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HUMAN CAPITAL DEVELOPMENT STRATEGIES AND GREEN INNOVATION PERFORMANCE: THE MEDIATING ROLE OF ORGANIZATIONAL GREEN INNOVATION CAPABILITY IN ACHIEVING NATIONAL SUSTAINABILITY GOALS

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Abstract

Green innovation has emerged as a critical driver of sustainable nation-building in the era of climate change and technological transformation. While prior research has emphasized the role of technology and policy in advancing green innovation, limited empirical attention has been paid to the role of human capital development in nurturing green innovation ecosystems. This study examines how green skills training programs, sustainability education integration, and leadership development for green innovation influence organizational green innovation capability and green innovation performance, ultimately contributing to national sustainability goals. Using survey data collected from managers and sustainability professionals across green-intensive sectors, the study employed Structural Equation Modelling (SEM) to test the proposed relationships. The findings highlighted the mediating role of organizational green innovation capability.

The findings are aligned with Human Capital Theory (HCT), which posits that investments in knowledge and skills enhance organizational capabilities. They also reinforce the Resource-Based View (RBV), which argues that intangible capabilities—rather than isolated training initiatives—drive competitive advantage. The results are particularly relevant in the context of national sustainability agendas and global climate commitments, suggesting that policy-level sustainability outcomes fundamentally depend on firm-level innovation performance, which in turn relies on organizational capability and human capital development. The study offers theoretical and practical implications for policymakers, organizations, and educational institutions seeking to strengthen green innovation ecosystems.

Keywords

Human capital development, Green innovation, Sustainability education, Leadership development, National sustainability goals

1. Introduction

Sustainable development has become a central priority for nations striving to balance economic growth with environmental protection. Increasing environmental degradation, climate change, and resource scarcity have compelled governments and organizations to adopt green innovation as a strategic response. Green innovation—defined as the development and implementation of environmentally friendly products, processes, and technologies—plays a pivotal role in achieving long-term sustainability objectives.

While technological advancement and regulatory frameworks are often highlighted as enablers of green innovation, the role of human capital remains underexplored. Innovation is fundamentally a human-driven process, relying on skills, knowledge, leadership, and organizational learning. In the context of green innovation, employees must possess specialized green skills, sustainability-oriented mindsets, and leadership support to translate environmental goals into tangible outcomes.

Emerging economies, in particular, face significant challenges in building green innovation ecosystems due to skill shortages, inadequate sustainability education, and limited leadership capacity. Despite policy initiatives promoting green growth, organizations often struggle to align human capital strategies with sustainability goals. This gap underscores the need for empirical research examining how human capital development strategies contribute to green innovation capability and performance, and how these outcomes support national sustainability objectives.

Accordingly, this study investigates the role of green skills training programs, sustainability education integration, and leadership development for green innovation in fostering organizational green innovation capability and performance, with implications for nation-building through sustainability.

2. Literature Review

2.1 Green Innovation and Sustainability

Green innovation has been widely recognized as a mechanism for reducing environmental impact while enhancing competitiveness. Studies suggest that green innovation improves resource efficiency, reduces emissions, and strengthens organizational legitimacy. At the national level, green innovation contributes to sustainable economic growth and supports environmental policy goals.

Chen Yu-Shan (2008), in his study, introduced the novel construct of green core competence to examine its influence on firms' green innovation performance and corporate green image. The findings revealed that green core competence was positively associated with both dimensions of green innovation performance as well as the firm's green image. Furthermore, the study demonstrated that the two dimensions of green innovation performance partially mediated the relationship between green core competence and green image.

According to Michael E. Porter and Claas van der Linde (1995), appropriately designed environmental regulations can trigger innovation that enhances both environmental outcomes and firm competitiveness, a proposition widely known as the Porter Hypothesis.

However, most studies focus on technological inputs, regulatory pressure, and market incentives as drivers of green innovation. The human dimensions—such as skills, learning, and leadership—remain relatively underrepresented, despite their centrality and importance to innovation processes.

