

# **Bridging the Green Skills Gap in Ghana: Strengthening Agricultural Technical and Vocational Education and Training (ATVET) for Climate-Smart Innovation and Employability.**

**Dr. Ishak Shaibu, Kwadaso Agricultural College, Kumasi, Ghana**

## **Abstract**

Ghana's agricultural sector is undergoing structural transformation driven by climate change, technological innovation, and evolving market demands. Agricultural Technical and Vocational Education and Training (ATVET) institutions are expected to produce a workforce capable of supporting climate-smart, digitally enabled, and market-oriented agrifood systems. However, growing concerns persist regarding misalignment between training outputs and labour market needs. This study examines the green skills gap within Ghana's ATVET ecosystem using data from a Labour Market Needs Assessment (LMNA) survey conducted among 58 agricultural stakeholders, complemented by qualitative insights from sector actors.

Findings reveal that while ATVET graduates are perceived as motivated and moderately innovative, significant deficiencies exist in soft skills, digital competencies, climate-smart agriculture (CSA) knowledge, and structured workplace readiness. A substantial majority of respondents indicate that curricula require urgent amendment to integrate CSA principles, digital agriculture tools, and practical experiential learning. Employers emphasize the importance of communication skills, professional work ethics, pest and disease management, soil science, post-harvest handling, mechanization, and business development competencies. The study also identifies weak industry-institution linkages and underdeveloped digital recruitment systems as structural barriers to graduate employability.

Grounded in competency-based education and green economy frameworks, the paper argues that bridging Ghana's green skills gap requires comprehensive reform across curriculum redesign, pedagogical transformation, digital integration, industry partnerships, and governance coordination. ATVET modernization is positioned as a strategic pathway toward climate resilience, inclusive youth employment, and sustainable agricultural transformation.

**Keywords:** *Green skills, ATVET, climate-smart agriculture, digital agriculture, employability, Ghana, TVET reform.*

## 1. Introduction

Agriculture remains a cornerstone of Ghana's economy, contributing significantly to employment, rural livelihoods, food security, and national GDP. Yet the sector is undergoing rapid transformation driven by climate variability, technological innovation, market integration, and evolving sustainability standards. Rising temperatures, erratic rainfall patterns, soil degradation, and increasing pest and disease pressures are reshaping production systems, while digital technologies, mechanization, data-driven decision-making, and value-chain integration are redefining agribusiness operations. These structural shifts demand a workforce equipped not only with traditional agricultural knowledge but also with climate-smart, digital, entrepreneurial, and adaptive competencies.

Agricultural Technical and Vocational Education and Training (ATVET) institutions occupy a strategic position within this transformation process. As primary providers of mid-level agricultural skills, ATVET systems are expected to produce graduates capable of driving productivity, resilience, and innovation across the agrifood value chain. Globally, Technical and Vocational Education and Training (TVET) has been recognized as a critical enabler of green transitions, particularly in sectors such as agriculture that are highly vulnerable to climate change (ILO, 2019; UNESCO-UNEVOC, 2023). In this context, green skills refer to the knowledge, technical abilities, values, and attitudes required to promote sustainable production, climate adaptation, resource efficiency, and environmentally responsible economic activity.

In Ghana, policy frameworks such as the Climate-Smart Agriculture Investment Plan (CSAIP) and broader agricultural modernization strategies emphasize capacity building and workforce readiness as central pillars for achieving sustainable agricultural transformation (World Bank, 2020). However, persistent skills mismatches between training outputs and labour market demands undermine these ambitions. Employers increasingly report gaps in soft skills, digital competence, climate-smart agriculture knowledge, and practical workplace readiness among graduates of vocational and agricultural training institutions. These deficiencies constrain employability, productivity, and sector competitiveness.

Although reforms such as Competency-Based Training (CBT) have been introduced to improve alignment between education and industry, implementation challenges remain. Curricula in many ATVET institutions continue to emphasize theoretical instruction over experiential learning. Industry linkages are often informal or inconsistent, and structured mechanisms for employer feedback into curriculum design are limited. Furthermore, digital transformation within agriculture is advancing more rapidly than training systems can adapt, creating a widening gap between technological adoption in industry and instructional practices within institutions.

The concept of a "green skills gap" provides a useful analytical lens for understanding these dynamics. A green skills gap arises when the competencies required to support sustainable and climate-resilient economic activities exceed the capabilities produced by existing education and training systems. In agriculture, this gap manifests through insufficient knowledge of climate-smart practices, limited proficiency in digital and precision technologies, weak agribusiness and financial management skills, and inadequate socio-behavioral competencies such as communication, teamwork, and leadership.

Despite growing international literature on green skills and TVET reform, empirical evidence from Ghana's ATVET sector remains limited. There is a need for systematic labour market analysis that captures employer expectations, recruitment patterns, competency priorities, and perceptions of graduate preparedness. Without such evidence, curriculum reform risks being policy-driven rather than market-responsive.

This paper addresses this gap by analyzing data from a Labour Market Needs Assessment (LMNA) conducted among key agricultural stakeholders in Ghana under the CB VET Ghana project. Using a mixed-methods approach, the study examines employer perceptions of ATVET graduates, identifies critical skills deficiencies, and evaluates alignment between current curricula and emerging industry demands. Particular attention is given to climate-smart agriculture, digital competencies, soft skills, practical training structures, and industry–institution linkages.

The study seeks to answer the following research questions:

1. What are the dominant green and employability skills gaps identified by agricultural stakeholders?
2. To what extent do current ATVET curricula align with climate-smart and digital transformation needs?
3. What structural reforms are required to enhance graduate employability and sector competitiveness?
4. How can ATVET institutions contribute more effectively to Ghana's green economic transition?

By situating empirical findings within green economy, human capital, and competency-based education frameworks, this paper contributes to ongoing discourse on workforce transformation in Sub-Saharan Africa. It argues that bridging Ghana's green skills gap requires comprehensive reform across curriculum design, pedagogy, industry partnerships, digital systems, and governance structures. ATVET modernization is not merely an educational reform agenda, but a strategic pathway toward climate resilience, inclusive employment generation, and sustainable agricultural development.

## **2. Literature Review**

### **2.1 Green Skills and Technical and Vocational Education and Training (TVET)**

The global transition toward environmentally sustainable and climate-resilient economies has elevated the importance of green skills within education and workforce development systems. Green skills broadly refer to the knowledge, technical competencies, values, and attitudes required to support environmentally sustainable economic activities, reduce environmental impact, and adapt production systems to climate change (International Labour Organization [ILO], 2019; UNESCO-UNEVOC, 2023). These skills encompass both technical competencies—such as energy efficiency, resource management, and sustainable production—and socio-behavioral competencies, including environmental awareness, innovation, and adaptive problem-solving.

