Article

The Role of TVET in Green Skills Development for Achieving Sustainable Economic Growth

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Abstract: This study investigates the role of Technical and Vocational Education and Training (TVET) in fostering green skills for sustainable economic growth in Ghana. Using a quantitative cross-sectional design with 139 respondents from TVET institutions, industry, and government, the research identifies key drivers of green skills integration. Findings reveal that government policy support, trainer competence, institutional infrastructure, and industry collaboration significantly predict the integration of green skills ($R^2 = 0.58$) and collectively enhance employability and economic growth ($R^2 = 0.49$). Despite commendable policy awareness, persistent barriers include inadequate funding, gender disparities, and weak industry engagement. The study contributes to Sustainable Development Goals 4, 8, and 9, underscoring the necessity of cross-sectoral partnerships and sustained capacity-building. It concludes that aligning TVET curricula with sustainable industry needs and strengthening trainer development are essential. Recommendations include targeted investment, policy coherence, and international collaboration to institutionalise sustainability and promote gender equity.

Keywords: Employability; SDG 4: Quality Education; SDG 8: Decent Work and Economic Growth; SDG 9: Industry, Innovation, and Infrastructure; Technical and Vocational Education and Training.

1. Introduction

Technical and Vocational Education and Training (TVET) play a pivotal role in building a resilient workforce for sustainable economic transformation. In Ghana, the integration of green skills, defined by the ILO (2019) as skills needed to adapt products,

services, and processes to meet climate change challenges while complying with environmental regulations and policies necessary for sustainable economic growth, which enable workers to support resource efficiency, renewable energy, and environmental stewardship- has become central to national development goals.

Globally, the International Labour Organisation (ILO, 2019) and UNESCO-UNEVOC (2020) highlight TVET's role in facilitating just transitions toward green economies. Within this framework, Ghana's TVET system is positioned to prepare its workforce to contribute to Sustainable Development Goals (SDGs) 4, 8, and 9, focusing on quality education, decent work and Industry, Innovation, and Infrastructure (Owusu-Agyeman & Aryeh-Adjei, 2023; Busemeyer et al., 2025).

Despite this strategic alignment, limited infrastructure, insufficient trainer capacity, and uneven policy implementation continue to constrain Ghana's green transition (CTVET, 2025; Joseph et al., 2025). Recent empirical evidence indicates that curricular reform, trainer upskilling, and industry collaboration are critical mechanisms for integrating sustainability into TVET (Albertz & Pilz, 2025; Pachatz et al., 2025). Accordingly, this study investigates the role of TVET in developing green skills for sustainable economic growth in Ghana, with a specific focus on career sustainability for green transformation.

2. Study Gap

Although extensive studies have examined TVET's contribution to employability and sustainability in sub-Saharan Africa (Ahmadu & Orisaremi, 2025; Chola & Kiplagat, 2025), few have empirically analyzed how Ghana's institutional, policy, and industry mechanisms have collectively influenced green skill integration. Existing works emphasize policy intent rather than implementation outcomes (Addaney et al., 2025; Cedefop, 2021). Moreover, the dynamics within green TVET remain underexplored (Ahmed et al., 2021; Owusu-Agyeman et al., 2024). This study bridges these gaps by offering a systematic and quantitative examination of how institutional, policy, and industrial factors can shape the development of green skills and career sustainability, thereby extending the discourse from conceptual advocacy to empirical validation.

3. An Empirical Perspective

Empirical evidence confirms that Technical and Vocational Education and Training (TVET) in Ghana is central to developing green skills, enhancing employability, and promoting sustainable growth. Quantitative analysis shows that government policy support, trainer capacity, institutional infrastructure, and industry collaboration significantly predict green skills integration, explaining 58% of curriculum effectiveness variance. These results affirm global evidence that institutional readiness and policy coherence underpin effective green transitions (Albertz & Pilz, 2025; Busemeyer et al., 2025; UNESCO-UNEVOC, 2020).

The gender composition, with 64.7% male and 35.3% female, reflects persistent disparities in participation, although the increasing inclusion of females indicates progress towards equity (Ahmed et al., 2021; Alhassan et al., 2024). Based on this findings and methodology, inclusive trainer capacity and adequate infrastructure positively influence both gender equity and employability outcomes. This study supports the ILO's (2019) assertion that equitable access to green TVET is fundamental to just transitions. Similarly, it was revealed that respondents agreed that green skills enhance employability and entrepreneurship (M = 3.72, p = 0.013) and contribute to national growth (M = 3.68, p = 0.028),

as this describes the current study's findings, (see Table 5), which seems consistent with Human Capital Theory's linkage between education and productivity (Thake, 2024; Ogur, 2023).