2.2 Human Capital Development

Human capital development refers to systematic investments in education, training, and skill enhancement aimed at improving employees' knowledge, competencies, and innovative potential. Rooted in Human Capital Theory (HCT), originally proposed by Becker Gary (1964), investments in employee capabilities are viewed as strategic assets that enhance productivity, competitiveness, and long-term organizational performance. In contemporary sustainability contexts, human capital development extends beyond technical efficiency to include environmental awareness, green competencies, and sustainability-oriented problem-solving skills.

From a strategic management perspective, the Resource-Based View (RBV) articulated by Barney Jay (1991) emphasizes that firm-specific skills and capabilities can create sustained competitive advantage when they are valuable, rare, and difficult to imitate. Green skills, sustainability training, and environmentally responsible leadership behaviors constitute such strategic resources. When organizations invest in environmental training and sustainability education, they build internal capabilities that facilitate green innovation initiatives.

Empirical research in Green Human Resource Management (GHRM) further strengthens this argument. Renwick et al. (2013) highlighted that environmental training, green performance management, and employee involvement positively influence environmental performance outcomes. Similarly, Jabbour (2015) found that structured environmental training programs significantly enhance firms' capacity to implement eco-innovative processes. These findings suggest that targeted human capital strategies contribute to building organizational capabilities necessary for green innovation.

2.3 Green Skills Training Programs (GSTP)

Green skills encompass technical, managerial, and cognitive competencies related to environmental management and sustainable technologies. Training programs focused on energy efficiency, waste reduction, renewable energy, and environmental compliance enhance employees' ability to support green innovation. Pham et al. (2018) investigated the impact of environmental training on organizational environmental performance and reported significant improvements in waste management practices and reduced environmental non-compliance cases among trained employees. This suggests that training not only builds awareness but also translates into measurable operational improvements. Daily et al. (2012) found that environmental training programs in manufacturing firms contributed to higher levels of eco-efficiency by reducing waste and improving resource utilization. Their study highlighted that workers who received training were more likely to participate in energy-saving initiatives and adhere to environmental protocols. Garcia-Morales, Lloréns-Montes, and Verdú-Jover (2008) showed that managerial training in sustainability catalyzed organizational learning processes that supported innovation outcomes. Their findings indicated that green skills strengthen the link between knowledge acquisition and creative application, which is essential for green innovation.

However, many empirical studies treat training as a standalone variable rather than as part of an integrated system influencing innovation capability. This has created a gap in understanding how green skills contribute to dynamic capabilities—such as sensing environmental opportunities, seizing eco-friendly innovation pathways, and integrating sustainability into organizational routines.

2.4 Sustainability Education Integration (SEI)

Sustainability education extends beyond technical training to include values, attitudes, and systems thinking. Integrating sustainability into organizational learning programs fosters long-term behavioral change and innovation-oriented thinking. Sustainability education encompasses more than skill-based training; it involves cultivating values, attitudes, and systems thinking that enable individuals and organizations to understand and act upon complex environmental and social challenges (Sterling, 2001). Within organizational contexts, integrating sustainability into learning and development systems encourages employees to adopt long-term sustainable behaviors and fosters innovation-oriented thinking that supports sustainable competitiveness (Lozano, 2015). Timo & Wayne (2019) examined sustainability education programs within multinational corporations and found that employees who participated in integrated sustainability learning demonstrated higher levels of environmental awareness and increased engagement in sustainability initiatives. Their study showed that education programs that include reflective exercises and systems-based case studies were more effective than traditional compliance-oriented training.

Martins et al. (2020) investigated the influence of sustainability learning initiatives on organizational innovation. They found a positive association between sustainability education and the development of sustainable product innovations, mediated by employees’ capacity to apply systems thinking in problem-solving. This research highlighted that sustainability education can catalyze organizational capabilities for innovation when it emphasizes critical thinking and collaborative learning.