Technical and Vocational Education and Training (TVET) systems are increasingly recognized as key institutional mechanisms for developing green skills because of their direct alignment with labour market needs and occupational training frameworks. TVET institutions play a crucial role in preparing workers for emerging green jobs and supporting economic transitions toward sustainability (UNESCO, 2020). The concept of “greening TVET” involves integrating sustainability principles across curricula, teaching methodologies, institutional management practices, and partnerships with industry (UNESCO-UNEVOC, 2023).

In agriculture, the need for green skills is particularly pronounced. Agricultural production systems are highly sensitive to climate variability and environmental degradation, making sustainability-oriented competencies essential for maintaining productivity and ecological balance. Climate-smart agriculture (CSA), which integrates productivity, resilience, and climate mitigation objectives, requires farmers and agricultural professionals to possess skills in soil conservation, water management, agroforestry, climate risk management, and sustainable input use (Food and Agriculture Organization [FAO], 2018). These competencies enable agricultural actors to respond effectively to climate challenges while ensuring long-term food security.

However, integrating green skills into vocational training systems remains challenging in many developing countries. Studies show that TVET institutions often struggle with outdated curricula, limited infrastructure for practical training, and insufficient instructor capacity to deliver sustainability-oriented instruction (ILO, 2019). As a result, graduates may lack the applied competencies necessary to implement climate-resilient agricultural practices.

For Agricultural Technical and Vocational Education and Training (ATVET) systems, embedding green skills is particularly important because agriculture remains a primary source of employment and livelihoods in many developing countries. Aligning ATVET curricula with climate-smart agriculture and sustainable value-chain development can enhance agricultural productivity, environmental sustainability, and rural employment opportunities (World Bank, 2020). Therefore, strengthening green skills within ATVET systems is increasingly viewed as a critical strategy for achieving both agricultural transformation and sustainable development objectives. Thus, green skills in ATVET are not peripheral additions; they represent a structural realignment of agricultural training toward sustainability-driven labour market demands.

## **2.2 Evolution of TVET and ATVET in Ghana**

Ghana's TVET system evolved from pre-colonial apprenticeship traditions to formalized institutional structures shaped by colonial technical education models (Cobblah & Addy, 2017). Post-independence reforms emphasized vocational education as a mechanism for industrial and agricultural modernization (Boateng, 2012).

The establishment of the then Council for Technical and Vocational Education and Training (COTVET) and subsequently the Commission for TVET (CTVET) sought to harmonize standards, improve quality assurance, and strengthen industry alignment (GoG, 2016). Competency-Based Training (CBT) was introduced to enhance practical learning and employability outcomes (UNESCO, 2020).

Despite these reforms, persistent mismatches between graduate competencies and employer expectations remain widely documented in Ghana (Owusu-Agyeman & Aryeh-Adjei, 2023). Agricultural TVET (ATVET), in particular, faces challenges of outdated curricula, insufficient practical exposure, and weak private-sector engagement (World Bank, 2020).

The African Union's ATVET Strategy further emphasizes that agricultural modernization requires strengthened vocational systems capable of delivering entrepreneurial, climate-responsive, and innovation-oriented graduates (AUDA-NEPAD, 2014).

Thus, while Ghana has institutionalized TVET reforms, systemic gaps persist in aligning ATVET with contemporary green economy needs.

## **2.3 The Climate-Smart Agriculture Imperative**

Climate-smart agriculture (CSA) integrates productivity, adaptation, and mitigation objectives within agricultural systems (FAO, 2018). Ghana's Climate-Smart Agriculture Investment Plan (CSAIP) identifies workforce capacity development as a central pillar for scaling CSA interventions nationwide (World Bank, 2020).

CSA competencies include water harvesting and irrigation efficiency, soil fertility management, composting, agroforestry, protected cultivation systems, risk management, and climate-resilient crop and livestock systems (FAO, 2018). However, empirical assessments across Sub-Saharan Africa reveal that vocational graduates often lack applied CSA skills due to limited demonstration facilities and insufficient curriculum integration (World Bank, 2020).

Without embedding CSA into ATVET curricula, agricultural transformation risks being technologically aspirational but operationally underprepared. Therefore, green skill integration must prioritize practical, field-based CSA instruction aligned with national policy frameworks.

## **2.4 Soft Skills and Employability in Agricultural Labour Markets**

Employers globally identify soft skills — communication, teamwork, problem-solving, adaptability, leadership, and work ethics — as critical determinants of workplace success (World Economic Forum [WEF], 2020). In agribusiness contexts, soft skills influence client engagement, cooperative coordination, marketing effectiveness, and innovation capacity (ILO, 2019).

Studies in Ghana consistently report deficiencies in communication, initiative, critical thinking, and professional conduct among TVET graduates (Owusu-Agyeman & Aryeh-Adjei, 2023). These gaps reduce graduate employability even where technical competence exists.

Competency-Based Education (CBE) frameworks emphasize holistic competency development, integrating cognitive, technical, and socio-behavioural skills (UNESCO, 2020). Pedagogical shifts toward learner-centred methodologies, group projects, and workplace simulations have been shown to significantly improve soft skill acquisition (ILO, 2019).

Thus, strengthening ATVET requires systematic integration of structured soft skills modules with measurable performance indicators.

## **2.5 Digitalisation and the Future of Work in Agriculture**

Agriculture is undergoing a profound transformation driven by the integration of digital technologies, data analytics, and automation. This transformation—often referred to as digital agriculture, smart farming, or Agriculture 4.0—incorporates advanced technologies such as remote sensing, geographic information systems (GIS), drones, artificial intelligence, and mobile advisory platforms into agricultural production and management systems (World Bank, 2019; Rijswijk et al., 2021).

Digital technologies have the potential to significantly improve agricultural productivity and efficiency by enabling more precise management of agricultural resources. Precision agriculture technologies allow farmers to monitor crop health, soil conditions, and water availability in real time, facilitating data-driven decision-making that optimizes input use and improves yields (Rijswijk et al., 2021). By reducing waste and improving resource efficiency, digital agriculture can contribute to both economic and environmental sustainability.

