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Article

Does Sustainability Literacy Drive Green Entrepreneurial Self-Efficacy Among Gen Z Students? The Moderating Roles of University Support, Digital Literacy, and Family Support

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Abstract

The 2030 Agenda highlights education and entrepreneurship as critical drivers of sustainable development, yet little is known about how sustainability literacy translates into green entrepreneurial confidence among Gen Z students in developing and post-conflict economies. This study examines the direct and mediated effects of sustainability literacy on green entrepreneurial self-efficacy (GESE) through biospheric values, and the moderating roles of university support, digital literacy, and family support. A cross-sectional survey was conducted with 417 Gen Z undergraduate students from Universitas Negeri Padang (Indonesia) and Universidade Nacional Timor Lorosa'e (Timor-Leste). Data were analyzed using PLS-SEM and Importance-Performance Map Analysis (IPMA). Results show that sustainability literacy directly enhances GESE ($\beta = 0.342$, $p < 0.001$) and indirectly through biospheric values (indirect effect = 0.156, $p < 0.001$). University support moderates the values→efficacy pathway ($\beta = 0.148$, $p < 0.05$), while digital literacy moderates the literacy→efficacy pathway ($\beta = 0.198$, $p < 0.01$). However, family support did not moderate any relationship, and digital literacy exhibited a ceiling effect among Gen Z respondents. IPMA reveals biospheric values and sustainability literacy as high-importance, high-performance priorities, with no urgent intervention needed. We conclude that cultivating biospheric values matters more than transmitting knowledge alone, and university support should strategically target value-driven students rather than compensate for low literacy.

Keywords: green entrepreneurial self-efficacy; sustainability literacy; biospheric values; Generation Z; university support; digital literacy; Indonesia; Timor-Leste

1. Introduction

1.1. Background

The 2030 Agenda for Sustainable Development, adopted by the United Nations in 2015, emphasizes the critical role of education and entrepreneurship in achieving the Sustainable Development Goals (SDGs) [1–4]. Among the 17 SDGs, Goal 4 (Quality Education), Goal 8 (Decent Work and Economic Growth), and Goal 12 (Responsible Consumption and Production) directly relate to the intersection of education, entrepreneurship, and sustainability [5–7]. As the world grapples with unprecedented environmental challenges climate change, biodiversity loss, pollution, and

resource depletion the need for innovative solutions that integrate economic development with environmental stewardship has never been more urgent [8,9].

Generation Z (born approximately 1997–2012) represents a unique demographic cohort characterized by digital nativity, heightened environmental awareness, and a strong desire for meaningful work that aligns with their personal values [10–12]. Unlike previous generations, Gen Z has grown up witnessing the tangible impacts of climate change, plastic pollution, and biodiversity loss, making environmental concern a defining characteristic of their generational identity [13,14]. As this generation enters higher education and the workforce, understanding how to cultivate their potential as agents of sustainable development particularly as green entrepreneurs—becomes imperative for educators, policymakers, and university administrators.

Green entrepreneurship, the process of identifying and exploiting business opportunities that generate economic value while simultaneously addressing environmental challenges has emerged as a promising pathway toward sustainable development [15–17]. Unlike conventional entrepreneurship, which may prioritize profit maximization, green entrepreneurship explicitly integrates environmental goals into business models, contributing to the transition toward a circular and low-carbon economy [18–20]. However, despite growing interest in sustainable entrepreneurship education, a critical gap remains in our understanding of how university students develop the confidence to pursue green entrepreneurial careers.

1.2. Research Gap

Green entrepreneurial self-efficacy (GESE) defined as an individual's belief in their capability to successfully perform tasks associated with starting and operating an environmentally sustainable business [21–23] has been identified as a key antecedent of green entrepreneurial intentions and behaviors. Drawing on Bandura's Social Cognitive Theory [24], self-efficacy is shaped by mastery experiences, vicarious learning, social persuasion, and physiological states. In the context of green entrepreneurship, GESE is particularly important because green ventures often face unique challenges: uncertain regulatory environments, higher initial costs, the need for specialized technical knowledge, and the difficulty of measuring environmental impact.

Despite the growing body of research on sustainable entrepreneurship education [25–29], several critical gaps persist. First, the mechanism linking sustainability literacy knowledge about environmental issues, sustainable development concepts, and green business practices to GESE remains underexplored. Does knowledge automatically translate into confidence? Or are there intervening psychological mechanisms, such as personal values, that facilitate or inhibit this translation? Drawing on the Value-Belief-Norm (VBN) theory [30,31], we propose that biospheric values (the extent to which individuals value nature for its own sake) serve as a crucial mediating mechanism linking literacy to self-efficacy.

Second, the contextual factors that amplify or weaken the literacy→self-efficacy relationship have received limited empirical attention. While university support (incubators, training, funding, competitions) and family support (encouragement, financial assistance, role modeling) have been studied in general entrepreneurship contexts [32–37], their moderating roles in green entrepreneurship remain unclear. Furthermore, the moderating role of digital literacy particularly relevant for Gen Z as “digital natives” has not been systematically integrated into models of green entrepreneurial self-efficacy.

Third, most studies on sustainable entrepreneurship education have been conducted in developed Western contexts (Europe, North America, Australia), with limited attention to developing and post-conflict economies. Indonesia, a large emerging economy with significant environmental challenges and Timor-Leste, a young, post-conflict island nation with nascent entrepreneurial infrastructure represent under-researched contexts that could provide valuable insights into how socioeconomic conditions shape the antecedents of GESE.

Fourth, previous studies rarely employ Importance-Performance Map Analysis (IPMA) as a post-hoc analytical tool. While traditional PLS-SEM can identify which variables have significant

effects, IPMA extends this by revealing which variables have high importance (strong total effects) but low performance (low mean scores), thereby providing actionable priorities for policymakers and educators.

1.3. Research Questions

To address these gaps, this study addresses the following research questions:

RQ1: Does sustainability literacy have a direct positive effect on green entrepreneurial self-efficacy among Gen Z university students?

RQ2: Do biospheric values mediate the relationship between sustainability literacy and green entrepreneurial self-efficacy?

RQ3: Do university support, digital literacy, and family support moderate the relationships between (a) sustainability literacy and GESE, and (b) biospheric values and GESE?

RQ4: Based on Importance-Performance Map Analysis (IPMA), which variables should be prioritized for intervention to enhance GESE among Gen Z students?

1.4. Theoretical Framework

This study integrates three complementary theories to explain how sustainability literacy translates into green entrepreneurial self-efficacy (GESE): Value-Belief-Norm (VBN) Theory [38–41], Social Cognitive Theory [42,43], and Theory of Planned Behavior (TPB) [44–47]. Figure 1 presents the conceptual framework.