However, neutral perceptions regarding wage differentials and foreign investment suggest that economic payoffs remain emergent, constrained by limited industry linkages and funding (Joseph et al., 2025; CTVET, 2025). While policy awareness was revealed to be high from that study (M = 3.68, p = 0.034), weak resource mobilization and low industry engagement were revealed to temper these gains (Chola & Kiplagat, 2025; Ahmadu & Orisaremi, 2025). In addition, findings from the study indicate that although Ghana's TVET sector demonstrates policy maturity, its transformative potential depends on strengthened institutional partnerships and equitable participation. Overall, TVET remains a strategic pathway for building an adaptive, inclusive workforce aligned with Ghana's sustainable development agenda.

4. Conceptual Perspectives

The study is grounded in Human Capital Theory and Network Governance Theory, offering complementary explanations of how TVET fosters sustainable development through gender inclusion and inter-sectoral collaboration. Human Capital Theory posits that educational investments enhance productivity and competitiveness (Ogur, 2023; Thake, 2024). Within Ghana's context, equipping both men and women with green skills strengthens innovation capacity, accelerates green transitions, and reduces socio-economic inequalities (Liu & Chen, 2025; Alhassan et al., 2024). The observed association between trainer competence, policy support, and employability outcomes validates the view that skill investments yield measurable developmental gains (Paryono, 2017; Busemeyer et al., 2025).

Studies highlight that cooperation among ministries, renewable energy NGOs, and industry actors is essential for Ghana's green transition (Pachatz et al., 2025; Tramonti & Dochshanov, 2025). Such networked governance promotes cross-sectoral learning, resource sharing, and mutual accountability mechanisms that are crucial for institutionalizing sustainability (Pujun, 2025; Cedefop, 2021; UNESCO-UNEVOC, 2020).

In practical terms, these frameworks call for equitable participation, institutional constructive interaction, and continuous learning within Ghana's TVET ecosystem. Gender inclusion thus emerges not merely as a social goal but as a strategic instrument for sustainable human capital development. Embedded in collaborative governance, it fosters innovation, resilience, and economic inclusivity – key conditions for a low-carbon, sustainable economy (Owusu-Agyeman, 2025; Addaney et al., 2025). The integration of human capital expansion and networked collaboration, therefore, presents a robust conceptual model for leveraging TVET in achieving Ghana's green growth aspirations.

Figure 1: A conceptual framework diagram to visualize the study's logic model. Source: Author's own work.

5. Methodology

This study examined the role of Technical and Vocational Education and Training (TVET) in fostering green skills for sustainable economic growth in Ghana, with particular focus on institutional, policy, and industry enablers. A quantitative cross-sectional survey design was adopted to capture diverse perspectives from key stakeholder groups across Ghana's TVET ecosystem. This approach enabled the exploration of relationships among policy support, trainer capacity, industry collaboration, and employability outcomes (Addaney et al., 2025; Albertz & Pilz, 2025).

Guided by a positivist paradigm, the study employed inferential statistical analyses, including chi-square tests, t-tests, and multiple regression, to validate relationships between variables, aligning with established empirical approaches in TVET research (Joseph et al., 2025; Chola & Kiplagat, 2025). The target population comprised TVET educators, industry representatives, and institutional administrators. Using stratified sampling, 139 participants were selected following the statistical power analysis method to ensure proportional representation across stakeholder categories, as done by Owusu-Agyeman et al. (2024).

A structured questionnaire was developed based on established frameworks for assessing green skills integration (Cedefop, 2021; UNESCO-UNEVOC, 2020). Items measured policy support, trainer competence, institutional infrastructure, and employability outcomes using a 5-point Likert scale. Data was collected through online surveys administered in collaboration with the Commission for TVET (CTVET) and partner institutions across major regions, following informed consent procedures (CTVET, 2025). Data were analyzed using SPSS version 20.

Instrument reliability was confirmed through Cronbach's Alpha values (α = 0.83–0.85), indicating high internal consistency. Content validity was established through expert review and alignment with validated TVET assessment models (Albertz & Pilz, 2025; Addaney et al., 2025).

Descriptive statistics were used to analyze respondent characteristics, while inferential analyses (chi-square, one-sample t-tests, and multiple regression) evaluated hypotheses regarding the institutional, policy, and industry determinants of green skills and

related economic outcomes. Statistical significance was set at p < 0.05, consistent with prior TVET studies (Owusu-Agyeman, 2025; Busemeyer et al., 2025).

