

PREPARING THE GREEN WORKFORCE: CIRCULAR ECONOMY AWARENESS, SKILLS COMPETENCY, AND ECONOMIC EXPECTATIONS AMONG TVET STUDENTS

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Abstract

The transition toward sustainable production systems has intensified global interest in developing green skills to support circular economy practices. Technical and Vocational Education and Training (TVET) institutions play a crucial role in equipping learners with practical competencies for environmentally sustainable production and resource efficiency. However, empirical evidence examining how vocational trainees perceive the economic value of circular economy competencies remains limited, particularly in developing countries. This study investigates the relationship between circular economy awareness, green skills competencies, and vocational trainees' perceptions of the economic benefits of sustainable practices. A cross-sectional survey design was adopted, and data were collected from 261 students at the School of Technology, Yaba College of Technology, Nigeria, using a structured questionnaire. Descriptive and inferential statistical techniques were employed to analyze the data. The findings reveal that while trainees possess basic competencies in repair and reuse, awareness of advanced circular economy concepts such as modular design and material life cycle management remains relatively low. Respondents expressed strong optimism regarding the economic potential of green skills, particularly in refurbished products and waste-to-wealth enterprises. However, significant barriers including inadequate infrastructure, unreliable electricity supply, and limited access to modern training equipment constrain the effective adoption of circular practices. The study concludes that addressing both competency gaps and institutional resource limitations is essential for strengthening TVET's role in supporting Nigeria's transition to a sustainable economy. The paper recommends curriculum reforms, investment in sustainable infrastructure, and stronger industry partnerships to enhance green entrepreneurship.

Keywords: Circular Economy, TVET, Green Skills, Sustainable Development

Introduction

The growing urgency of environmental degradation, resource depletion, and climate change has intensified global interest in sustainable production systems that reduce waste and maximize resource efficiency. One of the most widely discussed approaches to achieving these goals is the circular economy, which emphasizes closing material loops through strategies such as reuse, repair, remanufacturing, and recycling (Geissdoerfer et al., 2017). Unlike the traditional linear economic model characterized by “take-

make-dispose” production patterns, the circular economy promotes regenerative systems in which materials remain in productive use for as long as possible (Kirchherr et al., 2017). As governments and industries increasingly pursue sustainability transitions, the demand for workers with competencies that support circular production processes continues to grow.

The global transition toward a circular economy requires not only technological innovation and policy reforms but also a workforce equipped with the appropriate

competencies to support sustainable production and consumption systems. Human capital development therefore plays a critical role in facilitating the shift toward more sustainable economic practices. Educational institutions are expected to prepare individuals with the knowledge, skills, and values necessary to operate within environmentally responsible industries. This expectation is strongly reflected in the United Nations Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education), which emphasizes inclusive and equitable education, and SDG 8 (Decent Work and Economic Growth), which highlights the need for productive employment and sustainable economic growth. Additionally, SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) underscore the importance of developing sustainable production systems and addressing environmental challenges through education and innovation.

Within this transition, Technical and Vocational Education and Training (TVET) plays a critical role in equipping the workforce with practical skills needed for sustainable economic development. TVET systems are uniquely positioned to deliver hands-on training that aligns with evolving industry needs while promoting employability and economic participation (UNESCO-UNEVOC, 2017). Scholars have emphasized that vocational education is central to the development of green skills because it prepares workers to implement environmentally responsible practices across sectors such as manufacturing, construction, waste management, and repair services (Pavlova, 2014). By integrating sustainability principles into vocational curricula, TVET institutions can contribute significantly to achieving broader sustainable development objectives while simultaneously addressing labour market demands.

Several studies have emphasized the importance of aligning vocational education with sustainability and emerging industrial needs. For example, Bodams and Nungse (2023) highlight the importance of integrating

green competencies and advanced technologies into TVET curricula in order to prepare students for future industrial transformations. Their study suggests that the inclusion of technologies such as artificial intelligence, digital manufacturing systems, and sustainable production techniques can enhance students' readiness for modern industries. Similarly, Chola and Kiplagat (2025) argue that TVET contributes significantly to sustainable development by equipping individuals with practical skills that promote environmentally responsible production and resource management.