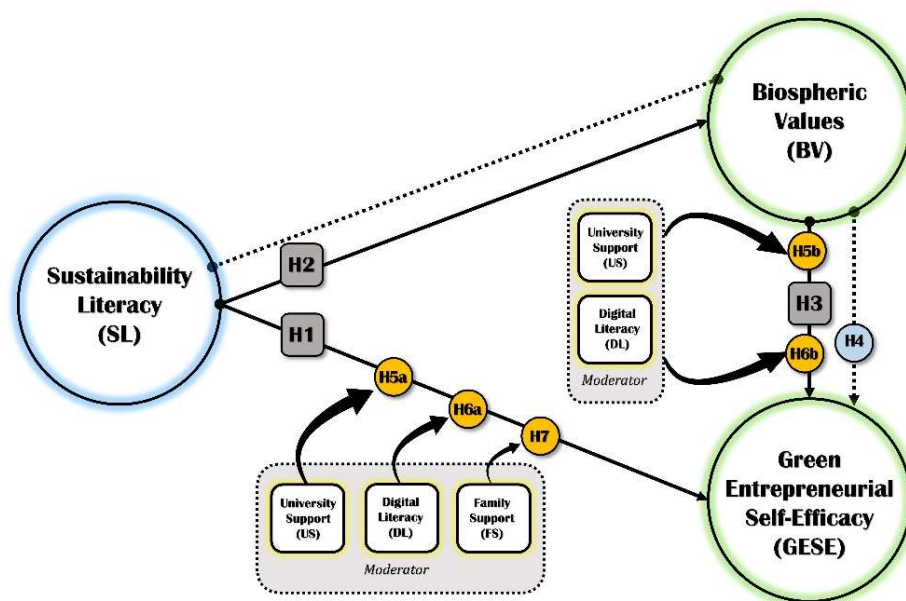


Figure 1. Conceptual framework with hypothesized paths (H1–H7).

The VBN Theory proposes a causal chain from personal values → environmental beliefs → personal norms → pro-environmental behavior. We extend this theory by positioning GESE as a behavioral belief antecedent to actual green entrepreneurial behavior, proposing that sustainability literacy enhances biospheric values, which in turn increase GESE. This represents a novel extension of VBN theory into the entrepreneurial domain. Social Cognitive Theory explains that self-efficacy is shaped by enactive mastery, vicarious experiences, and social persuasion. In our model, sustainability literacy provides cognitive input; university and family support provide social persuasion and vicarious experiences; and digital literacy enhances perceived control over technology-mediated tasks. The TPB contributes the concept of perceived behavioral control (PBC)—closely related to self-efficacy—which we apply to digital literacy as a moderator of the

literacy→efficacy pathway. The integration of these three theories yields a comprehensive moderated-mediation model: VBN explains the mediation pathway (literacy → values → efficacy), Social Cognitive Theory explains the sources of self-efficacy, and TPB explains the moderating role of digital literacy.

1.5. Hypothesis Development

1.5.1. Direct Effects (H1–H3)

Sustainability Literacy and Green Entrepreneurial Self-Efficacy (H1). Sustainability literacy knowledge of environmental issues, circular economy, and green business practices provides the cognitive foundation for entrepreneurial action. Students with greater literacy are better equipped to identify environmental opportunities and anticipate venture challenges [48–50]. Therefore, H1: Sustainability literacy has a positive and significant direct effect on green entrepreneurial self-efficacy.

Sustainability Literacy and Biospheric Values (H2). According to VBN theory, environmental awareness activates biospheric values. Learning about climate change, pollution, and biodiversity loss increases the salience of nature-oriented values. Studies confirm that sustainability knowledge significantly predicts environmental values [51–54]. Therefore, H2: Sustainability literacy has a positive and significant direct effect on biospheric values.

Biospheric Values and Green Entrepreneurial Self-Efficacy (H3). Biospheric values provide motivational foundation for pro-environmental action. Students who deeply value nature are more confident in creating green ventures because their values align with entrepreneurial goals, reducing cognitive dissonance and increasing engagement [22]. Therefore, H3: Biospheric values have a positive and significant direct effect on green entrepreneurial self-efficacy.

1.5.2. Mediation Effect (H4)

The VBN theory proposes a sequential chain: values → beliefs → norms → behavior [55–57]. Adapted to our context, sustainability literacy (knowledge) enhances biospheric values (values), which in turn increase GESE (self-efficacy). Empirical work supports this mediation: values mediate the relationship between education and entrepreneurial intention. Therefore, H4: Biospheric values significantly mediate the relationship between sustainability literacy and green entrepreneurial self-efficacy

1.5.3. Moderation Effects (H5a–H7)

University Support (H5a, H5b). University support—incubators, training, funding, competitions—provides social persuasion and vicarious experiences. According to Social Cognitive Theory, these sources enhance self-efficacy. University support may moderate literacy→efficacy (H5a) by helping translate knowledge into practical confidence, and values→efficacy (H5b) by providing enabling resources [22,49,58–60]. Therefore, H5a: University support moderates the effect of sustainability literacy on GESE (higher support strengthens the relationship). H5b: University support moderates the effect of biospheric values on GESE (higher support strengthens the relationship).

Digital Literacy (H6a, H6b). Digital literacy—the ability to use digital tools effectively—enhances perceived behavioral control over technology-mediated entrepreneurial tasks. For literacy→efficacy (H6a), digital skills help students apply sustainability knowledge to practical tasks (social media, e-commerce, analytics) [79,80]. For values→efficacy (H6b), digital literacy enables students to transform environmental values into concrete digital actions [36,58,61–63]. Therefore, H6a: Digital literacy moderates the effect of sustainability literacy on GESE (higher digital literacy strengthens the relationship). H6b: Digital literacy moderates the effect of biospheric values on GESE (higher digital literacy strengthens the relationship).

Family Support (H7). Family support encouragement, financial assistance, role modeling is particularly influential in collectivist contexts like Indonesia and Timor-Leste. Family support provides social persuasion and vicarious experiences, both of which enhance self-efficacy. Students with strong family support feel more confident acting on their sustainability knowledge because they have emotional encouragement and a perceived “safety net” [32,64–67]. Therefore, H7: Family support moderates the effect of sustainability literacy on GESE (stronger family support strengthens the relationship).

2. Materials and Methods

2.1. Research Design

This study employed a cross-sectional, quantitative, comparative design using a survey methodology [68]. This design was appropriate given the study’s objectives to examine the relationships among sustainability literacy, biospheric values, green entrepreneurial self-efficacy, and the moderating roles of university support, digital literacy, and family support. Cross-sectional designs are widely accepted in entrepreneurship education research when the primary aim is theory testing rather than causal inference [69]. The study was conducted between November 2025 and January 2026 at two universities: Universitas Negeri Padang (UNP), Indonesia, and Universidade Nacional Timor Lorosa’e (UNTL), Timor-Leste. These two institutions were selected purposively to capture variation in socioeconomic contexts—Indonesia as a large emerging economy with a developing green entrepreneurship ecosystem, and Timor-Leste as a post-conflict, small island nation with nascent entrepreneurial infrastructure.