6. Results and Discussion

6.1 Demographic Characteristics of Respondents

Table 1. Demographic Characteristics of Respondents

Category	Frequency	Percent.	Cumulative. Percent
Stakeholder category			
TVET Trainer/Educator	49	35.3	35.3
Industry/Employer Representative	46	33.1	68.4
TVET Institution Administrator/Manager	44	31.6	100.0
Total	139	100	
Gender			
Male	90	64.7	64.7
Female	49	35.3	100.0
Total	139	100	
Age group			
26–35 years	45	32.4	32.4
36–45 years	49	35.3	67.7
46 years and above	45	32.4	100.1
Total	139	100	
Years of experience do you have in your field			
More than 10 years	42	30.2	30.2
6–10 years	38	27.3	57.5
2–5 years	30	21.6	79.1
Less than 2 years	29	20.9	100.0
Total	139	100	

Table 1 presents the demographic characteristics of respondents, reflecting a balanced representation of key stakeholders within Ghana's Technical and Vocational Education and Training (TVET) ecosystem. The analysis focuses on stakeholder category, gender, age, and years of experience, each providing contextual depth for interpreting perspectives on TVET's role in green skills development for sustainable growth. TVET trainers/educators (35.3%), industry/employer representatives (33.1%), and administrators/managers (31.6%) were equally represented, ensuring comprehensive insights across

pedagogical, industrial, and administrative domains. Such diversity facilitates understanding of how training, policy, and employment interact to promote sustainability (Albertz & Pilz, 2025; Addaney et al., 2025; Joseph et al., 2025). The inclusion of these stakeholder groups enhances the system's responsiveness to sustainability imperatives and fosters collaborative innovation.

Gender data reveal a male dominance (64.7%) relative to female participation (35.3%), mirroring persistent gender disparities in technical fields, which aligns with findings from Ahmed, Shakeel, & Khan (2021). However, female involvement is gradually increasing, particularly in renewable energy and sustainable agriculture, driven by inclusive education policies (Alhassan et al., 2024). This aligns with UNESCO-UNEVOC's (2020) emphasis on gender equity as central to the green transformation of TVET. The age distribution of 26–35 years (32.4%), 36–45 years (35.3%), and 46 years and above (32.4%) illustrates a multigenerational mix that encourages knowledge exchange and innovation, just as revealed in Liu & Chen (2025). Mid-career professionals, who often hold managerial positions, play a pivotal role in institutionalising green skills (Busemeyer et al., 2025). The inclusivity of both emerging and seasoned professionals contributes to a dynamic and adaptive TVET workforce.

In terms of professional experience, 30.2% of respondents had over 10 years of experience, followed by 27.3% (6–10 years), 21.6% (2–5 years), and 20.9% (less than 2 years). The predominance of experienced stakeholders enhances the study's credibility through their institutional knowledge (Owusu-Agyeman et al., 2024). Experienced educators and administrators embed sustainability principles into curricula and partnerships (Paryono, 2017; Pachatz et al., 2025), while younger professionals introduce digital and innovative pedagogies (Owusu-Agyeman, 2025). Overall, the demographic structure reflects an inclusive and competent stakeholder ecosystem capable of advancing green skills development in Ghana's TVET sector. The balanced representation of educators, employers, and administrators reinforces policy–training–industry constructive interaction identified by Cedefop (2021) as vital for green transitions. Persistent gender gaps, however, indicate a need for targeted interventions such as mentorship and inclusive outreach to strengthen women's participation in green technical fields (ILO, 2019).

Diversity in age and experience further supports mentorship and institutional resilience (Tramonti & Dochshanov, 2025). These demographic dynamics position Ghana's TVET sector as a model for inclusive, adaptive capacity-building that underpins sustainable economic transformation. In line with global perspectives (Chola & Kiplagat, 2025; Ogur, 2023; CTVET, 2025; World of TVET, 2025), the study confirms TVET's role as a unifying mechanism that links education, industry, and policy to drive the green transition agenda.

6.2 Chi-Square Goodness-of-Fit Test on Demographic Characteristics

Table 2. Results of Chi-Square Goodness-of-Fit Test for Demographic Variables

Demographic Variable	χ^2 Value	df	p-value
Stakeholder Category	0.22	2	0.895
Gender	12.09	1	< 0.001**
Age Group	0.12	2	0.943
Years of Experience	3.27	3	0.352

*Note: **p < 0.01***

Chi-Square Goodness-of-Fit test was conducted to determine if the distribution of respondents across the demographic categories (stakeholder group, gender, age, and experience) was significantly different from an equal distribution. The results are presented in Table 2.

A significant gender disparity (χ^2 (1) = 12.09, p < .001) was observed with males comprising 64.7% of respondents (Table 2). This imbalance mirrors the broader gender gap in Ghana's TVET and technical sectors, consistent with Ahmed et al. (2021) and Owusu-Agyeman et al. (2024), who identified structural and cultural barriers limiting women's participation. Such disparities highlight a critical equity challenge: without intentional gender inclusion, green skills development risks perpetuating existing inequalities. As underscored by the International Labour Organisation (2019), a just transition to a green economy must ensure equitable access and participation for all.

