesses can easily connect with a network of angel investors through green startup acceleration programs
GVCA4	Investors not only provide capital but also support startups with management expertise and green-market networking
	Institutional Support: Developed based on Achmad et al. (2023) and Ishaq et al. (2024)
IS1	The government has clear legal regulations to encourage startups to invest in sustainable agriculture
IS2	Businesses receive technical support or training from public organizations to implement green projects
IS3	Government trade promotion programs help agricultural startups easily access the market for clean agricultural products
IS4	Administrative systems and certification processes (such as VietGAP, GlobalGAP, Organic) are supported quickly and transparently
	Eco-Innovation Capability: Developed based on Ceptureanu et al. (2020) and Tegethoff et al. (2025)
EIC1	Businesses capable of developing new agricultural products that have a positive impact on the environment (e.g., drought-resistant varieties, organic fertilizers)
EIC2	We are constantly improving our production processes to minimize waste of resources and chemicals
EIC3	Businesses capable of applying digital technologies (IoT, AI) to optimize water and energy use in farming
EIC4	The startup's team possesses strong knowledge and skills in implementing sustainable innovation initiatives
EIC5	EIC5: We have a strong collaborative network with research institutes and experts to transfer green agricultural technology
	Perceived Economic Performance: Developed based on Elkington (2013) and Hartmann (2020)
ECO1	The company's revenue growth rate is stable and meets expectations
ECO2	Businesses capable of maintaining a stable cash flow to reinvest in sustainable agricultural projects
ECO3	Access to green finance helps businesses reduce capital costs compared to traditional forms of borrowing
ECO4	Startup products/services that are highly competitive in terms of price and quality in the market for clean agricultural products
ECO5	Businesses have the ability to scale up production or expand their target market thanks to the credibility derived from green certifications
	Perceived Environmental Performance: Developed based on Elkington (2013) and Hartmann (2020)
ENV1	The company has significantly reduced chemical waste (fertilizers, pesticides) generated during farming
ENV2	The company's production process significantly reduces resource use (water, energy, land)
ENV3	Businesses implement effective measures to reduce greenhouse gas emissions or carbon footprint
ENV4	Startups that prioritize the use of recycled materials, eco-friendly packaging, or renewable energy sources
ENV5	ENV5: The business strictly adheres to local and international environmental protection standards/regulations
	Perceived Social Performance: Developed based on Elkington (2013) and Hartmann (2020)
SOC1	Startups contribute to creating stable jobs and better incomes for local workers
SOC2	Businesses support the enhancement of knowledge and skills in sustainable farming for farmers in the supply chain
SOC3	Business activities that contribute to improving health and food safety for the consumer community
SOC4	The company implements good welfare policies and ensures a safe and fair working environment for employees
SOC5	The company's image and reputation are positively recognized by the local community and stakeholders
	Climate Change Risk Perception: Developed based on Tian et al. (2024) and Todaro et al. (2021)
CCRP1	I recognize that climate change (droughts, saltwater intrusion, storms, and floods) is posing direct risks to the business operations of startups
CCRP2	Without timely adaptation measures, climate change will significantly reduce the productivity and quality of our agricultural products in the future
CCRP3	Climate change could increase operating costs and financial risks for my business.
CCRP4	I believe that failing to transition to a sustainable agricultural model will cause businesses to lose their competitive advantage as the climate changes drastically
CCRP5	Awareness of natural disasters motivates me to seek green funding sources to invest in adaptive technologies