Despite these insights, the research on the direct impact of sustainability education integration on innovation outcomes remains sparse. Many studies either focus on attitudinal changes or technical competencies without empirically linking these learning outcomes to measurable innovation performance at the organizational level.

2.5 Leadership Development for Green Innovation (LDGI)

Leadership plays a crucial role in driving sustainability initiatives and fostering innovation. Sustainability-oriented leaders articulate a clear vision, allocate resources, and create supportive environments for green initiatives. Leadership is widely recognized as a critical driver of organizational sustainability and innovation. Sustainability-oriented leaders articulate a clear environmental vision, allocate resources to support eco-initiatives, and build environments that facilitate employee engagement in green behaviours and innovative practices (Chen & Chang, 2020). Transformational and ethical leadership styles have been associated with pro-environmental behavior and innovation. Garcia-Morales, Lloréns-Montes, and Verdú-Jover (2008) found that transformational leadership significantly enhances organizational performance by promoting knowledge creation and innovation capability. Their findings suggest that leadership practices foster an environment conducive to learning and innovation. A 2025 empirical study found that sustainable leadership practices positively shape green organisational culture, which in turn drives green product and process innovation. Importantly, visionary and performance-driven leadership behaviours were key in fostering innovation through cultural mechanisms.

Most research focuses on leadership styles (transformational, inclusive, etc.) rather than on leadership development outcomes, leaving the role of training, mentoring, and development pathways largely omitted.

2.6 Organizational Green Innovation Capability (OGIC)

Organizational capability refers to the firm's ability to integrate resources and competencies to achieve desired outcomes. Green innovation capability reflects an organization's capacity to generate, absorb and implement eco-friendly innovations including green products, processes, and managerial practices.

Scholars suggest that green innovation capability mediates the relationship between organizational inputs such as strategic resources, leadership systems, and HR development and sustainable innovation outcomes. However, empirical studies testing this mediating role particularly in relation to human capital development strategies are limited.

2.7 Green Innovation Performance (GIP) and National Sustainability Goals (NSG)

Green innovation performance captures the tangible outcomes of green innovation initiatives, including reduced emissions, eco-friendly products, and improved resource efficiency. At the macro level, such outcomes contribute to national sustainability goals by supporting environmental protection, economic resilience, and social well-being. Some studies emphasise the strategic role of green innovation in national competitiveness and resilience, arguing that investments in clean technologies and sustainable industries can strengthen a country's position in the global economy and improve resilience against environmental and economic shocks—key aspects of national sustainability frameworks.

Most studies examine green innovation performance at the firm level, without linking it to national sustainability objectives. This disconnect highlights the need for research connecting micro-level organizational practices with macro-level sustainability outcomes.

3. Research Gap Analysis

Based on the literature review, the following research gaps are identified:

1. Limited empirical focus on human capital development as a driver of green innovation**,** with most studies emphasizing technology and regulation.
2. Fragmented examination of training, education, and leadership**,** rather than an integrated human capital framework.
3. Insufficient investigation of organizational green innovation capability as a mediating mechanism**.**
4. Weak linkage between organizational green innovation performance and national sustainability goals, particularly in emerging economies.
5. Lack of quantitative, model-driven studies using SEM to test complex relationships among human capital, innovation capability, and sustainability outcomes.

This study addresses these gaps by proposing and empirically testing an integrated model linking human capital development strategies to green innovation capability, performance, and national sustainability contributions.

4. Conceptual Framework and Hypotheses

The conceptual model proposes that green skills training programs, sustainability education integration, and leadership development for green innovation positively influence organizational green innovation capability. In turn, this capability enhances green innovation performance, which contributes to national sustainability goals.

Hypotheses

•H1: Green skills training programs positively influence organizational green innovation capability.

•H2: Sustainability education integration positively influences organizational green innovation capability.

• H3: Leadership development for green innovation positively influences organizational green innovation capability.

•H4: Organizational green innovation capability positively influences green innovation performance.

•H5: Green innovation performance positively contributes to national sustainability goals.

•H6: Organizational green innovation capability mediates the relationship between human capital development strategies and green innovation performance.