These findings have two key implications. First, the balanced stakeholder representation strengthens the credibility of the study's conclusions, suggesting that calls for curriculum reform, industry collaboration, and supportive policy frameworks reflect a shared consensus, aligning with Albertz and Pilz (2025). Second, the persistent gender imbalance underscores the urgent need for targeted interventions to enhance women's participation in green TVET programs. Inclusive approaches such as promoting female role models, designing gender-sensitive learning environments, and addressing curricular bias are consistent with recommendations by UNESCO-UNEVOC (2020) and Owusu-Agyeman and Aryeh-Adjei (2023). In summary, while the study captures diverse stakeholder perspectives, it also reveals that the success of Ghana's transition toward a sustainable green economy depends on embedding gender equity within TVET reform. Deliberate inclusivity is necessary to fully realize the transformative potential of green skills development.

The demographic characteristics of respondents provide a vital context for interpreting the study's findings on the role of Technical and Vocational Education and Training (TVET) in fostering green skills in Ghana. Chi-square analyses (Table 2) revealed balanced distributions across stakeholder categories, age groups, and years of experience, indicat-

ing that perceptions were not biased toward any specific demographic group. The equitable representation of TVET trainers (35.3%), industry representatives (33.1%), and institutional managers (31.6%) enhances data robustness and reflects a comprehensive view of the TVET ecosystem. This balance supports Addaney et al. (2025), who emphasize that an effective TVET policy requires the inclusion of educators, administrators, and employers. Similarly, the distribution across age and experience groups integrates both innovative and experiential insights, contributing to a deeper appreciation for green skills development.

Conversely, a significant gender disparity (χ^2 (1) = 12.09, p < .001) was observed, with males comprising 64.7% of respondents. This imbalance mirrors the broader gender gap in Ghana's TVET and technical sectors, consistent with Ahmed et al. (2021) and Owusu-Agyeman et al. (2024), who identified structural and cultural barriers limiting women's participation. Such disparities highlight a critical equity challenge: without intentional gender inclusion, green skills development risks perpetuating existing inequalities. As underscored by the International Labour Organisation (2019), a just transition to a green economy must ensure equitable access and participation for all.

6.3 How Current TVET Curricula in Ghana Integrate Green Skills to Align with Sustainable Development Goals

Table 3. One-Sample Test: Test Value = 3.5

ITEM	t	df	Sig. (2-tailed)	Mean	Std. Deviation	Mean Difference	95% CI Lower	95% CI Upper	Rank
The current TVET curriculum in my field explicitly includes topics on environmental conservation and sustainability.	-1.376	138	0.171	3.374	1.079	-0.126	3.193	3.555	4
Specific 'green skills' (e.g., energy efficiency, waste management, sustainable sourcing) are clearly defined in my training modules.	1.093	138	0.2763	3.597	1.048	0.097	3.421	3.773	2

The teaching and learning materials (e.g., textbooks, manuals) are up-to-date and reflect modern green technologies and practices.	1.086	138	0.2794	3.597	1.054	0.097	3.42	3.774	3
Practical training in workshops/labs adequately incorporates tools and techniques for green practices (e.g., solar panel installation, water recycling systems).	-1.781	138	0.077	3.331	1.119	-0.169	3.143	3.519	5
Overall, I believe the TVET curriculum effectively prepares graduates to contribute to Ghana's sustainable development goals (SDGs).	1.538	138	0.1264	3.626	0.965	0.126	3.464	3.788	1

Cronbach's Alpha = 0.838, 95% CI [0.789, 0.874], N of Items = 5. Good internal consistency.

Table 3 presents the findings on the integration of green skills in Ghana's current TVET curricula. The results indicate a moderate level of integration, with mean scores clustering around the neutral benchmark (M ≈ 3.4–3.6). The respondents agreed that the curricula incorporate green-related topics like energy efficiency and sustainability. However, there was comparatively lower agreement regarding the availability of practical training tools and updated instructional materials (M = 3.33). The curriculum's perceived effectiveness in preparing students to contribute to the Sustainable Development Goals (SDGs) recorded the highest mean score (M = 3.63), reflecting recognition of potential rather than full realization in practice.

These findings are consistent with Addaney et al. (2025), who reported that while Ghana's TVET system is advancing toward greater inclusivity and quality, it continues to lack sufficient environmental and sustainability depth. Similarly, Owusu-Agyeman and Aryeh-Adjei (2023) highlighted the need to integrate green skills across both formal and informal TVET pathways to support national sustainability transitions. In alignment, Albertz and Pilz (2025) and Pujun (2025) highlighted that curriculum modernization, and the contextualization of green training are indispensable for developing effective green skill sets.

Overall, the findings show that systemic and curricular limitations continue to constrain Ghana's TVET sector, despite its growing awareness and commitment to sustainability imperatives. This underscores the need for comprehensive curriculum reform that embeds sustainability principles across disciplines, enhances teacher capacity, and ensures access to modern, practice-oriented learning tools.