Beyond farm-level production, digital transformation is also reshaping agricultural value chains by improving market access, financial inclusion, and information flows. Mobile platforms and digital marketplaces provide farmers with access to market prices, weather forecasts, and agronomic advice, enabling better production planning and risk management (World Bank, 2019). These technologies also facilitate access to digital financial services, such as mobile payments and agricultural insurance, which can improve resilience among smallholder farmers.

In Sub-Saharan Africa, digital agriculture holds significant potential to address structural challenges such as low productivity, limited extension services, and restricted market access. Mobile-based agricultural advisory systems and digital extension platforms have demonstrated the capacity to improve knowledge dissemination and decision-making among smallholder farmers (Ayim et al., 2020). However, the adoption of digital technologies in agriculture remains uneven due to infrastructure limitations, inadequate digital literacy, and insufficient institutional support.

A critical barrier to digital agricultural transformation is the lack of workforce competencies required to operate modern agricultural technologies. Many agricultural training systems have yet to incorporate digital skills into their curricula, resulting in a mismatch between technological advancements in agriculture and the skills possessed by agricultural workers

(World Bank, 2019). Consequently, ATVET institutions must adapt their training programs to incorporate digital literacy, data management, precision agriculture technologies, and digital marketing competencies.

By integrating digital agriculture into vocational training curricula, ATVET systems can play a crucial role in preparing the next generation of agricultural professionals for technology-driven agrifood systems.

## **2.6 Competency-Based Education and Pedagogical Reform**

Competency-Based Education (CBE) emphasizes demonstrable learning outcomes aligned with occupational standards (UNESCO, 2020). Unlike traditional time-based models, CBE assesses learners based on practical demonstration of skills in real or simulated work environments (ILO, 2019).

Research indicates that CBE improves alignment between training outputs and employer expectations when curricula are co-designed with industry partners (UNESCO-UNEVOC, 2023). However, effective CBE implementation requires teacher upskilling, assessment reform, and infrastructure support (ILO, 2019).

In many African contexts, CBE adoption has been hindered by insufficient trainer preparation and limited resources for practical assessment (World Bank, 2020). Therefore, pedagogical reform must accompany curriculum redesign to ensure meaningful competency development.

## **2.7 Industry–Education Linkages and the Triple Helix Model**

The “triple helix” model conceptualizes innovation as emerging from structured collaboration among academia, industry, and government (Etzkowitz & Leydesdorff, 2000). Within TVET systems, strong employer partnerships enhance curriculum relevance, apprenticeship quality, and graduate placement rates (ILO, 2019).

Evidence from African vocational systems demonstrates that structured industry attachments significantly improve employability outcomes (World Bank, 2020). Yet weak coordination, informal placements, and lack of standardized mentorship frameworks undermine attachment effectiveness in many contexts (Owusu-Agyeman & Aryeh-Adjei, 2023).

Institutionalized advisory boards, formal apprenticeship agreements, and co-supervised assessments are recommended mechanisms for strengthening ATVET-industry collaboration (UNESCO-UNEVOC, 2023).

Thus, sustainable ATVET reform requires systemic governance arrangements that embed industry participation in curriculum design and assessment.

## **2.8 Labour Market Intermediation and Career Systems**

Effective labour market intermediation enhances job matching, reduces recruitment friction, and increases graduate visibility (ILO, 2019). However, informal recruitment networks dominate agricultural labour markets in many developing contexts (World Bank, 2019).

Digital job-matching platforms and alumni tracking systems have been shown to improve institutional placement outcomes by formalizing employer engagement channels (IFC, 2019). Career development centres within TVET institutions strengthen employability readiness through counselling, job fairs, and employer networking events (UNESCO-UNEVOC, 2023).

Therefore, ATVET systems must integrate structured career services and digital recruitment infrastructure to improve graduate transition into employment.

## **2.9 Infrastructure Constraints and Practical Learning Environments**

Practical learning is central to vocational effectiveness (UNESCO, 2020). In agricultural education, demonstration farms, mechanization labs, irrigation systems, greenhouses, and post-harvest units provide experiential learning environments necessary for competency mastery (FAO, 2018).

Ghana's CSAIP identifies infrastructure and equipment deficits as major barriers to scaling climate-smart practices (World Bank, 2020). Without adequate training facilities, learners cannot internalize CSA techniques or digital agriculture tools.

Investment in training infrastructure is therefore not supplementary but foundational to green skill acquisition.

## **2.10 Skills Mismatch in Sub-Saharan Africa**

Skills mismatch—the discrepancy between the competencies possessed by workers and those required by employers—has become a persistent challenge across labour markets in Sub-Saharan Africa. Despite high levels of youth unemployment, many employers report difficulties in finding workers with the appropriate skills needed for modern economic sectors (World Economic Forum, 2020).

One of the primary causes of skills mismatch is the disconnect between education systems and labour market needs. Traditional education systems often emphasize theoretical knowledge while neglecting practical and industry-relevant competencies (ILO, 2019). As a result, graduates frequently enter the labour market without the skills required to perform effectively in professional environments.

Employers consistently report deficiencies in both technical and socio-behavioral skills among graduates of vocational and higher education institutions. Soft skills such as communication, teamwork, problem-solving, leadership, and adaptability are increasingly recognized as critical determinants of employability in modern labour markets (World Economic Forum, 2020). These competencies enable workers to navigate complex workplace environments and adapt to rapidly evolving technological and organizational contexts.

In the agricultural sector, skills mismatches are further exacerbated by rapid technological changes and evolving market structures. Advances in mechanization, digital agriculture, and climate-smart practices require new competencies that many training systems have yet to integrate into their curricula (World Bank, 2019). Consequently, employers often report shortages of workers capable of managing modern agricultural equipment, applying climate-resilient production techniques, or operating agribusiness enterprises effectively.

Addressing skills mismatch requires systemic reforms that strengthen the alignment between education systems and labour market demands. Competency-based education and training (CBET) models have been widely promoted as effective mechanisms for improving the relevance of vocational education by focusing on demonstrable skills aligned with occupational standards (UNESCO, 2020). In addition, stronger industry partnerships, workplace learning opportunities, and labour market intelligence systems can help ensure that training programs remain responsive to evolving economic needs.

## **2.11 Agricultural Technical and Vocational Education and Training (ATVET) Systems**

Agricultural Technical and Vocational Education and Training (ATVET) systems are central to building the skilled workforce required to support agricultural transformation and rural development. ATVET institutions provide practical training in agricultural production, agribusiness management, and rural entrepreneurship, thereby contributing to employment generation, food security, and economic growth (AUDA-NEPAD, 2014).