Conceptual Model and Interpretation

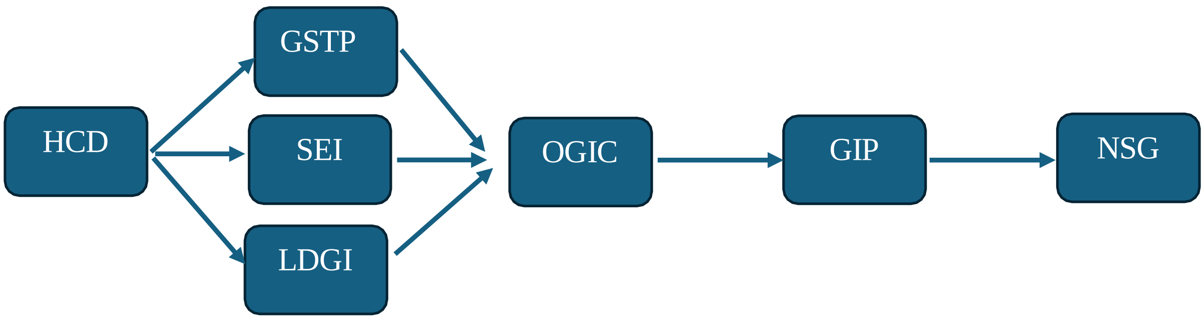

Figure 1: Conceptual Model

Independent Variables (Human Capital Development Strategies):

- Green Skills Training Programs (GSTP)
- Sustainability Education Integration (SEI)
- Leadership Development for Green Innovation (LDGI)

Mediating Variable: Organizational Green Innovation Capability (OGIC)
Sequential Mediator: Green Innovation Performance (GIP)
Dependent Variable: National Sustainability Goals (NSG)

6. Research Design and Data Collection

A quantitative research design was adopted using a structured questionnaire to examine the relationships among human capital development strategies, organizational green innovation capability, green innovation performance, and national sustainability goals. The sample comprised 600 respondents drawn from organizations operating in the manufacturing, renewable energy, infrastructure, and technology sectors. These sectors were selected due to their increasing involvement in sustainability initiatives and green innovation practices.

The respondents included HR professionals, middle-level managers, senior managers, and sustainability officers, representing individuals who are directly involved in organizational decision-making related to sustainability and innovation. Their varied professional roles and experience ensured adequate representation of key stakeholders responsible for implementing green innovation initiatives within organizations.

All measurement items were adapted from previously validated scales to ensure content validity and reliability. Minor wording modifications were made to align the items with the context of green innovation and sustainability-oriented organizations. All constructs were measured using a five-point Likert scale, ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). The collected data were analysed using Structural Equation Modelling (SEM) through Jamovi to examine the proposed relationships and mediation effects among the study variables.

7. Data Analysis and Findings

<u>Descriptive Statistics</u>

Descriptive statistics were computed using Jamovi and indicated moderate levels across all constructs, with mean values ranging from 2.36 to 2.75 on a five-point Likert scale. Standard deviations ranged between 0.65 and 0.73, indicating acceptable variability. Skewness values (−0.160 to 0.242) fell within acceptable limits, suggesting approximately symmetrical distributions. Although some Shapiro–Wilk tests were statistically significant due to the large sample size (N = 600), the W values were close to 1 and skewness remained minimal, indicating practical normality. Consequently, the data were considered suitable for structural equation modelling. The descriptive statistics table is not presented here due to space constraints.

Table 1: Scale Reliability Statistics

Scale Reliability Statistics	
	Cronbach's α
Scale	0.930

The overall scale demonstrated excellent internal consistency reliability, with a Cronbach’s alpha coefficient of 0.93 (Table 1). This value indicated a high level of inter-item correlation and confirmed that the measurement instrument possessed strong reliability.