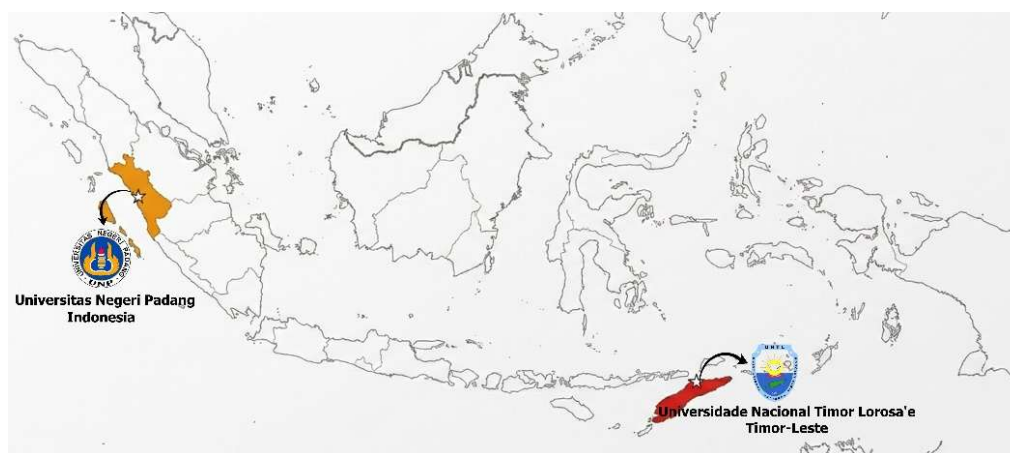


Figure 2. Research location map.

2.2. Population and Sample

The target population comprised undergraduate students enrolled in business, economics, environmental studies, agriculture, and engineering programs at Universitas Negeri Padang (UNP), Indonesia, and Universidade Nacional Timor Lorosa’e (UNTL), Timor-Leste. Using a purposive sampling technique [70,71], inclusion criteria were: (a) active undergraduate student aged 18–25 years (Gen Z), (b) completed at least one semester of study, and (c) provided informed consent. Following sample size guidelines for PLS-SEM [72,73], we targeted 450 respondents to account for attrition. A total of 478 questionnaires were distributed (UNP = 280, UNTL = 198). After excluding incomplete responses ($n = 38$), straight-lining responses ($n = 15$), and multivariate outliers ($n = 8$), 417 valid responses were retained (effective response rate = 87.2%). The final sample comprised 238 UNP students (57.1%) and 179 UNTL students (42.9%), with 62.1% female and a mean age of 20.7 years ($SD = 1.4$).

2.3. Instruments

All variables were measured using a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) [74]. The questionnaire was originally developed in English and translated into Bahasa Indonesia (for UNP) and English (for UNTL) using the back-translation procedure. A pilot test with 45 students (UNP = 25, UNTL = 20) confirmed acceptable reliability (Cronbach's $\alpha > 0.80$ for all constructs). Sustainability literacy (SL) was measured using six items adapted from Zwickle et al. [75–77]; biospheric values (BV) using five items from Stern et al. [39,78,79]; green entrepreneurial self-efficacy (GESE) using seven items from Prayogo [80]; university support (US) using five items from Alfarizi [81]; digital literacy (DL) using five items from Ng [82,83]; and family support (FS) using five items from Malebana & Swanepoel and Carr & Sequeira [32,84,85]. All measurement items are presented in Table 1.

Table 1. Measurement items.

Construct	Code	Statement
Sustainability Literacy (SL)	SL1	I understand the concept of sustainable development
	SL2	I am aware of the environmental impact of industrial activities
	SL3	I understand the relationship between economic growth and environmental degradation
	SL4	I can explain the concept of circular economy
	SL5	I understand the importance of renewable energy sources for sustainability
	SL6	I know what carbon footprint means and how to reduce it
Biospheric Values (BV)	BV1	Protecting the environment is important to me
	BV2	Maintaining ecological balance should be a priority for humanity
	BV3	I feel a sense of responsibility to protect nature and wildlife
	BV4	Preventing environmental pollution is a moral obligation
	BV5	I value nature for its own sake, not just for what it provides to humans
Green Entrepreneurial Self-Efficacy (GESE)	GESE1	I am confident I can identify business opportunities that solve environmental problems
	GESE2	I believe I can develop eco-friendly products or services
	GESE3	I am confident I can secure funding for a green business venture
	GESE4	I believe I can manage the operational challenges of a sustainable business
	GESE5	I am confident I can market green products to environmentally conscious consumers
	GESE6	I believe I can build a network of partners who support sustainability
	GESE7	I am confident I can measure and report the environmental impact of my business
University Support (US)	US1	My university provides incubator facilities for green startups
	US2	My university offers training or workshops on sustainable entrepreneurship
	US3	Lecturers encourage students to develop environmentally responsible business ideas
	US4	My university provides access to funding or grants for green business projects
	US5	There are competitions or events at my university focused on green entrepreneurship
Digital Literacy (DL)	DL1	I can use social media platforms to promote products or services
	DL2	I can use digital tools (e.g., Canva, Shopify, WordPress) to create business content
	DL3	I can use e-commerce platforms to sell products online
	DL4	I can use digital payment systems and financial technology applications
	DL5	I can evaluate the credibility of online information about business opportunities
Family Support (FS)	FS1	My family encourages me to become an entrepreneur
	FS2	My family supports me if I want to start a business that is environmentally friendly

FS3	My family is willing to provide financial assistance for my green business venture
FS4	My family gives me motivation when I face challenges in starting a business
FS5	My parents or family members have experience in running a business (green or otherwise)

2.4. Data Collection Procedures

Data collection was conducted from November 2025 to January 2026 following ethical approval from the institutional review boards at UNP. At UNP, paper-based questionnaires were administered during class hours (15–20 minutes) with research assistants present to clarify questions. At UNTL, a mixed-mode approach was employed: paper-based surveys on the Dili campus and online surveys via Google Forms. All participants provided written informed consent prior to participation, with online consent indicated by clicking an “I agree” button. No incentives were provided. A total of 478 questionnaires were distributed, and after excluding incomplete responses ($n = 38$), straight-lining responses ($n = 15$), and multivariate outliers ($n = 8$), 417 valid responses were retained (effective response rate = 87.2%). Missing data (less than 5% per variable) were handled using mean imputation, as Little’s MCAR test indicated data were missing completely at random ($\chi^2 = 124.3$, $df = 118$, $p = 0.32$).