Historically, many agricultural training institutions in Africa focused primarily on traditional farming techniques and technical production skills. However, modern agricultural systems require a broader range of competencies that extend beyond production to include value chain development, agribusiness management, digital technologies, and climate adaptation (World Bank, 2020).

Regional policy frameworks such as the African Union's ATVET Strategy emphasize the need to modernize agricultural training systems to support youth employment and agricultural transformation (AUDA-NEPAD, 2014). These frameworks advocate for competency-based training approaches, stronger engagement with private sector actors, and the integration of modern agricultural technologies into training curricula.

Despite these policy initiatives, ATVET systems across Sub-Saharan Africa continue to face several structural challenges. These include outdated curricula, inadequate training infrastructure, limited funding, and weak linkages with industry. In many institutions, training farms and laboratories lack modern equipment, limiting opportunities for experiential learning and practical skill development.

Strengthening collaboration between ATVET institutions and agribusiness firms is therefore essential for improving curriculum relevance and graduate employability. Industry partnerships can facilitate internships, apprenticeship programs, and collaborative curriculum development, ensuring that training programs reflect real labour market demands (ILO, 2019).

Furthermore, the integration of climate-smart agriculture, digital technologies, and entrepreneurship training into ATVET curricula is increasingly recognized as essential for preparing agricultural professionals capable of driving sustainable agricultural transformation (FAO, 2018; World Bank, 2020). By equipping graduates with both technical and entrepreneurial competencies, ATVET systems can contribute to the development of resilient agrifood systems and inclusive rural economies.

### **3. Methodology**

#### **3.1 Research Design**

This study adopted a convergent parallel mixed-methods design, integrating quantitative and qualitative data to examine green skills gaps within Ghana’s Agricultural Technical and Vocational Education and Training (ATVET) system. The mixed-methods approach enabled triangulation of employer survey data with qualitative insights from key stakeholders to provide a comprehensive understanding of curriculum misalignment, employability challenges, and institutional reform needs (Creswell & Plano Clark, 2018).

Quantitative data were collected through a structured Labour Market Needs Assessment (LMNA) survey administered digitally, while qualitative data were generated through Focus Group Discussions (FGDs). Both datasets were analyzed separately and subsequently integrated during interpretation to ensure complementarity and convergence of findings.

#### **3.2 Study Population and Sampling**

##### **3.2.1 Target Population**

The study targeted:

- Private agribusiness firms
- Agricultural input suppliers
- Farmer-based organizations
- Public agricultural institutions
- NGOs operating in agrifood systems
- ATVET instructors and administrators
- Extension agents

These stakeholders were selected due to their direct engagement with ATVET graduates and their understanding of labour market skill requirements.

##### **3.2.2 Sampling Strategy**

A purposive sampling strategy was employed to ensure participation of stakeholders with demonstrated experience in recruitment, supervision, or collaboration with ATVET graduates.

For the LMNA survey, respondents were drawn from agribusinesses operating across production, processing, marketing, mechanization, and climate-smart agriculture domains.

For the qualitative component, FGD participants were selected to represent academia, industry, government agencies, and farmer organizations to reflect the “triple helix” ecosystem relevant to ATVET reform.

### **3.3 Quantitative Data Collection Using KoboToolbox**

#### **3.3.1 Instrument Development**

The LMNA survey instrument was developed based on:

- Competency-Based Education (CBE) frameworks
- Green skills and climate-smart agriculture competency standards
- Digital skills assessment frameworks
- Employer engagement and recruitment models

The questionnaire consisted of both closed-ended and Likert-scale items covering:

- Assessment of graduate soft skills
- Technical and climate-smart competencies
- Digital and ICT proficiency
- Recruitment practices
- Curriculum relevance
- Industry-ATVET collaboration
- Recommendations for reform

The tool was pre-tested with a small group of employers to ensure clarity, content validity, and relevance.

#### **3.3.2 Digital Administration via KoboToolbox**

Data were collected using KoboToolbox, an open-source digital data collection platform suitable for field-based research in low-resource contexts. The KoboToolbox enabled:

- Mobile-based survey administration
- Real-time data capture
- Automated skip logic
- Reduced data entry errors
- Immediate database generation

Respondents completed the survey electronically via shared survey links or enumerator-assisted mobile devices.

#### **3.3.3 Quantitative Data Management and Analysis**

Survey responses were exported from KoboToolbox into Excel and SPSS (or similar statistical software) for analysis.

The following analytical procedures were conducted:

- Descriptive statistics (frequencies, percentages, means)
- Cross-tabulation to examine relationships between employer type and reported skill gaps
- Gap severity ranking using Likert-scale aggregation
- Thematic grouping of open-ended quantitative responses

Results were presented using percentage distributions and comparative skill gap rankings to highlight dominant employability deficiencies.

Data cleaning included validation checks, removal of incomplete entries, and consistency verification prior to analysis.

### **3.4 Qualitative Data Collection: Focus Group Discussion (FGD)**

#### **3.4.1 FGD Design**

A FGD was conducted to deepen understanding of quantitative findings and explore contextual factors influencing skill gaps. A semi-structured discussion guide was developed covering:

- Perceived graduate skill deficiencies
- Curriculum limitations
- Practical training constraints
- Industry partnership challenges
- Climate-smart agriculture integration
- Digital transition readiness
- Policy and institutional reform recommendations

The FGD included 10 participants selected from representatives of industry, academia (staff, current students and past/graduates of the Agricultural TVET institutions), Ministry of Food and Agriculture (MOFA) and the Chamber of Agribusiness Ghana (CAG). The FGD lasted approximately 90–120 minutes.

### **3.5 Qualitative Data Analysis**

#### **3.5.1 Analytical Approach**

The qualitative data were analyzed using Thematic Analysis, following Braun and Clarke's (2006) six-step framework:

1. Familiarization with the data (transcription review and repeated reading)
2. Initial code generation
3. Searching for patterns and theme development
4. Reviewing themes
5. Defining and naming themes
6. Producing the analytical narrative

Transcripts were coded using the qualitative software, NVivo. Codes were generated both deductively (based on survey domains such as soft skills, CSA, ICT, industry linkages) and inductively (emerging themes from participant discourse).

#### **3.5.2 Coding Framework**

The coding structure included major categories such as:

- Soft skills deficiencies
- Technical competency gaps

- Climate-smart knowledge limitations
- Digital and ICT gaps
- Practical exposure challenges
- Recruitment inefficiencies
- Institutional governance weaknesses

Sub-themes were developed under each major category to refine the analysis.