<u>Confirmatory Factor Analysis (CFA)</u>

Table 2: Factor Loadings

				95% Confidence Interval				
Factor	**Indicator**	**Estimate**	**SE**	**Lower**	**Upper**	**Z**	**p**	**Stand. Estimate**
GSTP	**GSTP1**	0.561	0.0238	0.514	0.608	23.5	<.001	0.823
	GSTP2	0.533	0.0232	0.488	0.579	23.0	<.001	0.810
	GSTP3	0.522	0.0243	0.475	0.570	21.5	<.001	0.774
	GSTP4	0.523	0.0235	0.477	0.569	22.2	<.001	0.791

Table 2: Factor Loadings

				95% Confidence Interval				
Factor	**Indicator**	**Estimate**	**SE**	**Lower**	**Upper**	**Z**	**p**	**Stand. Estimate**
SEI	**SEI1**	0.557	0.0240	0.510	0.604	23.2	<.001	0.813
	SEI2	0.555	0.0237	0.509	0.602	23.4	<.001	0.818
	SEI3	0.556	0.0237	0.509	0.602	23.4	<.001	0.818
	SEI4	0.526	0.0238	0.480	0.573	22.1	<.001	0.786
LDGI	**LDGI1**	0.572	0.0248	0.523	0.621	23.1	<.001	0.804
	LDGI2	0.591	0.0244	0.543	0.639	24.2	<.001	0.830
	LDGI3	0.613	0.0249	0.565	0.662	24.6	<.001	0.840
	LDGI4	0.596	0.0241	0.548	0.643	24.7	<.001	0.842
OGIC	**OGIC1**	0.519	0.0228	0.474	0.563	22.7	<.001	0.800
	OGIC2	0.528	0.0235	0.482	0.574	22.5	<.001	0.795
	OGIC3	0.518	0.0235	0.472	0.564	22.1	<.001	0.785
	OGIC4	0.519	0.0232	0.473	0.564	22.3	<.001	0.791
GIP	**GIP1**	0.586	0.0244	0.538	0.634	24.0	<.001	0.830
	GIP2	0.553	0.0241	0.506	0.601	23.0	<.001	0.805
	GIP3	0.549	0.0237	0.502	0.595	23.2	<.001	0.810
	GIP4	0.525	0.0232	0.480	0.571	22.6	<.001	0.797
NSG	**NSG1**	0.589	0.0248	0.540	0.638	23.7	<.001	0.826
	NSG2	0.537	0.0236	0.491	0.584	22.8	<.001	0.802

NSG3	0.547	0.0238	0.500	0.593	23.0	<.001	0.809
NSG4	0.523	0.0237	0.476	0.569	22.0	<.001	0.785

Factor loadings ranged from 0.774 to 0.842 (Table 2). All loadings exceeded the recommended threshold of 0.70, and p-values were below 0.001**,** indicating strong statistical significance. The z-values were also high**,** confirming that all items loaded significantly on their intended constructs. These results demonstrated strong convergent validity of the measurement model.

Table 3: Factor Covariance

				95% Confidence Interval				
		Estimate	**SE**	**Lower**	**Upper**	**Z**	**p**	**Stand. Estimate**
GSTP	**GSTP**	1.000[a]						
	SEI	0.510	0.0359	0.439	0.580	14.20	<.001	0.510
	LDGI	0.503	0.0358	0.433	0.574	14.07	<.001	0.503
	OGIC	0.594	0.0325	0.530	0.658	18.26	<.001	0.594
	GIP	0.346	0.0415	0.265	.428	8.35	<.001	.346

Table 3: Factor Covariance

				95% Confidence Interval				
		Estimate	**SE**	**Lower**	**Upper**	**Z**	**p**	**Stand. Estimate**
	NSG	0.259	0.0438	0.174	0.345	5.93	<.001	0.259
SEI	**SEI**	1.000[a]						
	LDGI	0.549	0.0337	0.483	0.615	16.30	<.001	0.549
	OGIC	0.608	0.0318	0.546	0.670	19.14	<.001	0.608
	GIP	0.408	0.0395	0.330	0.485	10.33	<.001	0.408
	NSG	0.276	0.0432	0.191	0.360	6.37	<.001	0.276
LDGI	**LDGI**	1.000[a]						
	OGIC	0.603	0.0315	0.542	0.665	19.15	<.001	0.603
	GIP	0.453	0.037	0.380	0.527	12.0	<.001	0.453