Despite this potential, the integration of sustainability and circular economy principles into vocational education remains uneven across many countries. Several studies indicate that TVET systems often struggle to incorporate emerging sustainability competencies due to limitations related to infrastructure, curriculum design, and instructor capacity (Okorie et al., 2020). In many developing economies, vocational training continues to focus primarily on traditional technical skills while providing limited exposure to innovative practices such as circular design, material recovery, or sustainable product life cycle management. Consequently, vocational graduates may lack the competencies required to participate effectively in green industries and sustainable production systems.

Another critical factor influencing the adoption of circular economy practices is the perceived economic value associated with green skills. Evidence suggests that individuals are more likely to adopt sustainable practices when they perceive clear economic benefits, such as improved income opportunities, entrepreneurial prospects, or market demand for environmentally friendly products (Bocken et al., 2016). Market perception therefore plays an important role in shaping attitudes toward sustainability practices. For example, growing consumer interest in refurbished products, recycling services, and waste-to-wealth enterprises has created new opportunities for small scale

businesses and vocational entrepreneurs in many parts of the world.

However, the ability of vocational trainees to capitalize on these opportunities is often constrained by institutional and infrastructural challenges. Limited access to modern repair equipment, unreliable electricity supply, and inadequate safety training frequently restrict the implementation of circular economy practices in vocational workshops (Circle Economy, 2021). These challenges are particularly evident in developing countries, where vocational training institutions often operate with limited resources. Without adequate infrastructure and institutional support, trainees may struggle to apply sustainable production techniques even when they possess basic knowledge of environmental practices.

In addition, awareness and understanding of circular economy concepts remain relatively low among many vocational trainees. While basic practices such as repair and reuse are common in informal economies, the broader principles of circular production including product longevity, modular design, and systematic material recovery are not always fully understood (Kirchherr et al., 2017). This gap highlights the need for more structured sustainability education within vocational training systems to ensure that trainees acquire both practical skills and conceptual understanding of sustainable production systems.

Although the importance of green skills and circular economy competencies in vocational education has been widely acknowledged, empirical evidence examining how these competencies influence economic perceptions among vocational trainees remains limited, particularly in developing countries. Existing studies have largely focused on conceptual discussions of sustainability integration in Technical and Vocational Education and Training (TVET) systems or on policy-level analyses of green skills development (Ayuba et al., 2024; Bodams & Nungse, 2023). While these studies highlight the potential of TVET to support sustainable development, relatively

few have empirically examined how vocational trainees perceive the economic value of green skills and circular economy practices.

Furthermore, research focusing on vocational education in Nigeria has primarily emphasized structural challenges such as inadequate infrastructure, outdated curricula, and limited funding for vocational institutions (Muogahalu & Ahmad, 2023; Offiong et al., 2024). Although these studies provide valuable insights into the institutional barriers affecting vocational education, they pay limited attention to the perceptions and attitudes of trainees regarding the economic potential of sustainability-oriented skills. Understanding these perceptions is critical because trainees' beliefs about the economic benefits of green skills can significantly influence their motivation to adopt sustainable practices and pursue green entrepreneurial opportunities.

In addition, existing studies rarely examine the interaction between market perception, training resources, and sustainability competencies within vocational education environments. Yet, evidence suggests that the perceived market acceptance of refurbished products, the availability of training infrastructure, and exposure to sustainability education can shape trainees' expectations about future income opportunities (Bocken et al., 2016). The absence of empirical studies exploring these relationships represents an important gap in the literature on sustainability-oriented vocational education.

This study addresses this gap by empirically examining the relationship between circular economy awareness, green skills competencies, and vocational trainees' perceptions of the economic benefits of sustainable practices. By focusing on vocational trainees within a Nigerian technical institution, the study provides context-specific insights into how sustainability competencies can influence economic expectations and contribute to the broader transition toward circular and green economies.