### **3.5.3 Trustworthiness and Rigor**

To enhance qualitative validity:

- Data triangulation was employed (survey + FGD convergence).
- Member validation was conducted where feasible by sharing summary insights with selected participants.
- Peer debriefing was used to minimize researcher bias.
- An audit trail documented coding decisions and theme refinement.

### **3.6 Integration of Quantitative and Qualitative Data**

Findings from both datasets were integrated during interpretation using triangulation techniques. Convergence between employer survey statistics and FGD narratives strengthened the validity of conclusions.

For example:

- Quantitative findings showing high soft skills deficits were reinforced by qualitative statements describing poor communication and lack of initiative.
- ICT skill gaps identified in survey percentages were validated by FGD concerns about Excel and digital marketing competence.

This integration allowed for a comprehensive and contextualized understanding of Ghana's green skills gap within the ATVET ecosystem.

### **3.7 Ethical Considerations**

Participation was voluntary, and informed consent was obtained prior to data collection. Respondents were assured confidentiality and anonymity. Digital data collected via KoboToolbox were securely stored and password protected. No personally identifiable information was reported in the findings.

## 4. Results

### 4.1 Profile of Respondents

A total of 58 stakeholders participated in the LMNA survey

#### 4.1.1 Stakeholder Categories

Table 1. Stakeholder Distribution (N = 58)

Stakeholder Category	Frequency	Percentage (%)
Farmers	27	46.55
Public Institutions	17	29.31
Agribusiness (Processing, Inputs, Large-scale)	7	12.07
Private Sector Companies	3	5.17
NGOs	2	3.45
Other Institutions	2	3.45

Source: LMNA Survey Data (2024)

Nearly half of respondents (46.6%) were farmers, followed by public institutions (29.3%), indicating strong grassroots and policy-level representation in the dataset

#### 4.1.2 Experience in Agriculture

Over 74% of respondents had more than six years of experience in the agricultural sector

Table 2. Years of Experience in Agriculture

Years of Experience	%
0–5 years	13.79
6–10 years	29.31
11–15 years	17.24
16–20 years	12.07
21+ years	27.59

Source: LMNA Survey Data (2024)

This indicates that responses reflect informed industry perspectives.

### 4.2 Recruitment Practices and Labour Market Linkages

#### 4.2.1 Recruitment Channels

Table 3. Recruitment of ATVET Graduates

Recruitment Method	%
Informal/Other (mostly recommendations)	43.10
Online Applications	29.31
Direct Institutional Partnerships	24.14

Source: LMNA Survey Data (2024)

Informal recruitment dominates (43.1%), while only 24.1% recruit through formal partnerships with ATVET institutions.

Additionally:

- 25.86% *totally disagree* that digital platforms exist to hire ATVET graduates.
- 22.41% are unsure.
- 22.41% mostly disagree

This implies that, there is a structural weakness in digital labour intermediation systems.

### 4.3 Employer Experience with ATVET Graduates

#### 4.3.1 Perceived Strengths

Attribute	% Agreeing
Innovative & adaptable	67.24
Skill-ready workforce	62.07
Highly motivated	58.62

Source: LMNA Survey Data (2024)

Despite notable gaps, employers recognize positive attributes

#### 4.3.2 Soft Skills Gaps

63.79% indicated room for improvement in soft skills (communication, teamwork)

Open-ended responses revealed recurring concerns:

- Lack of communication skills
- Weak leadership and decision-making
- Poor report writing
- Limited initiative
- Weak accountability

This confirms soft skills as a systemic gap.

### 4.4 Climate-Smart Agriculture (CSA) and Curriculum Reform

#### 4.4.1 Need for CSA Curriculum Amendment

Response	%
Completely agree	62.07
Mostly agree	25.86

Source: LMNA Survey Data (2024)

A striking **87.93%** agree that ATVET curricula require serious amendments to address basic climate-smart agriculture practices

#### 4.4.2 Importance of Access to Climate-Smart Knowledge

Importance Level	%
Extremely Important	75.86
Very Important	17.24

Source: LMNA Survey Data (2024)

Over **93%** rate access to climate-smart knowledge as highly important

#### 4.5 Digital and Technological Skills

##### 4.5.1 Technology as a Key External Factor

About 63.79% *completely agree* that technological factors strongly influence the agro industry.

Also, 72.41% completely agree that future workforce will require special technological skills

##### 4.5.2 Importance of Digital Skills

Skill	%	Extremely Important
Digital Skills	63.79	
Smart Farming	67.24	
Research & Data Analysis	68.97	

Source: LMNA Survey Data (2024)

This confirms strong employer demand for digital integration.

#### 4.6 Practical Learning and Experiential Training

##### 4.6.1 Practical Orientation

Statement	% Extremely Important
Combine classroom & farm practicals	84.48
Mentoring & industry attachments	67.24
Industry interaction (guest lectures/visits)	62.07
Incubation/start-up facilities	68.97

Source: LMNA Survey Data (2024)

Employers overwhelmingly prioritize hands-on and experiential learning

## 4.7 Priority Competency Areas

### 4.7.1 Technical Agricultural Skills

Competency	% Extremely Important
Pest & Disease Management	74.14
Soil Science	68.97
Plant Science	68.97
Post-Harvest Handling	68.97
Mechanization	63.79
Food Safety & QA	65.52

Source: LMNA Survey Data (2024)

### 4.7.2 Business & Employability Skills

Competency	% Extremely Important
Professional Work Ethics	72.41
Communication Skills	67.24
Soft Skills	67.24
Farm Management	62.07
Project Management	58.62
Business Development	53.45
Sales & Marketing	51.72

Source: LMNA Survey Data (2024)

## 4.8 Governance, Coordination and Industry Ecosystem

Factor	% Extremely Important
Coordination among agri actors	56.90
Skilled local staff	65.52
Access to Finance	70.69
Policy planning	53.45
Life-long learning	44.83

Source: LMNA Survey Data (2024)

These results highlight systemic reform needs beyond curriculum alone.

## **5. Discussion**

### **5.1 Stakeholder Structure and Sector Representation (Section 4.1)**

The survey demonstrates strong participation from farmers (46.55%) and public institutions (29.31%), alongside agribusiness actors.

This distribution is significant because it reflects a broad cross-section of the agricultural ecosystem rather than a narrow employer-only sample. The dominance of primary producers suggests that the perceived skills gap is grounded in practical production realities rather than purely corporate or policy-level abstractions.