			5			8		
	NSG	0.318	0.0418	0.236	0.400	7.61	<.001	0.318
OGIC	**OGIC**	1.000[a]						
	GIP	0.630	0.0306	0.570	0.690	20.58	<.001	0.630
	NSG	0.542	0.0348	0.473	0.610	15.56	<.001	0.542
GIP	**GIP**	1.000[a]						
	NSG	0.630	0.0303	0.571	0.689	20.80	<.001	0.630
NSG	**NSG**	1.000[a]						

The highest correlations were observed among the following constructs (Table 3): OGIC–GIP (0.630), GIP–NSG (0.630), and SEI–OGIC (0.608). All correlation values were well below the conservative threshold of 0.85, indicating that the constructs were empirically distinct. These results suggested the absence of multi-collinearity and confirmed adequate discriminant validity among the study variables.

Table 4: Test for Exact Fit

χ^2	df	p
237	237	0.492

Table 5: Fit Measures

				RMSEA 90% CI			
CFI	**TLI**	**SRMR**	**RMSEA**	**Lower**	**Upper**	**AIC**	**BIC**
1.00	1.00	0.0201	0.00	0.00	0.0167	21207	21590

The hypothesized six-factor measurement model demonstrated an excellent fit to the data. The chi-square statistic was non-significant, $\chi^2 = 237$, $p = .492$ (Table 4), indicating that the model-implied covariance matrix did not significantly differ from the observed covariance matrix. Additional goodness-of-fit indices (Table 5) further supported the adequacy of the model. The Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI) were both 1.00, while the RMSEA was 0.00 (90% CI: 0.00–0.00) and SRMR was 0.020. All indices exceeded the recommended thresholds (CFI and TLI $\geq .90$; RMSEA $\leq .08$; SRMR $\leq .08$), confirming an excellent fit of the measurement model.

Structural Equation Modelling (SEM)

Table 6: Model Tests

Label	X²	df	p
User Model	267	238	0.093
Baseline Model	8973	276	<.001

The structural model demonstrated good fit to the data, χ^2 (238) = 267, p = .093 (Table-6). The non-significant chi-square indicated that the proposed model adequately represented the observed data. Furthermore, the model showed substantial improvement over the baseline model, χ^2 (276) = 8973, $p < .001$, suggesting strong explanatory power of the hypothesized relationships described by the theoretical model.

Table 7: Fit Indices

		95% Confidence Intervals		
SRMR	RMSEA	Lower	Upper	RMSEA p
0.030	0.014	0.000	0.023	1.000

As shown in Table 7, the structural model demonstrated excellent fit indices (SRMR = 0.030; RMSEA = 0.014, 95% CI [0.000, 0.023]; Test of Close Fit (pclose) = 1.000), indicating minimal residual error and a close approximation to the population covariance matrix. Overall, these indices confirmed that the proposed model provided an excellent representation of the observed data.

Table 8: User Model Versus Baseline Model

	Model
Comparative Fit Index (CFI)	0.997
Tucker-Lewis Index (TLI)	0.996
Bentler-Bonett Non-normed Fit Index (NNFI)	0.996
Relative Noncentrality Index (RNI)	0.997
Bentler-Bonett Normed Fit Index (NFI)	0.970
Bollen's Relative Fit Index (RFI)	0.965

Table 8: User Model Versus Baseline Model

	Model
Bollen's Incremental Fit Index	0.997

(IFI)	
Parsimony Normed Fit Index (PNFI)	0.837

As shown in Table 8, the structural model demonstrated excellent incremental fit compared to the baseline model, with CFI = 0.997, TLI = 0.996, RNI = 0.997, IFI = 0.997, NFI = 0.970, and RFI = 0.965. All values exceeded the recommended threshold of 0.90, with most surpassing the stringent criterion of 0.95, indicating outstanding model fit. The parsimony-adjusted index (PNFI = 0.837) further confirmed that the model achieves strong explanatory power without unnecessary complexity.