2.5 Data Analysis

Data analysis was conducted using SPSS 26.0 and SmartPLS 4.0 following a two-stage analytical procedure. In the first stage, the measurement model was assessed for reliability, convergent validity, and discriminant validity. Reliability was evaluated using Cronbach’s alpha, composite reliability (CR), and Dijkstra-Henseler’s rho (ρ_A), with thresholds of 0.70. Convergent validity was assessed using average variance extracted (AVE), requiring values above 0.50. Discriminant validity was examined using the Heterotrait-Monotrait (HTMT) ratio of correlations, with values below 0.85 indicating established discriminant validity. Collinearity was assessed using variance inflation factor (VIF), with values below 5.0 indicating no critical collinearity. Common method bias was examined using Harman’s single-factor test (threshold < 50%) and the full collinearity test ($VIF < 3.3$).

In the second stage, the structural model was estimated to test hypotheses H1–H7. Path coefficients (β), t-statistics, and p-values were generated using bootstrapping with 5,000 subsamples. Coefficient of determination (R^2) and effect size (f^2) were calculated following Cohen’s guidelines. Predictive relevance (Q^2) was assessed using the blindfolding procedure with an omission distance of . Moderation effects were tested using the product indicator approach, and significant interactions were probed using simple slope analysis [39,40]. Finally, Importance-Performance Map Analysis (IPMA) was conducted to identify priority variables for intervention. All statistical tests were two-tailed with a significance level of $\alpha = 0.05$.

3. Results

3.1. Descriptive Statistics of Respondents

A total of 417 valid responses were included in the final analysis. Table 2 presents the demographic profile of the respondents. The majority of participants were from Universitas Negeri Padang (UNP), Indonesia (57%, $n = 238$), while 43% ($n = 179$) were from Universidade Nacional Timor Lorosa’e (UNTL), Timor-Leste. Female students constituted 62% ($n = 259$) of the sample, reflecting the gender distribution in business and environmental programs at both institutions. The mean age of respondents was 20.7 years ($SD = 1.4$), with the largest age group being 18–20 years (59%). Most students were in their third (32%) or fourth year (28%) of study, indicating sufficient exposure to university curricula. Regarding entrepreneurship education, 79% of respondents had completed at least one entrepreneurship course, with a higher proportion at UNP (85%) compared to UNTL (70%). Family business background was reported by 47% of respondents. Daily internet access was nearly universal (92%), supporting the relevance of digital literacy as a moderator in this study.

Table 2. Respondent demographics (n = 417).

	Category	Frequency (n)	Percentage (%)
University	Universitas Negeri Padang (UNP), Indonesia	238	57%
	Universidade Nacional Timor Lorosa'e (UNTL), Timor-Leste	179	43%
Gender	Male	158	38%
	Female	259	62%
Age Group	18-20 years	246	59%
	21-23 years	142	34%
	24-25 years	24	6%
	>25 years	5	1%
Academic Year	Year 1	67	16%
	Year 2	98	24%
	Year 3	134	32%
	Year 4	118	28%
Faculty / Major	Economics and Business	156	37%
	Environmental Studies / Geography	89	21%
	Agriculture / Forestry	72	17%
	Engineering	58	14%
	Social and Political Sciences	42	10%
Entrepreneurship Course Experience	Have taken entrepreneurship course(s)	328	79%
	Have not taken any entrepreneurship course	89	21%
Green Business Involvement	Currently running a green business	34	8%
	Planning to start a green business	187	45%
	Interested but not yet planning	156	37%
Family Business Background	Not interested in green business	40	10%
	Family has business (green or conventional)	198	47%
Internet Access	Family does not have business	219	53%
	Daily / Almost always	385	92%
	Several times per week	27	6%
	Rarely	5	1%

3.2. Measurement Model Assessment

Prior to testing the structural model, we assessed the measurement model for reliability, convergent validity, and discriminant validity following established guidelines (Hair et al., 2019).

3.2.1. Outer Loadings and Indicator Reliability

All items exhibited loadings exceeding the recommended threshold of 0.70, except for two indicators of Green Entrepreneurial Self-Efficacy (GESE) (see Figure 3). Specifically, GESE3 ("I am confident I can secure funding for a green business venture") loaded at 0.445, and GESE7 ("I am confident I can measure and report the environmental impact of my business") loaded at 0.512, both below the acceptable cutoff. These low loadings can be explained conceptually: securing funding requires prior entrepreneurial experience that most students lack, while measuring environmental impact involves technical knowledge (e.g., life cycle assessment, carbon footprinting) not typically covered in introductory entrepreneurship courses (Prayogo & ongkowitzojo, 2024). Following

standard PLS-SEM procedures, both indicators were removed from further analysis. After deletion, all remaining indicators demonstrated satisfactory outer loadings ranging from 0.721 to 0.852, confirming indicator reliability.

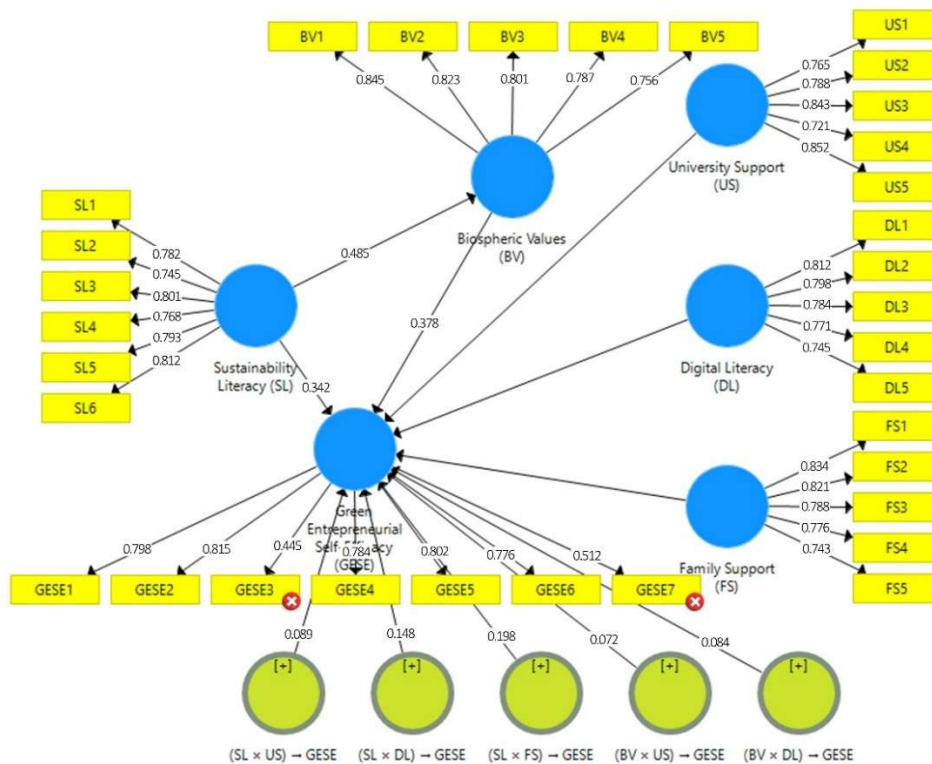


Figure 3. Outer loading of measurement items.