In moving forward, policymakers and educational stakeholders should prioritize the alignment of TVET curricula with green industry demands, foster public–private partnerships to strengthen implementation, and invest in continuous curriculum review mechanisms. Such coordinated efforts will not only accelerate Ghana's progress toward the SDGs but also position its TVET graduates as key contributors to the emerging green economy.

6.4 Institutional, Policy, and Industry-Level Factors Influence the Capacity of Ghana's TVET Sector to Promote Green Skills Development

Table 4. One-Sample Test: Test Value = 3.5

ITEM	t	df	Sig. (2-tailed)	Mean	Std. Deviation	Mean Difference	95% CI Lower	95% CI Upper	Rank
My TVET institution has the necessary physical infrastructure (labs, workshops) to teach green skills effectively.	0.773	138	0.4411	3.568	1.043	0.068	3.393	3.743	3
TVET trainers in my institution have received sufficient training on green technologies and sustainable practices.	1.291	138	0.1987	3.612	1.018	0.112	3.441	3.782	4

I am aware of government policies (e.g., Ghana's Energy Transition Framework, Education Strategic Plan) that promote green skills in TVET.	2.138	138	0.0343	3.676	0.972	0.176	3.513	3.839	1
There is adequate funding and resources from the government dedicated to greening the TVET sector.	-1.104	138	0.2715	3.396	1.114	-0.104	3.209	3.583	5
Local industries actively collaborate with my TVET institution to update curricula with needed green skills.	1.666	138	0.0981	3.655	1.095	0.155	3.471	3.838	2
There is a strong demand from employers for graduates with certified green skills.	-0.642	138	0.5222	3.439	1.124	-0.061	3.25	3.627	6

Cronbach's Alpha = 0.853; 95% CI [0.804, 0.888]   The number of items is six, indicating good internal consistency.

Table 4 presents the results on institutional, policy, and industry-level factors influencing Ghana's TVET sector's capacity to advance green skills development. The findings reveal a prominent level of policy awareness among respondents (M = 3.68, p = .034), reflecting Ghana's alignment with sustainability frameworks such as the Energy Transition Framework. This indicates that the policy discourse on green skills has gained substantial traction within the TVET ecosystem. However, persistent concerns regarding inadequate funding (M = 3.39) and limited industry collaboration (M = 3.65, p = .098) point to structural weaknesses that constrain policy translation into practice. Taken together, these results highlight a paradox of institutional readiness coexisting with weak implementation capacity, both structurally and financially.

This observation resonates with Busemeyer et al. (2025), who contend that institutional architecture critically mediates the extent to which green skill formation contributes to broader economic and environmental objectives. The CTVET (2025) report corroborates this view, emphasizing that Ghana's green transition efforts remain hampered by resource deficits and uneven institutional engagement across sectors. Similarly, Chola and Kiplagat (2025) as well as Ahmadu and Orisaremi (2025) underscore that robust intersectoral cooperation and sustained investment are indispensable for transforming TVET systems into effective vehicles for sustainable development.

The limited collaboration between industry and TVET institutions observed in this study further validates Joseph et al. (2025)'s argument that strategic private-sector partnerships are essential to future-proof green skills ecosystems, particularly in the Global South. Industry engagement not only enhances curriculum relevance but also facilitates technology transfer, innovation, and work-based learning opportunities, which are key enablers for a resilient green economy.

Overall, the findings suggest that while Ghana's TVET sector demonstrates commendable policy consciousness and institutional commitment toward sustainability, systemic barriers, especially financial constraints, and weak industry linkages, continue to inhibit its transformative potential. Strengthening governance coordination, enhancing resource mobilization, and fostering multi-stakeholder partnerships are therefore critical steps towards operationalizing a coherent, industry-responsive green skills agenda capable of supporting Ghana's sustainable development trajectory.

6.5 Acquisition of Green Skills Through TVET Contributes to Employability, Decent Work Opportunities, and Economic Growth in Ghana

Table 5. One-Sample Test: Test Value = 3.5

ITEM	t	df	Sig. (2-tailed)	Mean	Std. Deviation	Mean Difference	95% CI Lower	95% CI Upper	Rank
Possessing green skills makes a TVET graduate more attractive to employers in Ghana.	0.45	138	0.6537	3.54	1.037	0.04	3.366	3.714	3
Jobs requiring green skills offer better wages and working conditions (decent work).	0.039	138	0.9687	3.504	1.079	0.004	3.323	3.685	4
Green skills are essential for the future of my industry and Ghana's economic growth.	2.228	138	0.0275	3.683	0.971	0.183	3.521	3.846	1
TVET graduates with green skills are better equipped to start their own sustainable businesses (entrepreneurship).	2.516	138	0.013	3.727	1.062	0.227	3.549	3.905	2

The development of a green-skilled workforce is critical for attracting foreign investment in sustainable industries.	-0.038	138	0.97	3.496	1.125	-0.004	3.308	3.685	5

Cronbach's Alpha = 0.838, 95% CI [0.787, 0.875] N of Items = 5. Good internal consistency.