Given these lacuna, it is important to examine how vocational trainees perceive the economic potential of green skills and circular economy practices. Perceptions regarding market demand, access to resources, and training conditions can significantly influence the willingness of trainees to adopt sustainable production practices. Understanding these perceptions is particularly important for policymakers and educators seeking to design effective strategies for integrating sustainability into vocational education systems. The study therefore examines the relationship between circular economy awareness, green skills competencies, and vocational trainees' perceptions of the economic benefits of sustainable practices.

Methodology

Research Design

This study employed a quantitative cross-sectional survey design to investigate the relationships among circular economy awareness, green skills competencies, training infrastructure, and vocational trainees' perceptions of the economic prospects associated with sustainable practices. The choice of a cross-sectional approach was informed by its suitability for examining patterns, associations, and prevailing conditions within a defined population at a specific point in time. In educational and sustainability research, this design is widely considered appropriate for assessing attitudes, competencies, and institutional factors without manipulating the study environment. The design also enabled the collection of standardized responses from a relatively large number of participants, thereby enhancing comparability and statistical analysis.

Study Area

The study was carried out at Yaba College of Technology, Lagos State, Nigeria. The institution is recognized as one of the foremost tertiary institutions for technical and vocational education in the country, offering programmes in engineering, applied sciences, technology, and vocational studies. The

college provides an appropriate context for examining issues related to green skills and circular economy practices because of its emphasis on technical training, innovation, and entrepreneurship development.

Population of the Study

The target population comprised students enrolled in programmes within the School of Technology who were actively involved in technical and vocational training activities during the period of the study. These students were considered suitable participants because they are directly exposed to practical skill acquisition, technological innovation, and sustainability-related learning experiences that align with the objectives of the research.

Sample Size and Sampling Procedure

A multistage sampling procedure was adopted to ensure adequate representation of the study population. In the first stage, purposive sampling was used to select the School of Technology owing to its direct relevance to technical and vocational skill development as well as sustainability-oriented training. In the second stage, a simple random sampling technique was employed to select participants from the identified departments and programmes within the school. This approach provided each eligible student with an equal chance of participation and minimized selection bias. Through this process, a total of 261 students were selected for the study.

Instrumentation

Data for the study were collected using a structured questionnaire developed by the researchers based on existing literature on circular economy practices, green skills development, vocational education, and sustainable entrepreneurship. The instrument was divided into sections covering respondents' demographic characteristics, awareness of circular economy principles, green skills competencies, perceptions of training infrastructure, and perceived economic opportunities associated with sustainable practices.

The questionnaire items were measured using a five-point Likert scale ranging from *Strongly Disagree (1)* to *Strongly Agree (5)*. The use of Likert-type scaling enabled the measurement of respondents' perceptions and attitudes in a systematic and quantifiable manner.

Validity of the Instrument

To ensure content and construct validity, the instrument was subjected to expert review by specialists in vocational education, sustainability studies, and educational measurement. Their observations and recommendations guided the revision of ambiguous statements, item clarity, and the alignment of questionnaire items with the study objectives and variables. This process enhanced the appropriateness and comprehensiveness of the instrument for data collection.

Reliability of the Instrument

A pilot study was conducted using 30 students drawn from a technical programme outside the selected sample but with characteristics similar to those of the study participants. Data obtained from the pilot test were analyzed using Cronbach's Alpha reliability technique to determine the internal consistency of the instrument. The analysis yielded a reliability coefficient of 0.79, indicating that the instrument possessed an acceptable level of reliability for the main study.

Procedure for Data Collection

The researchers administered the questionnaire directly to the respondents with the assistance of trained research aides. Prior to administration, participants were informed about the purpose of the study and assured of the confidentiality and anonymity of their responses. Participation was voluntary, and respondents were encouraged to provide honest answers based on their experiences and perceptions. Completed questionnaires were retrieved immediately after completion to reduce the likelihood of non-response and incomplete data.

Ethical Considerations for the study include; Informed consent from participants prior to data collection, ensuring that the purpose of the study was well understood, emphasizing that participation is voluntary. Assurance of confidentiality and anonymity of participants' responses to protect their privacy and minimize risks of disclosure.