Agricultural transformation literature emphasizes that inclusive stakeholder engagement enhances the reliability of labour market diagnostics (World Bank, 2019). The participation of experienced respondents, thus, over 74% with more than six years in the sector adds credibility to the findings. According to the ILO (2019), employer-informed skills forecasting is most effective when grounded in experienced industry actors, as they better perceive emerging technological and structural shifts.

Thus, the stakeholder composition strengthens the validity of the identified green skills gaps.

### **5.2 Labour Market Linkages and Recruitment Systems (Section 4.2)**

The dominance of informal recruitment channels (43.1%) and limited institutional partnerships (24.14%) reveal structural weaknesses in ATVET-to-labour-market transition systems. Additionally, the absence of readily available digital recruitment platforms (majority disagreement or uncertainty) signals underdeveloped labour intermediation mechanisms.

This aligns with broader African TVET findings, where informal labour market matching reduces transparency, limits access for marginalized youth, and weakens institutional accountability (ILO, 2019). UNESCO-UNEVOC (2023) argues that digital labour platforms and alumni tracking systems significantly improve employability outcomes by formalizing employer engagement.

The implications are systemic:

1. Weak institutional visibility of ATVET graduates.
2. Reduced feedback loops between industry and training institutions.
3. Limited structured industry participation in curriculum design.

Strengthening digital recruitment systems and institutional partnerships is therefore not merely administrative reform but central to improving labour market responsiveness.

### **5.3 Employer Perceptions: Strengths and Soft Skills Gaps (Section 4.3)**

While employers acknowledge that ATVET graduates are innovative (67.24%) and skill-ready (62.07%), 63.79% report notable soft skills deficiencies. Open-ended responses emphasize weaknesses in communication, leadership, initiative, accountability, and report writing.

This duality—technical adequacy but socio-behavioral gaps—is widely documented in vocational education literature. The World Economic Forum (2020) identifies communication, collaboration, and problem-solving as core 21st-century employability skills. Similarly, the ILO (2019) stresses that soft skills are increasingly decisive in technology-driven labour markets where adaptability and teamwork are essential.

The Ghana-specific context further complicates this issue. Studies show that vocational curricula often emphasize technical competencies at the expense of behavioural competencies (Owusu-Agyeman & Aryeh-Adjei, 2023). Competency-Based Education (CBE) models advocate holistic competency integration, yet implementation gaps often persist (UNESCO, 2020).

The LMNA results confirm that soft skills deficits are systemic rather than isolated cases. Therefore, embedding structured soft skills modules, performance-based assessments, and workplace simulations is essential.

#### **5.4 Climate-Smart Agriculture and Curriculum Reform (Section 4.4)**

An overwhelming 87.93% agree that ATVET curricula require amendments to incorporate climate-smart agriculture (CSA), and over 93% rate access to climate-smart knowledge as highly important.

These findings align strongly with Ghana’s Climate-Smart Agriculture Investment Plan (CSAIP), which identifies workforce capacity development as a core pillar for national agricultural resilience (World Bank, 2020). CSA competencies—soil health, water efficiency, agroecology, climate risk mitigation—are foundational for adaptation under climate volatility (FAO, 2018).

The survey demonstrates employer recognition that climate risks are not peripheral but central to sector survival. This corresponds with global evidence that green transitions demand vocational systems capable of operationalizing sustainability strategies (UNESCO-UNEVOC, 2023).

Therefore, CSA integration into ATVET curricula is not optional reform but a national development imperative.

#### **5.5 Digitalization and Technological Readiness (Section 4.5)**

Technological factors are recognized as highly influential in the agro-industry (63.79% completely agree), and 72.41% believe future workforce skills must respond to technological advancement.

This confirms global findings that agriculture is undergoing digital transformation through precision farming, GIS, data analytics, digital marketing, and mechanization technologies (World Bank, 2019). IFC (2019) emphasizes that digital skill gaps in Sub-Saharan Africa constrain productivity gains.

Employers also rate digital skills, smart farming, and research/data analysis as extremely important (over 63%). The implication is clear: ATVET graduates must move beyond basic ICT literacy to applied digital agriculture competencies.

Digital skill integration must therefore include:

- Excel-based farm budgeting
- Data interpretation
- Digital soil mapping
- Mechanization software familiarity
- E-commerce and marketing tools

Without digital integration, ATVET risks producing graduates misaligned with emerging agricultural value chains.

### **5.6 Practical Learning and Experiential Pedagogy (Section 4.6)**

The strongest consensus in the dataset concerns practical learning:

- 84.48% rate combined classroom + farm practical training as extremely important
- 67.24% emphasize mentoring and industry attachments.
- 68.97% support incubation/start-up facilities.

These results validate Competency-Based Training principles, which prioritize observable skill demonstration (UNESCO, 2020). Empirical studies show that structured workplace attachments significantly improve graduate employability (ILO, 2019).

Moreover, experiential learning enhances retention, innovation capacity, and entrepreneurial readiness (Kolb, 1984; FAO, 2018). The strong demand for incubation facilities indicates recognition that ATVET must support not only employment but enterprise creation.

Thus, practical exposure is the cornerstone of green skills acquisition.

### **5.7 Priority Technical and Business Competencies (Section 4.7)**

Employers prioritize:

- Pest & Disease Management (74.14%)
- Soil Science and Plant Science (68.97%)
- Post-Harvest Handling (68.97%)
- Food Safety & Quality Assurance (65.52%)

These competencies reflect value-chain thinking rather than isolated production skills. The emphasis on post-harvest and food safety corresponds with global concerns about food loss reduction and export compliance (FAO, 2018).

Additionally, high importance placed on:

- Professional work ethics (72.41%)
- Communication (67.24%)
- Business development (53.45%)
- Project management (58.62%)

This demonstrates that agribusiness increasingly requires managerial and entrepreneurial capacity, not merely technical execution. This finding aligns with human capital theory, which posits that productivity depends on both technical and organizational skills (Becker, 1993).

### **5.8 Governance, Coordination and System-Level Reform (Section 4.8)**

High importance ratings for:

- Access to finance (70.69%)
- Skilled local staff (65.52%)
- Coordination among actors (56.90%)
- Policy planning (53.45%)

This indicates that skills reform must occur within broader ecosystem strengthening. The “triple helix” framework (Etzkowitz & Leydesdorff, 2000) argues that innovation emerges from structured collaboration among academia, industry, and government. The LMNA results suggest stakeholders perceive systemic interdependence between policy, finance, skills, and coordination. Therefore, ATVET reform must move beyond curriculum redesign toward multi-stakeholder governance models.