Table 5 presents the empirical results on the interrelationships among green skills, employability, and economic growth. The findings reveal that respondents agreed that the acquisition of green skills enhances employability and entrepreneurship (M = 3.72, p = .013) and serves as a catalyst for Ghana's economic growth (M = 3.68, p = .028). However, perceptions were more neutral regarding the influence of green skills on wage levels and foreign investment attraction (M ≈ 3.50). This suggests that while there is optimism about the relevance of green skills for sustainable employment and innovation, there remains some skepticism about their immediate monetary and investment outcomes.

The respondents' emphasis on employability and entrepreneurship implies that green skills function as an evolving form of human capital that enhances adaptability in emerging sectors of the economy. Yet, the neutral perceptions concerning wages and foreign investment may indicate that the economic returns to green skills are more long-term and contingent upon broader structural reforms and policy alignment.

These findings are consistent with prior research. Ogur (2023) and Alhassan et al. (2024) found that Technical and Vocational Education and Training (TVET) significantly contribute to employability outcomes, although systemic and institutional constraints often limit their multiplier effects on economic growth. Owusu-Agyeman (2025) underscored that microlearning and upskilling in green skills promote just transitions and foster entrepreneurship, reinforcing the respondents' belief in the transformative potential of such skills. Similarly, Thake (2024) associated green skill acquisition with enhanced labour market adaptability, suggesting that Ghana's TVET graduates equipped with sustainability-orientated competencies can better align with the demands of an evolving green economy.

These findings also resonate with the Sustainable Development Goals (SDGs), particularly Goals 4 (Quality Education), 8 (Decent Work and Economic Growth), and 9 (Industry, Innovation, and Infrastructure). By integrating green skills into TVET curricula, Ghana can accelerate progress toward inclusive and sustainable economic transformation. Such integration supports not only environmental stewardship but also enhances industrial competitiveness and social equity, key components of the Green Economy Framework advocated by UNEP and other global agencies (Morley, 2025; UNEP, 2025)

In sum, the evidence reinforces the strategic value of investing in green skills development as a means of strengthening Ghana's human capital base, stimulating entrepreneurship, and preparing the workforce for the transition to low-carbon industries. To maximise the economic returns from such investments, however, complementary policies are required, such as industry partnerships, incentives for green innovation, and labour market reforms to ensure that skill acquisition translates into tangible economic opportunities.

6.6 Important Partnerships for the Future of Green TVET

Table 6. One-Sample Test: Test Value = 3.5

ITEM	t	df	Sig. (2-tailed)	Mean	Std. Deviation	Mean Difference	95% CI Lower	95% CI Upper	Rank
Ministry of Education & Skills Agencies (e.g., COTVET)	1.789	138	0.0758	3.655	1.019	0.155	3.484	3.826	3
Ministry of Environment, Science & Technology	3.974	138	0.0001	3.82	0.95	0.32	3.661	3.979	1
Local Private Companies & Industries	1.814	138	0.0718	3.655	1.005	0.155	3.486	3.823	3
International Development Partners (e.g., GIZ, World Bank)	0.768	138	0.4441	3.568	1.05	0.068	3.392	3.744	5
Renewable Energy & Environmental NGOs	2.707	138	0.0077	3.719	0.956	0.219	3.559	3.88	2

Cronbach's Alpha = 0.84, 95% CI [0.791, 0.877], N of Items = 5. Good internal consistency.

Table 6 presents the results on Important Partnerships for the Future of Green TVET. The data reveal that respondents attached the highest priority to partnerships with the Ministry of Environment (M = 3.82, p < .001) and renewable energy NGOs (M = 3.72, p = .008). This suggests a strong recognition that advancing Green TVET requires cross-sectoral collaboration that extends beyond the traditional boundaries of education ministries. Partnerships with other ministries and local industries also received high ratings (M = 3.65), reflecting a growing appreciation for domestic institutional constructive interaction.

In contrast, international development partners were rated lower (M = 3.57), signalling an underutilisation of global networks and resources despite their potential contributions to sustainable capacity building.

This interpretation aligns with UNESCO-UNEVOC (2020) and ILO (2019), both of which emphasize multi-level and cross-sectoral collaboration spanning governmental, private, and international stakeholders as critical to greening TVET systems. Moreover, comparative evidence from Pachatz et al. (2025) and Tramonti & Dochshanov (2025) demonstrates how countries such as Austria and other European nations have effectively institutionalized sustainability within TVET through integrated partnerships involving public agencies, industry, and civil society organizations.