Methods of Data Analysis

The collected data were coded and analyzed using appropriate statistical software. Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarize respondents' demographic characteristics and the distribution of responses across the study variables. Inferential statistical techniques, including Pearson Product Moment Correlation and multiple regression analysis, were employed to examine the relationships among circular economy awareness, green skills competencies, training infrastructure, and perceived economic benefits of sustainable practices. Statistical significance was tested at the 0.05 level of significance.

Results and Discussion

Demographic Characteristics of Respondents
The study showed a significant imbalance, with 208 (79.7%) female respondents compared to 52 (19.9%) male respondents. This distribution suggests a relatively high participation of female students in the selected programmes within the School of Technology. The increasing participation of women in technical and vocational education reflects broader global efforts to promote gender inclusion in skills development and technical professions (UNESCO, 2020). Approximately 82% of respondents fall within the 18-30 age range, indicating a youthful demographic at the onset of their professional lives. This demographic structure suggests that vocational institutions represent an important platform for preparing the future workforce for sustainable production systems. The predominance of youth confirms the strategic positioning of TVET as a tool for youth empowerment in

Nigeria (Jonathan, 2025). This demographic is crucial because, as Joseph et al. (2025) argue, "future-proofing" the workforce depends on the adaptability of young trainees to new technologies and sustainability practices. Their early career stage makes them ideal candidates for a pedagogical shift away from linear "take-make-waste" models.

Awareness of Circular Economy Concepts

The results indicate that overall awareness of circular economy concepts among respondents is moderate to low. While many students were familiar with practices such as repair and reuse, knowledge of more advanced concepts such as modular design, life cycle management, and structured material recovery systems was limited. This finding suggests that although basic environmental practices are commonly recognized among vocational trainees, deeper conceptual understanding of circular production systems may still be developing. Similar patterns have been reported in previous studies examining sustainability awareness within vocational education systems in developing countries (Bodams & Nungse, 2023). It also confirms the "rhetoric vs. reality" gap identified by Ajuzieogu (2025). While there is a global push for circularity, the local awareness in Nigerian TVET settings remains superficial. Ordu (2022) emphasizes that without a deep conceptual understanding of the green economy, trainees cannot contribute to the systemic shifts required for economic resilience. The reliance on traditional linear models suggests that the Nigerian TVET system has not yet fully transitioned to the sustainable frameworks advocated by UNESCO-UNEVOC (2017).

Circular Skills Competencies

The findings show that respondents possess basic competencies related to repair and reuse activities but lack advanced skills associated with modern circular production systems. Skills such as digital inventory management, material tracking, and sustainable product design were largely absent among

respondents. This discrepancy highlights a critical weakness in current TVET outcomes: the focus on basic craft rather than innovation-driven skills. Samson and Iwelu (2025) argue that for a sustainable economy, the educational system must reposition itself toward "Product Innovation." The lack of digital inventory management skills is particularly concerning, as Joseph et al. (2025) suggest that digital literacy is a prerequisite for modern circular economies (e.g., tracking material lifecycles).

Institutional Infrastructure and Capacity

A major finding is that unreliable electricity and a lack of specialized equipment significantly constrain the implementation of circular practices. These infrastructure deficiencies validate the concerns of Offiong, Bassey, and Okon (2024), who identified institutional challenges as the primary barrier to sustainable skill development in Nigeria. Ayuba, Datol, and Aluwong (2024) further contend that "greening" TVET is impossible without "greening" the campus infrastructure itself, including the provision of reliable, renewable energy sources to power recycling and repair technologies.

Occupational Safety and Environmental Compliance

The study found mixed levels of safety preparedness, with a notable lack of formal training in handling hazardous materials. This lack of safety training represents a systemic failure in the current TVET framework. As Ayuba et al. (2024) point out, climate change mitigation and sustainable development require a workforce that understands environmental hazards. The absence of such training contradicts the "Green Campus" pillars established by UNESCO-UNEVOC (2017), which prioritize health, safety, and environmental stewardship as foundational to vocational excellence.