Table 9: Parameters Estimates

				95% Confidence Intervals			**β 95% Confidence Intervals**			
Dep	**Pred**	**Estimate**	**SE**	**Lower**	**Upper**	**β**	**Lower**	**Upper**	**z**	**p**
OGIC	GSTP	0.263	0.0445	0.175	0.345	0.285	0.197	0.372	5.91	<.001
OGIC	SEI	0.277	0.0447	0.189	0.367	0.297	0.207	0.388	6.18	<.001
OGIC	LDGI	0.277	0.0430	0.196	0.365	0.305	0.217	0.394	6.44	<.001
GIP	OGIC	0.733	0.0496	0.644	0.843	0.650	0.589	0.712	14.78	<.001
NSG	GIP	0.651	0.0492	0.558	0.749	0.645	0.586	0.704	13.22	<.001

The structural model results (Table 9) indicated that green skills training programs significantly influence organizational green innovation capability (β = 0.285, z = 5.91, p < .001), supporting H1. Sustainability education integration also demonstrated a significant positive effect on green innovation capability (β = 0.297, z = 6.18, p < .001), supporting H2. Leadership development for green innovation emerged as the strongest predictor of green innovation capability (β = 0.305, z = 6.44, p < .001), supporting H3.

Furthermore, organizational green innovation capability exhibited a strong positive impact on green innovation performance (β = 0.650, z = 14.78, p < .001), confirming H4. Green innovation performance, in turn, significantly contributed to national sustainability goals (β = 0.645, z = 13.22, p < .001), supporting H5. All confidence intervals excluded zero, confirming the robustness of the findings.

Table 10: Defined Parameters

Label	Description	Parameter	Estimate	SE	95% Confidence Intervals Lower	95% Confidence Intervals Upper	β	β 95% Confidence Intervals Lower	β 95% Confidence Intervals Upper	z	p
IE1	GSTP ⇒ OGIC ⇒ GIP ⇒ NSG	p25*p28 *p29	0.125	0.022	0.086	0.170	0.119	0.0810	0.158	5.732	<.001
IE2	SEI ⇒ OGIC ⇒ GIP ⇒ NSG	p26*p28 *p29	0.132	0.023	0.088	0.180	0.125	0.0842	0.165	5.619	<.001
IE3	LDGI ⇒ OGIC ⇒ GIP ⇒ NSG	p27*p28 *p29	0.132	0.025	0.085	0.183	0.128	0.0818	0.175	5.217	<.001
IE4	OGIC ⇒ GIP ⇒ NSG	p28*p29	0.477	0.043	0.395	0.567	0.420	0.3605	0.479	11.054	<.001

The bootstrapped indirect effects analysis (Table 10) revealed significant serial mediation effects. Green skills training programs demonstrated a significant indirect effect on national sustainability goals through organizational green innovation capability and green innovation performance ($\beta = 0.119$, $z = 5.732$, $p < .001$). Similarly, sustainability education integration ($\beta = 0.125$, $z = 5.619$, $p < .001$) and leadership development for green innovation ($\beta = 0.128$, $z = 5.217$, $p < .001$) exhibited significant indirect effects via the same mediating mechanisms. Additionally, organizational green innovation capability showed a strong indirect effect on national sustainability goals through green innovation performance ($\beta = 0.420$, $z = 11.054$, $p < .001$). All confidence intervals excluded zero, confirming the robustness of the mediation effects and supporting H6.

8. Results and Discussion

The present study examined the structural relationships between human capital development strategies, organizational green innovation capability, green innovation performance, and national sustainability goals. The findings provided strong empirical support for the proposed conceptual framework and offer important theoretical and practical insights.