In this context, the Ghanaian findings reveal both progress and opportunity: while there is clear awareness of the importance of collaborative frameworks, the potential to engage international actors remains untapped. Strengthening ties with global development agencies and sustainability networks could provide not only technical expertise but also access to innovative financing and knowledge exchange mechanisms. Such partnerships would enhance the resilience and global competitiveness of Ghana's Green TVET agenda, facilitating its alignment with the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 13 (Climate Action).

7 Multiple Regression Analysis

Table 7: Results of Multiple Regression Analysis Predicting Green Skills Integration and Contribution to Employability & Economic Growth

Model and Predictor Variables	B	SE	β	t	p-value	R²	Adjusted R²
Model 1: DV = Green Skills Curriculum Integration						0.58	0.56
(Constant)	0.85	0.32		2.66	0.009		
Institutional Infrastructure	0.18	0.07	0.17	2.57	0.011		
Trainer Capacity	0.25	0.06	0.26	4.17	<0.001		
Government Policy Support	0.31	0.06	0.31	5.17	<0.001		
Industry Collaboration	0.22	0.07	0.21	3.14	0.002		

Model and Predictor Variables	B	SE	β	t	p-value	R²	Adjusted R²
Model 2: DV = Contribution to Employability & Economic Growth						0.49	0.47
(Constant)	1.12	0.38		2.95	0.004		
Green Skills Curriculum Integration	0.35	0.08	0.33	4.38	<0.001		
Institutional Infrastructure	0.15	0.07	0.14	2.14	0.034		
Industry Demand for Graduates	0.28	0.08	0.26	3.50	0.001		

Note: DV = Dependent Variable; B = Unstandardized Coefficient; SE = Standard Error; β = Standardized Coefficient.

The multiple regression analysis (Table 7) provides vital quantitative insights into the mechanisms shaping the integration of green skills and their broader impact within Ghana's TVET sector. Results from the two models reveal a coherent predictive relationship: systemic enablers are significantly associated with the incorporation of green skills into the curriculum, which in turn predicts TVET's contribution to employability and economic growth.

7.1 Model 1: Determinants of Green Skills Curriculum Integration

The first regression model ($R^2 = 0.58$) identifies four significant predictors of Green Skills Curriculum Integration, with Government Policy Support emerging as the strongest driver ($\beta = 0.31$, $p < .001$). This underscores that policy frameworks are not merely rhetorical but serve as critical instruments for embedding sustainability into educational content. The result aligns with the prominent level of policy awareness observed in the descriptive findings and resonates with global calls by UNESCO-UNEVOC (2020) and Cedefop (2021), which emphasize that clear and supportive policy directives are foundational for "greening" TVET systems. Trainer Capacity ($\beta = 0.26$, $p < .001$) also exhibited a strong influence, reaffirming that effective policy implementation depends on the skills and readiness of educators. This finding supports Owusu-Agyeman (2025), who identified microlearning and upskilling as key strategies for embedding green skills, and Pachatz et al. (2025), who highlighted the upskilling of trainers as central to Austria's successful green transition in vocational education and training.

In addition, Industry Collaboration ($\beta = 0.21$, $p = .002$) and Institutional Infrastructure ($\beta = 0.17$, $p = .011$) were both significant, though comparatively weaker predictors. This

indicates that the practical realization of green skills depends on tangible resources and active engagement from the private sector. The significance of industry collaboration echoes findings by Joseph et al. (2025), which identified strategic partnerships as vital for futureproofing TVET in the Global South. The lower beta for infrastructure reflects systemic constraints that limit institutional readiness, consistent with Busemeyer et al. (2025), who argued that institutional architecture critically mediates the effectiveness of green skill development.

7.2 Model 2: Pathways to Employability and Economic Growth

The second regression model (R^2 = 0.49) demonstrates that the integration of green skills into the curriculum is the most powerful predictor of TVET's contribution to employability and economic growth (β = 0.33, $p < .001$). This provides robust empirical support that curricular reform serves as a direct lever for improving graduate outcomes and national economic resilience. The finding substantiates the theoretical premise of Human Capital Theory, which posits that investment in relevant, future-orientated skills such as green skills enhance labour productivity and adaptability (Thake, 2024; Ogur, 2023).

The significant influence of industry demand for graduates (β = 0.26, $p = .001$) further reinforces the importance of aligning TVET outputs with labour market needs. When industries actively seek green-skilled professionals, a "pull effect" is created that elevates the value and applicability of TVET training. This aligns with Albertz and Pilz (2025), who argued that synchronizing TVET curricula with green industry demands is essential for sustainable workforce development. Finally, institutional infrastructure retained a smaller yet significant effect (β = 0.14, $p = .034$), suggesting that access to well-equipped facilities continues to enhance the practical proficiency of graduates, thereby strengthening their employability.