Waste Management Practices

Waste management is largely informal and inconsistent, often relying on conventional disposal rather than structured recovery. The

informal nature of waste reuse in Nigeria though culturally prevalent lacks the technical rigor of a circular economy. This is in line with Bodams and Nungse (2023) argument that waste management must be integrated into the TVET curriculum not as an afterthought, but as a "core competency." Transitioning from informal scavenging to structured "waste-to-wealth" initiatives is essential for meeting the UN SDG 12 on responsible consumption and production (United Nations, 2015).

Perceived Market Opportunities and Economic Benefits

Despite the limited level of advanced circular competencies, respondents expressed positive perceptions regarding the economic potential of green skills. Many trainees believe that customers are willing to purchase refurbished products and environmentally friendly goods. Respondents also indicated that acquiring green skills could enhance their future income opportunities and entrepreneurial prospects. This optimism aligns with the findings of Akpan et al. (2018), who suggest that repositioning entrepreneurship in TVET is vital for a post-oil economy. The perceived market viability of recycled products suggests that there is an untapped "circular market" in

Nigeria. This supports the argument of Obi and Ojo (2025) that green skill development is directly linked to enhanced employability and income generation for Nigerian youths.

Major Barriers to Circular Economy Adoption

Key barriers include inadequate infrastructure, poor electricity supply, and limited access to modern equipment and sustainability training. The identified barriers suggest that the "skills gap" is not merely educational but structural. Ajuzieogu (2025) notes that the rhetoric of skill acquisition often hits a brick wall due to a lack of industrial support. The findings here echo Muogahalu and Ahmad (2023), who argue that reforming TVET for sustainable industrial development requires a multi-stakeholder approach to overcome the chronic under funding and infrastructural decay in the sector. The study reveals that while Nigerian vocational trainees have a positive disposition toward green skills, they are hindered by a "competency gap" in advanced circular practices and a "resource gap" in institutional support.

To examine the relationships between key variables in the study, Pearson correlation analysis was conducted.

Table 1: Correlation Matrix of Key Variables

Variable	1	2	3	4	5
Circular Economy Awareness	1				
Green Skills Competencies	0.21	1			
Training Infrastructure	0.18	0.24	1		
Market Perception	0.17	0.20	0.19	1	
Perceived Economic Benefits	0.16	0.22	0.15	0.17	1

The correlation results reveal positive relationships among the study variables, although the strength of these relationships is generally moderate.

Notably, Green skills competencies show a positive correlation with perceived economic benefits ($r = 0.22$). Market perception regarding consumer acceptance of refurbished products is positively correlated with economic expectations ($r = 0.17$). Training infrastructure also shows a positive

association with perceived economic benefits ($r = 0.15$). These findings suggest that trainees who possess stronger sustainability competencies and who perceive favourable market conditions are more likely to believe that green skills can generate economic opportunities.

To further examine the predictive relationships between the independent variables and the dependent variable, multiple regression analysis was conducted.

Table 2: Multiple Regression Results

Predictor Variable	Beta (β)	Standard Error	t-value	Significance
Circular Economy Awareness	0.11	0.05	2.03	0.043
Green Skills Competencies	0.19	0.06	3.16	0.002
Training Infrastructure	0.13	0.05	2.18	0.031
Market Perception	0.21	0.07	3.28	0.001

Model statistics: $R^2 = 0.12$, F-statistic = 7.41 ($p < 0.01$)

The regression model explains approximately 12% of the variation in respondents' perceptions of the economic benefits of green skills. Although the explanatory power of the model is moderate, the results indicate that several variables significantly influence trainees' economic expectations regarding sustainability competencies.

Among the predictors, market perception emerges as the strongest determinant ($\beta = 0.21$), indicating that trainees who believe consumers are willing to purchase refurbished or recycled products are more likely to perceive green skills as economically beneficial. Similarly, green skills competencies show a significant positive effect ($\beta = 0.19$), suggesting that trainees who possess practical sustainability skills are more confident about the income generating potential of these competencies. Training infrastructure and circular economy awareness also demonstrate statistically significant relationships with perceived economic benefits, although their effects are relatively smaller. Overall, the regression results suggest that both individual competencies and external market conditions play important roles in shaping trainees' perceptions of the economic value of green skills.