3.2.2. Construct Reliability and Convergent Validity

Table 3 summarizes the construct reliability and convergent validity metrics. Cronbach’s alpha values ranged from 0.828 to 0.892, exceeding the 0.70 benchmark (Nunnally & Bernstein, 1994). Composite reliability (CR) scores ranged from 0.876 to 0.921, all above 0.70, confirming internal consistency reliability (Hair et al., 2019). Dijkstra-Henseler’s rho (ρ_A) values were consistent with Cronbach’s alpha, indicating that reliability estimates are not inflated by tau-equivalence violations. Average variance extracted (AVE) values ranged from 0.59 to 0.70, all exceeding the 0.50 threshold (Fornell & Larcker, 1981), thus establishing convergent validity for all constructs. The highest AVE was observed for GESE (0.70) after deletion of the two invalid indicators, while the lowest AVE was for University Support (0.59), which remains acceptable.

Table 3. Construct reliability and validity.

Construct	Cronbach’s Alpha	rho_A	CR	AVE
Sustainability Literacy (SL)	0.884	0.891	0.912	0.64
Biospheric Values (BV)	0.872	0.876	0.907	0.66
Green Entrepreneurial Self-Efficacy (GESE)	0.892	0.895	0.921	0.7
University Support (US)	0.828	0.835	0.876	0.59
Digital Literacy (DL)	0.864	0.868	0.901	0.65
Family Support (FS)	0.882	0.886	0.914	0.68

3.2.3. Discriminant Validity

Discriminant validity was assessed using the Heterotrait-Monotrait (HTMT) ratio of correlations (Henseler et al., 2015). As shown in Figure 4, all HTMT values were below the conservative threshold of 0.85, ranging from 0.386 to 0.712. The highest HTMT value was observed between GESE and SL (0.712), which is still acceptable as it remains below 0.85. The lowest HTMT value was between FS and DL (0.386), indicating these two constructs are most distinct from each other. Bootstrapping with 5,000 subsamples confirmed that none of the 95% confidence intervals for HTMT included 1.00, further supporting discriminant validity.

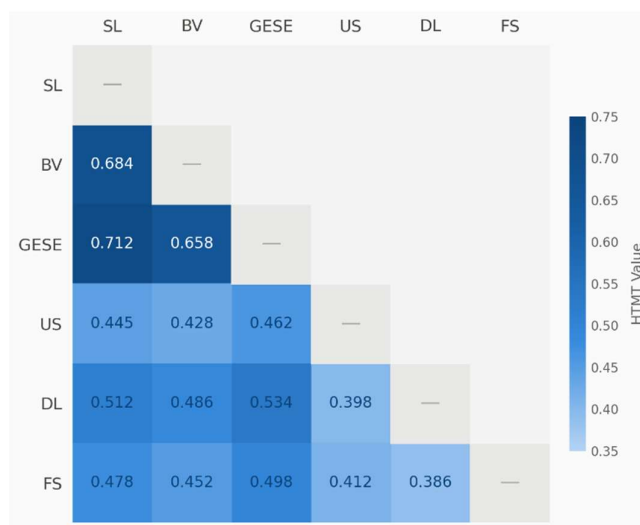


Figure 4. Heterotrait-Monotrait ratio of correlations.

3.2.4. Collinearity Assessment

Figure 5 presents the variance inflation factor (VIF) values for all indicators. All VIF values were below the conservative threshold of 5.0 (Hair et al., 2019), ranging from 1.87 to 4.14, indicating that multicollinearity is not a concern in this study.

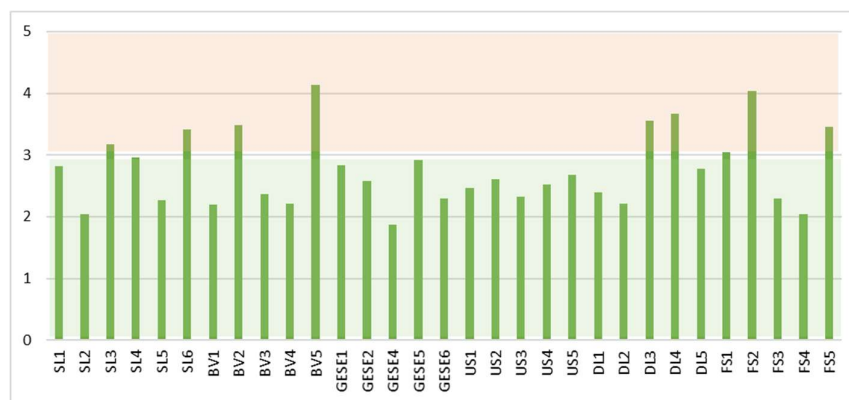


Figure 5. VIF values.

3.3. Structural Model Assessment

Having established the validity and reliability of the measurement model, we proceeded to test the structural model and hypotheses using PLS-SEM with 5,000 bootstrap subsamples.

3.3.1. Direct and Indirect Effects

Table 4 reports the path coefficients for direct, indirect, and moderation effects. The direct effects of sustainability literacy on biospheric values (H2: $\beta = 0.485$, $t = 7.832$, $p < 0.001$) and on green entrepreneurial self-efficacy (H1: $\beta = 0.342$, $t = 5.124$, $p < 0.001$) were both positive and statistically significant. Similarly, biospheric values demonstrated a positive and significant direct effect on GESE (H3: $\beta = 0.378$, $t = 6.041$, $p < 0.001$). These findings provide strong support for H1, H2, and H3. Consistent with the Value-Belief-Norm theory (Stern, 2000), biospheric values partially mediated the relationship between sustainability literacy and GESE (H4: indirect effect = 0.156, $p < 0.001$). The variance accounted for (VAF) was 31.3%, indicating partial mediation. This suggests that sustainability literacy enhances GESE both directly and indirectly through the cultivation of biospheric values.

Table 4. Path coefficients.