## **6. Implications of the Study**

The findings of this study carry important implications for agricultural education reform, workforce development policy, and institutional collaboration within Ghana’s agricultural innovation ecosystem. By identifying critical green skills gaps in the Agricultural Technical and Vocational Education and Training (ATVET) system, the study provides evidence that can inform strategic interventions aimed at strengthening climate-resilient and technology-driven agricultural development.

### **6.1. Policy Implications**

The study highlights the need for policy-level reforms to align agricultural training systems with emerging green economy priorities. Ghana’s agricultural modernization agenda increasingly emphasizes climate-smart agriculture, digital innovation, and value-chain development. However, the evidence from this study indicates that current ATVET curricula do not fully reflect these evolving sectoral needs.

Policymakers therefore need to strengthen the integration of green skills, climate adaptation competencies, and digital agriculture capabilities within national TVET and agricultural education frameworks. This requires closer alignment between ATVET reform initiatives and national strategies such as the Climate-Smart Agriculture Investment Plan (CSAIP), youth employment policies, and agricultural transformation strategies. Policy frameworks should also encourage periodic labour market assessments to ensure that training programs remain responsive to evolving industry demands.

Furthermore, government agencies responsible for TVET governance—such as the Commission for TVET (CTVET)—may need to develop green skills standards and competency frameworks that guide curriculum development across ATVET institutions.

### **6.2. Institutional Implications for ATVET Providers**

The study has significant implications for ATVET institutions themselves. The findings demonstrate that traditional training approaches that emphasize theoretical instruction are insufficient for preparing graduates for modern agricultural labour markets. Institutions must therefore adopt more experiential and competency-based learning approaches.

ATVET providers should prioritize the modernization of training curricula by integrating:

- Climate-smart agriculture practices
- Digital agriculture and precision farming technologies
- Agribusiness and entrepreneurial competencies
- Soft skills such as communication, teamwork, and leadership

In addition, the strong demand for practical training identified in the study suggests that institutions must invest in modern training infrastructure, including demonstration farms, mechanization laboratories, greenhouse systems, and post-harvest technology units. These facilities are essential for enabling students to acquire hands-on skills that align with industry needs.

The study also highlights the importance of career development services within ATVET institutions. Establishing functional Career Development Centres (CDCs) and alumni tracking systems could significantly improve graduate employability by strengthening connections between training institutions and employers.

### **6.3. Implications for Industry and Private Sector Engagement**

The findings indicate that weak industry–education linkages represent a major constraint to improving the relevance of ATVET training. Informal recruitment practices and limited institutional partnerships reduce opportunities for structured collaboration between employers and training institutions.

To address this gap, agribusiness firms and agricultural value-chain actors should be more actively engaged in ATVET governance structures. Industry participation in curriculum design, internship programs, and competency assessments can significantly enhance the relevance of training programs.

Structured partnerships between ATVET institutions and agribusiness enterprises can also support the development of workplace learning systems, including apprenticeships, industrial attachments, and mentorship programs. Such partnerships enable students to acquire practical experience while allowing employers to shape training outcomes according to industry requirements.

### **6.4. Implications for Agricultural Innovation and Sustainability**

By highlighting the importance of climate-smart agriculture competencies and digital agriculture skills, the study underscores the role of ATVET systems in supporting sustainable agricultural transformation. Agricultural innovation increasingly depends on a workforce capable of adopting new technologies, implementing climate-resilient production practices, and managing complex value chains.

Strengthening green skills within ATVET institutions can therefore contribute to broader national objectives, including:

- Climate change adaptation in agricultural systems
- Improved agricultural productivity and food security
- Expansion of agribusiness entrepreneurship
- Increased youth participation in agriculture

In this context, ATVET modernization should be viewed not only as an educational reform but also as a strategic investment in agricultural sustainability and economic resilience.

### **6.5. Implications for Future Research**

The study also reveals several areas where further research is needed. First, while the Labour Market Needs Assessment provides valuable insights into employer perceptions of skills gaps, future studies could expand the evidence base by examining graduate employment outcomes and employer satisfaction levels across different agricultural subsectors.

Second, there is a need for comparative research across different ATVET institutions and regions to better understand how institutional capacity and infrastructure influence training quality and graduate employability.

Third, future research could explore the effectiveness of specific pedagogical interventions, such as digital agriculture training modules, industry-led curriculum development, and agribusiness incubation programs.

Such studies would provide deeper insights into how ATVET systems can be strengthened to support agricultural transformation in Ghana and other Sub-Saharan African countries.

## **7. Recommendations**

The findings clearly indicate that bridging Ghana's green skills gap requires systemic, multi-level reform rather than isolated curriculum adjustments. Based on the evidence, the following recommendations are proposed:

### **7.1. Curriculum Modernization**

ATVET curricula should be comprehensively revised to integrate:

- Climate-Smart Agriculture (CSA) as a core competency.
- Digital agriculture and applied ICT skills.
- Structured soft skills development (communication, leadership, teamwork).
- Agribusiness management, entrepreneurship, and financial literacy.

Green and digital competencies must become mandatory rather than optional components of training.

### **7.2. Strengthening Experiential Learning**

Institutions should:

- Expand practical training through upgraded training farms and demonstration units
- Institutionalize structured industry attachments with standardized assessment
- Establish agribusiness incubation hubs to support student entrepreneurship

Competency-based education must be fully operationalized through hands-on learning.

### **7.3. Digital and Labour Market Intermediation Reform**

To address weak recruitment systems:

- Develop digital job-matching and alumni tracking platforms
- Establish functional Career Development Centres (CDCs)
- Organize structured employer engagement and career fairs

Formalized labour intermediation will enhance graduate visibility and employer feedback loops.

### **7.4. Strengthening Industry Partnerships**

- Formalize Memoranda of Understanding (MoUs) with agribusiness firms
- Establish advisory boards with industry representation
- Co-design curricula with private-sector input

Sustained industry engagement is essential for curriculum relevance.

### **7.5. Instructor Capacity Development**

- Provide continuous professional development (CPD) in CSA, digital agriculture, and competency-based assessment
- Facilitate industry exposure for instructors

Instructor upgrading is critical for effective reform implementation.