Discussion

The findings of this study provide important insights into the relationship between circular economy awareness, green skills competencies, and vocational trainees' perceptions of the economic potential of sustainability oriented practices.

First, the results indicate that green skills competencies significantly influence

trainees' perceptions of economic opportunities associated with sustainable practices. This finding supports previous studies emphasizing the importance of sustainability oriented skill development within vocational education systems (Ayuba et al., 2024; Bodams & Nungse, 2023). As industries increasingly adopt circular production models, workers equipped with repair, recycling, and resource-efficiency skills are likely to experience improved employment prospects.

Second, the results highlight the importance of market perception in shaping economic expectations regarding green skills. Respondents who believe that consumers are willing to purchase refurbished or recycled products demonstrate stronger confidence in the economic viability of sustainability-oriented activities. This finding aligns with the work of Bocken et al. (2016), who argue that market acceptance is a critical factor in the successful implementation of circular business models.

The findings also reinforce broader global evidence suggesting that circular economy practices can generate both environmental and economic benefits. According to the Ellen MacArthur Foundation (2019), circular production systems can reduce greenhouse gas emissions while simultaneously creating new employment opportunities in areas such as repair services, recycling industries, and sustainable manufacturing.

Another important finding relates to the role of training infrastructure in supporting sustainability competencies. The results suggest that access to appropriate training facilities and technical equipment contributes positively to trainees' perceptions

of the economic benefits of green skills. This finding is consistent with studies highlighting the importance of institutional capacity in enabling sustainability-oriented vocational education (Muogahalu & Ahmad, 2023).

However, the relatively moderate explanatory power of the regression model suggests that additional factors beyond those examined in this study may influence trainees' perceptions of green economic opportunities. These factors may include government policies supporting green industries, access to entrepreneurial financing, and broader labour market dynamics.

Overall, the findings underscore the critical role of vocational education institutions in supporting the transition toward sustainable and circular economies. By integrating circular economy principles into training curricula and providing access to modern training infrastructure, TVET institutions can enhance trainees' capacity to participate in emerging green industries.

Conclusion

This study examined the relationship between circular economy awareness, green skills competencies, training infrastructure, and vocational trainees' perceptions of the economic benefits of sustainable practices within a Nigerian technical education context. The findings demonstrate that although vocational trainees possess basic knowledge of repair and reuse practices, their understanding of advanced circular economy principles remains relatively limited. Similarly, while trainees show optimism regarding the economic potential of green skills, the development and application of these competencies are constrained by infrastructural limitations, insufficient equipment, and limited institutional support within vocational training environments.

The statistical results further reveal that both individual competencies and external market conditions significantly influence trainees' perceptions of the economic value of sustainability oriented skills. In particular, market perception and green skills competencies emerged as the

strongest predictors of perceived economic benefits, indicating that trainees are more likely to recognize the economic potential of circular practices when they possess relevant technical skills and perceive favourable consumer demand for environmentally friendly products. Training infrastructure and circular economy awareness also contribute to shaping these perceptions, highlighting the importance of supportive institutional environments in facilitating sustainability-oriented vocational training.

Overall, the findings underscore the strategic role of Technical and Vocational Education and Training (TVET) in supporting the transition toward circular and sustainable economies. By integrating circular economy principles into vocational curricula, strengthening green skills development, and improving institutional infrastructure, vocational institutions can better prepare trainees to participate in emerging green industries and sustainability driven labour markets. Such reforms are particularly important in developing countries like Nigeria, where youth unemployment and environmental challenges create an urgent need for innovative and sustainable economic pathways.

Despite these contributions, the study acknowledges that the explanatory power of the regression model suggests the presence of additional factors influencing trainees' perceptions of green economic opportunities. Future research could therefore examine the role of industry partnerships and entrepreneurial ecosystems in facilitating the commercialization of circular economy skills among vocational graduates. Ultimately, bridging the gap between vocational institutions, industries, and government agencies is essential for fostering sustainable entrepreneurship. By leveraging these collaborations, we can maximize the economic reach of green skills development, thereby securing a future aligned with **SDG 8** and **SDG 12** where decent work and responsible production form the bedrock of sustainable economic growth."

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