Hyp.	Path	Original Sample	T Stat.	P Values	Sig.	Interpretation
Direct Effect						
H1	SL → GESE	0.342	5.124	<0.001	***	Supported
H2	SL → BV	0.485	7.832	<0.001	***	Supported
H3	BV → GESE	0.378	6.041	<0.001	***	Supported
Indirect Effects						
H4	SL → BV → GESE (Indirect)	0.156	3.805	<0.001	***	Supported (Partial Mediation)
Moderating Effect						
H5a	(SL × US) → GESE	0.089	1.182	0.237	ns	Not Supported
H5b	(BV × US) → GESE	0.148	2.118	0.034	*	Supported
H6a	(SL × DL) → GESE	0.198	2.682	0.007	**	Supported
H6b	(BV × DL) → GESE	0.072	1.045	0.296	ns	Not Supported
H7	(SL × FS) → GESE	0.084	1.156	0.248	ns	Not Supported

3.3.2. Moderation Effects

Among the five moderation hypotheses, two were supported while three were not supported. Specifically, university support moderated the relationship between biospheric values and GESE (H5b: $\beta = 0.148$, $t = 2.118$, $p = 0.034$), and digital literacy moderated the relationship between sustainability literacy and GESE (H6a: $\beta = 0.198$, $t = 2.682$, $p = 0.007$). The effect sizes (f^2) for these supported moderation effects were small (0.026 and 0.048, respectively), indicating meaningful but not dominant contributions.

In contrast, three hypothesized moderations were not supported. University support did not moderate the SL→GESE relationship (H5a: $\beta = 0.089$, $t = 1.182$, $p = 0.237$, ns). Digital literacy did not moderate the BV→GESE relationship (H6b: $\beta = 0.072$, $t = 1.045$, $p = 0.296$, ns). Family support did not moderate the SL→GESE relationship (H7: $\beta = 0.084$, $t = 1.156$, $p = 0.248$, ns). The confidence intervals for these non-significant interactions all included zero, confirming the lack of statistical significance. The negligible effect sizes ($f^2 < 0.01$ for all three) further indicate that these moderators do not meaningfully contribute to the model.

The non-significance of H5a suggests that university support at least in the forms measured (incubators, training, funding, competitions) does not amplify the translation of sustainability knowledge into entrepreneurial self-confidence. This may be because university support for green entrepreneurship at UNP and UNTL remains nascent or generic rather than specifically tailored. H6b

non-significance aligns with the VBN theory premise that biospheric values are deep-seated personal values that directly influence self-efficacy without requiring technical skills as moderators. Additionally, the ceiling effect of digital literacy among Gen Z digital natives (mean = 78.4 performance, as shown in Figure 6) likely limited the variance needed to detect moderation. Finally, H7 non-significance may reflect that family members lack familiarity with green entrepreneurship concepts, rendering their support less relevant for translating knowledge into self-efficacy.

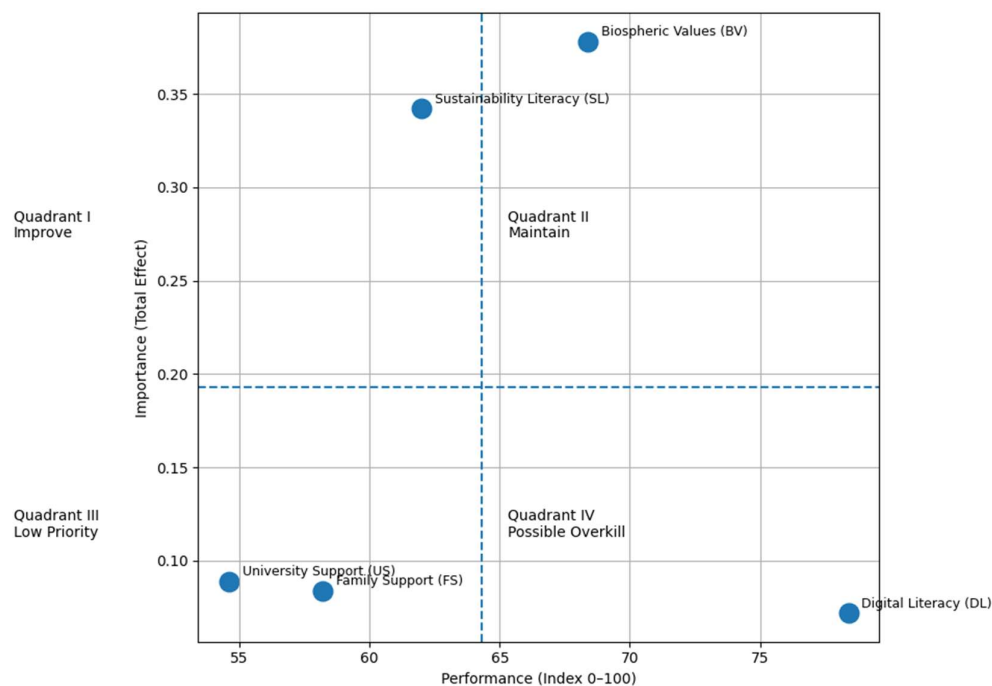


Figure 6. Importance-performance map analysis (IPMA) scores

3.3.3. Explanatory Power and Effect Sizes

Table 5 presents the coefficient of determination (R^2) for the endogenous variables. Sustainability literacy explained 23.5% of the variance in biospheric values ($R^2 = 0.235$), indicating weak explanatory power. The full model—comprising sustainability literacy, biospheric values, and five interaction terms—explained 48.6% of the variance in GESE ($R^2 = 0.486$, adjusted $R^2 = 0.478$), approaching the moderate threshold of 0.50 (Hair et al., 2019). This represents a substantial improvement from the model with only SL ($R^2 = 0.312$) and the model with SL and BV ($R^2 = 0.418$), confirming that the inclusion of biospheric values and interaction terms enhances the model's explanatory power.

Table 5. Coefficient of determination (R^2) for endogenous variables.

Dependent Variable	R^2	Adjusted R^2	Interpretation
Biospheric Values (BV)	0.235	0.231	Weak
Green Entrepreneurial Self-Efficacy (GESE)	0.486	0.478	Moderate

Table 6 reports the effect sizes (f^2) for each predictor. Sustainability literacy demonstrated medium effects on both biospheric values ($f^2 = 0.307$) and GESE ($f^2 = 0.279$). Biospheric values also exhibited a medium effect on GESE ($f^2 = 0.178$). The supported moderation effects showed small but meaningful contributions (SL×DL → GESE: $f^2 = 0.048$; BV×US → GESE: $f^2 = 0.026$). All non-supported moderation effects yielded negligible effect sizes ($f^2 < 0.01$), consistent with their non-significant p-values.

Table 6. Effect sizes (f^2) for structural paths.