7.3 Synthesis and Policy Implications

The regression results highlight how important drivers of educational development are interrelated. The overarching strategic direction is established by government policy, trainer capacity translates this vision into effective classroom practice, industry collaboration aligns training outcomes with labour market demands, and sufficient infrastructure fosters experiential and applied learning. Together, these interdependent components drive the effective integration of green skills, which in turn catalyze employability and economic growth. This study advances discourse by establishing significant predictive relationships linking systemic enablers, green skills integration, and economic outcomes, providing an empirical foundation for understanding how these factors are associated. It demonstrates that conceptual alignment must be matched with coordinated action across all pillars to overcome operational constraints. As Chola and Kiplagat (2025) and Ahmadu and Orisaremi (2025) contended, fragmented or isolated interventions are unlikely to succeed; what is required is a coherent, multi-stakeholder strategy.

For Ghana, this implies that ongoing policy initiatives led by CTVET (2025) should be reinforced through large-scale professional development programmed for trainers, incentivized industry partnerships, and targeted investments in modernizing TVET infrastructure. Only through such a holistic and collaborative approach can Ghana unlock the full potential of its TVET system as an engine for sustainable and inclusive economic transformation.

8. Limitations of the Study

While this study offers valuable insights into the role of TVET in green skills development in Ghana, its findings should be interpreted considering several methodological limitations.

First, the cross-sectional design provides a snapshot of relationships and perceptions at a single point in time. Consequently, it establishes correlation but cannot definitively determine causality between the identified enablers (e.g., policy support, trainer capacity) and the outcomes of green skills integration and employability.

Second, the data are based on self-reported measures from a survey. This approach is susceptible to social desirability bias, where respondents may provide answers, they believe are socially acceptable rather than reflecting their true perceptions. Additionally, the perceptual nature of the data may not always align with objective realities on the ground.

Third, although stratified sampling was employed, the sample representativeness is constrained by the study's scope and sample size (n=139). The views captured, while diverse across key stakeholder groups, may not be fully generalizable to the entire TVET ecosystem in Ghana, particularly for remote or under-represented institutions.

Finally, the study suffers from a lack of longitudinal tracking. It does not assess the long-term impact of green skills on graduates' career trajectories, wage progression, or their sustained contribution to the green economy. A longitudinal study would be required to capture these dynamic effects and the true return on investment in green TVET.

Future research would benefit from addressing these limitations by employing longitudinal designs, triangulating self-reports with observational or administrative data, and expanding the sampling frame to enhance generalizability.

9. Conclusion

This study provides robust empirical evidence that Technical and Vocational Education and Training (TVET) is a critical lever for green skills development and sustainable economic growth in Ghana. By quantitatively establishing the significant predictive associations between government policy, trainer competence, institutional infrastructure, and industry collaboration with green skills integration, this research moves beyond theoretical advocacy to offer an empirically-supported framework for understanding green skills development. The findings demonstrate that a synergistic approach where strategic policy is operationalized by skilled trainers, reinforced by industry partnerships, and supported by adequate infrastructure is indispensable for cultivating a workforce capable of driving Ghana's green transition.

The study makes a distinct contribution by bridging a critical gap in the literature, offering a systemic analysis of how institutional, policy, and industrial mechanisms collectively shape green skills outcomes in a sub-Saharan African context. It confirms that Ghana's TVET sector possesses the policy awareness and institutional readiness to advance sustainability. However, it also uncovers the persistent structural barriers of inadequate funding, weak industry engagement, and gender disparities that threaten to derail this progress. Addressing these challenges is not merely an educational imperative but an economic necessity for achieving a just and inclusive transition.

The implications for national strategy are profound. For Ghana to realize its green economy aspirations, TVET must be positioned at the centre of its human capital development agenda. This requires:

- **Policy Coherence:** Transforming high-level policy awareness into actionable, funded implementation plans.

- **Ecosystem Development:** Fostering deep, incentivized collaboration between TVET institutions, industry, and environmental agencies to ensure curriculum relevance and graduate employability.

- **Inclusive Capacity Building:** Implementing targeted interventions to bridge the gender gap and empower women as leaders in green technical fields.

This study, by its cross-sectional nature and reliance on perceptual data, presents a snapshot in time. Future research should adopt longitudinal designs to track the long-term socio-economic returns on green skills investments and utilise mixed methods to explore the nuanced barriers and success factors at the institutional level. Furthermore, investigating the role of digital technologies in scaling green TVET delivery presents a promising avenue for inquiry.

In sum, this research affirms that a revitalized, green-focused TVET system is not just an educational asset but a cornerstone of national resilience and competitiveness. By heeding the evidence presented here, policymakers, educators, and industry leaders can collectively forge a pathway where Ghana's human capital becomes its most powerful engine for sustainable, inclusive, and prosperous economic transformation.

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