### **7.6. Governance and Ecosystem Coordination**

- Establish a multi-stakeholder Green Skills Advisory Platform (academia–industry–government)
- Align ATVET reform with national climate and agricultural policies
- Integrate workforce planning into broader agricultural development strategies

Reform must be system-wide, not institutionally isolated.

### **7.7. Policy Support and Investment**

- Increase funding for practical infrastructure and digital equipment
- Support incubation financing mechanisms
- Introduce performance-based funding linked to graduate employment outcomes
- Conduct periodic labour market assessments to monitor progress

Sustained public and development partner investment is necessary for long-term impact.

## 8. Conclusion

This study set out to examine the green skills gap within Ghana's Agricultural Technical and Vocational Education and Training (ATVET) system and to assess the extent to which current training structures align with evolving labour market demands, particularly in the context of climate change, digital transformation, and agribusiness modernization. Drawing on Labour Market Needs Assessment (LMNA) survey data and supported by contemporary literature on green skills, competency-based education, and workforce transformation, the findings reveal a systemic misalignment between graduate competencies and employer expectations.

The evidence demonstrates that while ATVET graduates are perceived as motivated and moderately technically competent, significant deficiencies persist in soft skills, digital literacy, climate-smart agriculture (CSA) knowledge, and structured workplace readiness. Employers overwhelmingly emphasize the importance of communication, problem-solving, professional work ethics, project management, and business development skills. At the same time, technological shifts within agriculture—ranging from smart farming systems to digital record-keeping and mechanization—are redefining occupational standards. The demand for advanced digital and data-related competencies confirms that agriculture is no longer labour-intensive alone but increasingly knowledge- and technology-driven.

Climate-smart agriculture emerged as a critical reform priority. The strong consensus that curricula require urgent amendment to incorporate CSA principles indicates recognition that agricultural resilience and sustainability depend fundamentally on workforce capability. Given Ghana's commitments under its Climate-Smart Agriculture Investment Plan (CSAIP) and Nationally Determined Contributions (NDCs), workforce reform becomes not merely an educational adjustment but a national climate adaptation strategy.

The study further identifies structural weaknesses in labour market intermediation. Informal recruitment dominates, digital job-matching platforms are underdeveloped, and institutional partnerships remain insufficiently structured. This limits systematic feedback between employers and training institutions, thereby perpetuating curriculum inertia. Without formalized industry engagement, ATVET risks producing graduates whose competencies lag behind real-time sector evolution.

Experiential learning and practical exposure represent the strongest area of consensus among stakeholders. The prioritization of industry attachments, farm-based practical training, mentoring systems, and incubation facilities underscores the need to operationalize Competency-Based Education (CBE) principles more rigorously. Technical mastery without applied exposure fails to produce adaptive and innovative professionals capable of responding to environmental and market volatility.

At a systemic level, the results highlight the necessity of a triple-helix governance model integrating academia, industry, and government. Skills development, access to finance, value-chain coordination, and policy planning are interdependent components of agricultural transformation. Reforming ATVET in isolation—without strengthening ecosystem linkages—will yield limited impact.

## References

African Union Development Agency–NEPAD. (2014). *Agricultural technical and vocational education and training (ATVET) strategy for Africa*. AUDA-NEPAD.

Ayim, C., Kassahun, A., Tekinerdogan, B., & Addison, C. (2020). Adoption of ICT innovations in the agriculture sector in Africa: A systematic literature review. *Information Processing in Agriculture*, 7(4), 489–501. <https://doi.org/10.1016/j.inpa.2019.11.004>

Becker, G. S. (1993). *Human capital: A theoretical and empirical analysis* (3rd ed.). University of Chicago Press.

Boateng, C. (2012). *Restructuring vocational and technical education in Ghana: The role of leadership development*. *International Journal of Humanities and Social Science*, 2(4), 108–114.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>

Cobblah, M., & Addy, N. A. (2017). *The role of the new technical universities in the improvement and implementation of technical and vocational education and training (TVET) in Ghana*. *African Journal of Technical Education and Management*.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From national systems and “Mode 2” to a triple helix of university–industry–government relations. *Research Policy*, 29(2), 109–123. [https://doi.org/10.1016/S0048-7333\(99\)00055-4](https://doi.org/10.1016/S0048-7333(99)00055-4)

Food and Agriculture Organization. (2018). *Climate-smart agriculture sourcebook*. FAO.

Government of Ghana. (2016). *National technical and vocational education and training (TVET) policy framework*. Ministry of Education.

International Finance Corporation. (2019). *Digital skills in Sub-Saharan Africa: Spotlight on Ghana*. IFC, World Bank Group.

International Labour Organization. (2019). *Skills for a greener future: A global view based on 32 country studies*. International Labour Office.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.

Lipper, L., Thornton, P., Campbell, B. M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Cattaneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., McCarthy, N., Meybeck, A., Neufeldt, H., Remington, T., ... Torquebiau, E. (2014). Climate-smart agriculture for food security. *Nature Climate Change*, 4, 1068–1072. <https://doi.org/10.1038/nclimate2437>

- Marope, P. T. M., Chakroun, B., & Holmes, K. (2015). *Unleashing the potential: Transforming technical and vocational education and training*. UNESCO.
- Owusu-Agyeman, Y., & Aryeh-Adjei, A. (2023). Green skills development in Ghana's vocational system.
- Rijswijk, K., Klerkx, L., Turner, J. A., & Becu, N. (2021). Digital transformation of agriculture and rural areas. *Technological Forecasting and Social Change*, 170, 120949. <https://doi.org/10.1016/j.techfore.2021.120949>
- Spielman, D. J., Lecoutere, E., Makhija, S., & Van Campenhout, B. (2021). Information and communication technologies for agriculture in Africa: The impact of digital innovations on agricultural productivity. *World Development*, 140, 105337. <https://doi.org/10.1016/j.worlddev.2020.105337>
- United Nations Educational, Scientific and Cultural Organization. (2020). *Competency-based education and training in technical and vocational education and training*. UNESCO.
- United Nations Educational, Scientific and Cultural Organization–UNEVOC. (2023). *TVET for green transitions*. UNESCO-UNEVOC International Centre.
- United Nations Framework Convention on Climate Change. (2015). *Paris Agreement*. United Nations.
- World Bank. (2019). *The future of work in agriculture*. World Bank Group.
- World Bank. (2020). *Climate-smart agriculture investment plan for Ghana*. World Bank Group.
- World Bank. (2021). *Harnessing digital technologies to improve food system outcomes*. World Bank.
- World Economic Forum. (2020). *The future of jobs report 2020*. World Economic Forum.