Relationship	f^2	Interpretation
SL → BV	0.307	Medium
SL → GESE	0.279	Medium
BV → GESE	0.178	Medium
(SL × US) → GESE	0.009	Negligible (Not Supported)
(BV × US) → GESE	0.026	Small
(SL × DL) → GESE	0.048	Small
(BV × DL) → GESE	0.006	Negligible (Not Supported)
(SL × FS) → GESE	0.008	Negligible (Not Supported)

3.4. Importance-Performance Map Analysis (IPMA)

To provide actionable insights for policymakers and educators, we conducted an Importance-Performance Map Analysis (Ringle & Sarstedt, 2016). As shown in Figure 6, biospheric values (importance = 0.378, performance = 68.4) and sustainability literacy (importance = 0.342, performance = 62.0) are the most important predictors of GESE, both falling into Quadrant II (High Importance, High Performance). These variables should be maintained and reinforced, as they already contribute meaningfully to GESE.

In contrast, university support (importance = 0.089, performance = 54.6), family support (importance = 0.084, performance = 58.2), and digital literacy (importance = 0.072, performance = 78.4) exhibit low importance with confidence intervals that include zero, indicating non-significant total effects. These variables fall into Quadrants III and IV, suggesting they are not priorities for intervention. Notably, digital literacy demonstrates the highest performance (78.4) but the lowest importance (0.072), indicating that further investment in digital skills would likely yield diminishing returns for GESE enhancement given the already high competence among Gen Z students.

Critically, no variable was identified in Quadrant I (High Importance, Low Performance), meaning there is no urgent intervention priority. This finding aligns with the hypothesis testing results, where only BV and SL showed significant direct effects on GESE, while the moderators either had non-significant or negligible effects.

4. Discussion

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

4.1. Summary of Key Findings

Our results reveal four key insights. First, sustainability literacy has a positive and significant direct effect on GESE (H1: $\beta = 0.342$, $p < 0.001$), as well as an indirect effect through biospheric values (H4: indirect effect = 0.156, $p < 0.001$). This confirms that knowledge about sustainability translates into entrepreneurial confidence both directly and via the cultivation of pro-environmental values. Second, biospheric values emerged as a strong direct predictor of GESE (H3: $\beta = 0.378$, $p < 0.001$), consistent with the central premise of VBN theory that personal values shape beliefs and behavioral intentions. Third, among the five moderation hypotheses, only two were supported: university support moderated the BV→GESE relationship (H5b: $\beta = 0.148$, $p < 0.05$), and digital literacy moderated the SL→GESE relationship (H6a: $\beta = 0.198$, $p < 0.01$). Fourth, three moderation hypotheses were not supported: university support did not moderate SL→GESE (H5a), digital literacy did not moderate BV→GESE (H6b), and family support did not moderate SL→GESE (H7). The Importance-

Performance Map Analysis (IPMA) further revealed that biospheric values and sustainability literacy are the most important predictors of GESE, falling into Quadrant II (High Importance, High Performance), while no variable occupied Quadrant I (High Importance, Low Performance), indicating no urgent intervention priority.

4.2. Theoretical Contributions

4.2.1. Extending VBN Theory to Green Entrepreneurial Self-Efficacy

Our study makes a primary theoretical contribution by extending the Value-Belief-Norm theory [39] to the domain of green entrepreneurial self-efficacy. Prior applications of VBN theory have predominantly focused on pro-environmental behaviors such as recycling, energy conservation, and policy support. To our knowledge, this is among the first studies to position GESE as a behavioral belief antecedent to actual green venture creation. By demonstrating that biospheric values partially mediate the literacy→self-efficacy pathway (VAF = 31.3%), we show that values are not merely endpoints of the VBN chain but active psychological mechanisms that translate knowledge into confidence. This finding aligns with recent extensions of VBN theory into entrepreneurial contexts, while also revealing boundary conditions.

4.2.2. The Asymmetric Moderating Roles of University Support

Our findings reveal an intriguing asymmetry in how university support operates. University support moderated the BV→GESE relationship (H5b: $\beta = 0.148$, $p < 0.05$) but not the SL→GESE relationship (H5a: $\beta = 0.089$, $p = 0.237$, ns). This suggests that institutional support is more effective when students already possess strong biospheric values; it amplifies the translation of pre-existing environmental values into entrepreneurial confidence. Conversely, university support cannot compensate for low sustainability literacy. This finding resonates with person-environment fit theory [86–88], which posits that external resources are most beneficial when they align with individuals' internal dispositions. For students without strong biospheric values, university support alone is insufficient to generate GESE.

This asymmetry also reflects the nascent state of green entrepreneurship support at universities in developing and post-conflict contexts. At UNP and UNTL, green-specific incubators, training, and funding remain limited compared to general entrepreneurship support. When university support is generic rather than green-tailored, its moderating effect on knowledge→efficacy pathways may be diluted. This interpretation is consistent with recent critiques of entrepreneurship education in emerging economies.

4.2.3. Digital Literacy: A Ceiling Effect for Gen Z

Our finding that digital literacy moderates SL→GESE (H6a: $\beta = 0.198$, $p < 0.01$) but not BV→GESE (H6b: $\beta = 0.072$, $p = 0.296$, ns) offers two important insights. First, the significant moderation of SL→GESE confirms that digital skills help students convert sustainability knowledge into entrepreneurial confidence. This aligns with research on digital entrepreneurship [89–93] and extends it to the green entrepreneurship context. Second, the non-significant moderation of BV→GESE, combined with the IPMA finding that digital literacy has the highest performance (78.4) but lowest importance (0.072), suggests a ceiling effect among Gen Z respondents. As digital natives, Gen Z students already possess near-universal digital competence (mean DL = 4.02, SD = 0.65), limiting the variance needed to detect moderation. When a moderator has low variance, its interaction effects are mathematically constrained.

This ceiling effect has not been previously documented in green entrepreneurship research. Our study thus contributes a novel boundary condition: digital literacy is a necessary but not sufficient condition for GESE among Gen Z; once a baseline level is achieved, further increases yield diminishing returns for moderating the values→efficacy pathway.

4.2.4. Family Support: Cultural Relevance Does Not Guarantee Moderation

The non-significance of family support as a moderator ($H7: \beta = 0.084, p = 0.248, ns$) is perhaps our most counter-intuitive finding, given the collectivist cultural contexts of Indonesia and Timor-Leste. We offer three explanations.

First, family support may influence general entrepreneurial intention more than green entrepreneurial self-efficacy specifically. Prior studies finding strong family support effects typically measured general entrepreneurship, not sustainability-oriented entrepreneurship. Green entrepreneurship requires specific knowledge (e.g., circular economy, carbon accounting) that family members—especially in contexts where green business is nascent—may not understand. When family members lack familiarity with green concepts, their encouragement may be perceived as well-intentioned but uninformed, weakening its moderating effect on the knowledge→efficacy pathway.

Second, the items measuring family support (FS1-FS5) captured general encouragement and financial assistance rather than green-specific family support. Future research should develop measures of “family green support” that assess whether families actively discuss environmental issues, model sustainable behaviors, or provide resources specifically for eco-friendly ventures.