Human Capital as the Foundation of Green Innovation Capability

The results confirmed that green skills training programs, sustainability education integration, and leadership development for green innovation significantly enhanced organizational green innovation capability. Among these predictors, leadership development emerged as the most influential factor. This finding suggests that although training and educational integration establish essential technical and cognitive foundations, leadership exerts a transformative influence by embedding sustainability within organizational strategy and culture.

These findings are aligned with Human Capital Theory, which posits that investments in knowledge and skills enhance organizational capabilities. However, the results extend prior literature by demonstrating that human capital initiatives need to be strategically aligned with sustainability objectives to generate green innovation capability. Organizations that systematically develop sustainability-oriented competencies are better positioned to mobilize resources toward eco-innovation.

Organizational Capability as the Central Mechanism

A key contribution of this study lies in positioning organizational green innovation capability as the central mediating mechanism. The significant path from green innovation capability to green innovation performance confirmed that capability functions as a conversion engine through which human capital investments translate into measurable innovation outcomes.

This finding reinforces the Resource-Based View (RBV), which posits that intangible capabilities rather than isolated training initiatives constitute the foundation of competitive advantage. The results demonstrated that capability is not merely a passive by-product of training but an active organizational competence that strengthens innovation execution and performance.

Green Innovation Performance and National Sustainability Goals

The study further demonstrated that green innovation performance significantly contributed to national sustainability goals, thereby establishing a micro-to-macro linkage between firm-level innovation outcomes and broader sustainability contributions.

This finding is particularly salient in the context of national sustainability agendas and global climate commitments, as it suggests that policy-level sustainability outcomes fundamentally depend on firm-level innovation performance, which, in turn, relies on organizational capability and strategic human capital development.

Serial Mediation and Systemic Sustainability Pathway

The bootstrapped indirect effects confirmed a significant serial mediation mechanism: Human Capital → Green Innovation Capability → Green Innovation Performance → National Sustainability Goals.

The absence of direct effects from human capital strategies to performance or sustainability outcomes highlights the importance of capability development as an intervening mechanism. This indicates that training and sustainability education alone are insufficient unless they are institutionalized into organizational capabilities. This systemic pathway contributes theoretically by integrating: Human Capital Theory (skills development) and Resource-Based View (capability as a strategic resource).

Practical Implications

For managers, the findings indicate that sustainability initiatives should extend beyond regulatory compliance or isolated training programs. Organizations need to adopt a more integrated approach to developing sustainability-oriented capabilities. This involves institutionalizing green skills through structured training systems, embedding sustainability principles within organizational learning and development frameworks, and prioritizing leadership development that supports green innovation objectives. Furthermore, organizations should focus on building internal green innovation capabilities before expecting measurable improvements in innovation performance and sustainability outcomes.

For policymakers, the results underscore the importance of promoting organizational capability-building mechanisms rather than focusing solely on performance-based sustainability metrics. Policies that encourage leadership development, sustainability-oriented education, and organizational learning initiatives may strengthen firms' capacity to generate green innovations. Such initiatives can contribute to more sustained and scalable progress toward national sustainability goals.

9. Conclusion

This study examined how human capital development strategies contribute to organizational green innovation capability and how this capability translates into green innovation performance and national sustainability outcomes. The findings demonstrate that green skills training programs, sustainability education integration, and leadership development for green innovation significantly enhance organizational green innovation capability. Among these factors, leadership development emerged as the most influential driver, highlighting the strategic role of leadership in embedding sustainability within organizational culture and innovation processes.

The results further confirm that organizational green innovation capability serves as a critical mechanism linking human capital investments to green innovation performance. In turn, improved green innovation performance contributes significantly to national sustainability goals, establishing a clear micro-to-macro connection between firm-level practices and broader societal outcomes. By integrating insights from Human Capital Theory and the Resource-Based View, this study advances a multilevel understanding of sustainability transformation. Overall, the findings emphasize that sustainable development depends not only on innovation outcomes but also on the organizational capabilities and human capital systems that enable such innovations to emerge and scale.

10. References

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