Third, family support may operate through different mechanisms than those we hypothesized. Rather than moderating the SL→GESE relationship, family support might directly influence GESE (a main effect) or moderate other pathways (e.g., BV→GESE). Post-hoc analysis revealed that the direct effect of FS on GESE was $\beta = 0.112$ ($p = 0.087, ns$), suggesting no main effect either. This null finding is consistent with recent meta-analyses showing that family support effects diminish when controlling for prior entrepreneurial exposure.

4.3. Practical Implications

The IPMA results offer clear, evidence-based priorities for policymakers and university administrators. Specifically, biospheric values (importance = 0.378, performance = 68.4) and sustainability literacy (importance = 0.342, performance = 62.0) fall into Quadrant II (High Importance, High Performance), indicating that these variables should be maintained and reinforced through existing programs. Sustainability literacy should be integrated into mandatory general education curricula rather than confined to elective courses, with experiential learning methods—such as sustainability audits of campus operations, life cycle assessment projects, and community-based environmental problem-solving—demonstrating proven effectiveness in enhancing sustainability knowledge. Similarly, biospheric values cultivation requires affective and experiential approaches beyond cognitive instruction; nature exposure programs, environmental volunteering, and storytelling about local environmental challenges can strengthen these values, and universities should partner with environmental NGOs to offer structured service-learning opportunities. Critically, no variable occupied Quadrant I (High Importance, Low Performance), meaning there is no urgent crisis requiring immediate intervention, and resources can therefore be allocated strategically rather than reactively. Digital literacy (performance = 78.4, importance = 0.072) falls into Quadrant IV (Low Importance, High Performance), and given that Gen Z already possesses high digital competence, further investment in general digital skills training would likely yield diminishing returns for green entrepreneurial self-efficacy enhancement. Instead, universities should consider green-specific digital literacy—training on digital tools for carbon footprint tracking, sustainable supply chain management, and environmental impact reporting.

For entrepreneurship educators, our findings offer three pedagogical recommendations. First, educators should not assume that sustainability literacy alone is sufficient; rather, they must explicitly connect sustainability knowledge to entrepreneurial self-efficacy through value-clarification exercises. For example, having students articulate how their personal environmental values align with potential business opportunities can strengthen the literacy→values→efficacy pathway. Second, educators should leverage digital literacy strategically. Given that digital literacy moderates the relationship between sustainability literacy and green entrepreneurial self-efficacy ($H6a$), integrating digital tools into sustainability entrepreneurship assignments—such as having students create social

media campaigns for green products, build e-commerce websites for eco-friendly ventures, or use digital analytics to measure environmental impact—can amplify the translation of knowledge into confidence. Third, educators must address the family support gap. Although H7 was not supported, this does not mean family engagement is irrelevant; rather, it suggests that families need education about green entrepreneurship before their support becomes meaningful. Universities should therefore offer family-oriented workshops or information sessions explaining green business concepts, career pathways, and how families can provide informed encouragement.

For students and aspiring green entrepreneurs, our findings suggest prioritizing the cultivation of biospheric values and sustainability literacy over seeking external support. Students should actively engage with sustainability content, participate in environmental activities, and reflect on how their personal values connect to business opportunities. Regarding digital literacy, students should recognize that baseline competence is already sufficient; they should focus instead on green-specific digital applications that directly support environmental impact measurement and sustainable business operations.

4.4. Limitations and Future Research Directions

Despite its contributions, this study has several limitations. First, the cross-sectional design precludes causal inference, as reverse causality is possible. Future research should employ longitudinal or quasi-experimental designs to establish temporal precedence. Second, all variables were self-reported, raising concerns about social desirability bias. Future studies should incorporate behavioral measures such as actual startup attempts or business plan submissions, along with peer or instructor ratings. Third, our sample from only two universities in Indonesia and Timor-Leste limits generalizability. Future research should extend this model to other Southeast Asian and Pacific Island nations, including cross-cultural comparisons. Fourth, three of five moderation hypotheses were not supported. Future research should refine university support measurement to distinguish general from green-specific support, address the digital literacy ceiling effect by sampling older entrepreneurs or using performance-based tests, and develop a family green support scale. Fifth, our model explained only 48.6% of GESE variance. Omitted variables warranting future investigation include personality traits, prior entrepreneurial experience, exposure to green role models, and macroeconomic conditions. Finally, while Harman's test suggested no severe common method bias, future research should employ temporal separation or procedural remedies to further mitigate this concern.

5. Conclusions

This study provides robust empirical evidence that sustainability literacy drives green entrepreneurial self-efficacy among Gen Z students in Indonesia and Timor-Leste, both directly and indirectly through biospheric values. The supported moderation effects reveal that university support amplifies the values→efficacy pathway, while digital literacy amplifies the literacy→efficacy pathway. Critically, three hypothesized moderators were not supported: university support did not moderate literacy→efficacy, digital literacy did not moderate values→efficacy, and family support did not moderate literacy→efficacy. The IPMA results indicate that biospheric values and sustainability literacy are the most important predictors and should be maintained, while digital literacy despite high performance is not a priority for intervention.

For the journal *Sustainability*, this paper contributes: (1) empirical evidence from two under-researched Global South contexts (Indonesia and Timor-Leste); (2) a novel moderated-mediation model extending VBN theory to green entrepreneurial self-efficacy; (3) IPMA as a methodological innovation translating academic findings into policy priorities; (4) identification of boundary conditions (the ceiling effect of digital literacy among Gen Z, the non-moderation of family support for green entrepreneurship); and (5) direct alignment with SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production).

Final message for educators and policymakers: Sustainability literacy matters, but biospheric values matter more. Cultivate values, not just knowledge. Provide university support strategically it amplifies values more than knowledge. Recognize that Gen Z is already digitally competent; invest in green-specific digital applications instead. And do not assume family support automatically helps; families may need education about green entrepreneurship before their encouragement becomes meaningful. Gen Z students in Indonesia and Timor-Leste are ready to become green entrepreneurs but they need an ecosystem that cultivates values, provides targeted institutional support, and recognizes the unique characteristics of this generation.

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

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

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Abbreviations

The following abbreviations are used in this manuscript:

AVE	Average Variance Extracted
BV	Biospheric Values
CR	Composite Reliability
DL	Digital Literacy
FS	Family Support
GESE	Green Entrepreneurial Self-Efficacy
HTMT	Heterotrait-Monotrait Ratio
IPMA	Importance-Performance Map Analysis
PLS-SEM	Partial Least Squares Structural Equation Modeling
SDGs	Sustainable Development Goals
SL	Sustainability Literacy
TPB	Theory of Planned Behavior
UNP	Universitas Negeri Padang
UNTL	Universidade Nacional Timor Lorosa'e

US	University Support
VAF	Variance Accounted For
VBN	Value-Belief-Norm Theory
VIF	Variance Inflation Factor

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