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Research Article

Forecasting Future Green Skill Demands for Green Jobs in Addis Ababa: The Case Study of Dajazmach Geresu Duki Industrial College

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Abstract

The shift to a green economy is drastically changing Addis Ababa's labor market, raising demand for green skills and competencies in a variety of industries. Technical and Vocational Education and Training (TVET) institutions like Dajazmach Geresu Duki Industrial College still struggle to match training programs with changing labor market demands, despite Ethiopia's strong national commitments through the Climate-Resilient Green Economy Strategy. In addition to evaluating current skill gaps and institutional preparedness at DGIC, this study sought to project future green skill requirements from 2026 to 2031. A mixed-method research methodology was used, combining primary data gathered from 126 instructors via questionnaires and interviews with a systematic synthesis of papers published between 2020 and 2025. SPSS was used in conjunction with hybrid forecasting methods to analyze quantitative data. The results showed that instructors and trainees had a moderate level of green skill availability. Waste management (Mean = 3.33) and environmental management (Mean = 3.07) were shown to be relative strengths, however renewable energy technologies (Mean = 2.73) and green ICT competencies (Mean = 2.79) showed significant weaknesses. According to forecasting results, 66.7% of respondents prioritized skills linked to solar energy as the most important short-term need, while 60.3% of respondents favored AI applications for sustainability as the top long-term demand area. The overall level of institutional preparedness for the green transition was determined to be moderate, with concerns about capacity building, curricular integration, and infrastructure. DGIC is in a transitional stage of green skills development, with growing demand but insufficient training capacity, requiring curriculum reform and stronger industry alignment.

Keywords

Green Skills, Green Jobs, Skill Forecasting, TVET, Renewable Energy, Skill Gaps, Workforce Development

1. Introduction

By creating new job opportunities and altering preexisting occupational structures, the worldwide transition to a green economy has drastically changed labor markets. Green jobs, which are jobs that support resource efficiency, climate resilience, and environmental sustainability, are becoming more widely acknowledged as important forces behind sustainable development [5, 11]. This change is especially crucial in developing nations where young unemployment and environmental issues overlap.

The spread of renewable energy, climate adaption plans,

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and sustainable urbanization are closely associated with the green transition in Africa. Because of their concentration of industry, infrastructural development, and technological institutions, cities like Addis Ababa are emerging as key hubs for the creation of green jobs [14, 26]. In this regard, Technical and Vocational Education and Training (TVET) institutes are essential in preparing trained workers for new green industries.

As one of Addis Ababa's TVET institutions, Dajazmach Geresu Duki Industrial College (DGIC) is well-positioned to help with this change by educating students in technical subjects like manufacturing, energy, construction, and environmental management. The college is actively involved in competency-based training and skill development that is in line with national development priorities, such as programs for job creation and environmental sustainability, according to institutional reports.

Ethiopia has incorporated the green economy goal into national frameworks like the Job Creation Plan (2020–2025) and the Climate Resilient Green Economy (CRGE) plan. But despite these legislative pledges, there is still a big gap between the supply of graduates with the necessary training and the demand for green skills. According to [22], many developing nations lack reliable forecasting tools to predict future labor market demands, especially in burgeoning industries like waste management, green building, and renewable energy. In order to match TVET curricula with changing labor market demands in Addis Ababa, especially at institutions like Dajazmach Geresu Duki Industrial College, it is crucial to estimate future demands for green skills. This study fills this gap by doing a thorough evaluation of the literature from 2020 to 2025 and analyzing the collected primary data.

2. Statement of the Problem

Ethiopia's commitment to a green economy is demonstrated by national programs like the Climate-Resilient Green Economy (CRGE) Strategy, yet the country still has a serious mismatch between workforce capabilities and labor market demands. Waste management, urban transportation, renewable energy, and construction are among the rapidly growing industries in Addis Ababa that are hampered by a lack of green labor with the necessary skills [6, 23, 26]. The issue is made worse at the institutional level by Dajazmach Geresu Duki Industrial College's inadequate integration of emerging green competencies into training programs. Graduates frequently lack the technical and practical skills needed by green industries, which widens the gap between educational outcomes and labor market expectations.

Since the majority of current research and institutional practices are still mostly descriptive rather than predictive, a significant obstacle is the lack of systematic forecasting tools to identify future green skill demands. Many TVET systems in developing nations lack trustworthy labor market intelligence systems, which restricts their capacity to react proactively to new skill demands, according to [19]. Additionally, this problem is made worse by a lack of cooperation between TVET schools and industry partners, which makes it impossible for training programs like those at DGIC to match real labor market demands. As a result, this mismatch leads to underutilization of human resources, graduate unemployment, and ongoing skill gaps.

The absence of a methodical, evidence-based forecasting framework for future green skill demands in Addis Ababa, with particular reference to Dajazmach Geresu Duki Industrial College, is thus the main issue this study attempts to solve.

3. Research Questions

Key research questions that assess major skill gaps among TVET graduates, especially at Dajazmach Geresu Duki Industrial College, identify emerging green skills in sectors relevant to Addis Ababa, and examine global and local trends in green jobs and skill development from 2020 to 2025 serve as the basis for this study. It also outlines the most important skills anticipated to be in demand between 2026 and 2031 and examines forecasting techniques used to predict future green skill demands. In order to improve graduate employability and promote sustainable development, the study's ultimate goal is to ascertain how Dajazmach Geresu Duki Industrial College can better match its training programs with the changing demands of the green labor market.

4. Objectives of the Study

With an emphasis on the consequences for Dajazmach Geresu Duki Industrial College, the overall goal of this study is to anticipate future green skill demands for green occupations in Addis Ababa by synthesizing previous research efforts (2020–2025). The study's specific objectives are to evaluate current green skill gaps in TVET institutions, particularly DGIC, identify new competences needed in important economic sectors, and examine local and international research on green job and skill trends. It also looks at forecasting techniques used in studies of the green labor market, projects future skill requirements for 2026–2031, and suggests workable ways to match institutional training programs with changing needs for green jobs.

5. Significance of the Study

This study is significant in several important ways. First, it contributes to academic knowledge by systematically synthesizing recent literature on green jobs and skill forecasting (2020–2025), with particular emphasis on TVET institutions in developing economies. Second, it provides valuable insights for policymakers in Ethiopia by supporting evidence-based planning for green economy development, job creation, and skills development strategies under the Climate-Resilient

Green Economy (CRGE) Strategy framework [11, 14]. In doing so, the study helps bridge the gap between policy intentions and practical implementation in the green transition.

Furthermore, the study holds strong practical relevance for institutions and industry. It provides actionable recommendations for Dajazmach Geresu Duki Industrial College, particularly in curriculum improvement, training modernization, and the integration of green competencies to enhance graduate employability and institutional performance. In addition, it benefits industry stakeholders by identifying future skill requirements in key sectors such as renewable energy, sustainable construction, and environmental management, thereby supporting more effective workforce planning. Ultimately, the study contributes to sustainable development in Addis Ababa by strengthening alignment between education systems and labor market needs, promoting environmental protection, economic growth, and youth employment.

6. Research Methodology

With a focus on Dajazmach Geresu Duki Industrial College (DGIC), the study used a mixed-method research technique to predict future demands for green skills in Addis Ababa. It combined quantitative and qualitative empirical analysis with a Systematic Literature Review (SLR) to offer a thorough understanding of labor market trends, institutional preparedness, and green skill shortages. A cross-sectional survey approach was employed to gather primary data from institutional stakeholders, and the SLR adhered to the PRISMA framework to guarantee an open and methodical selection of studies published between 2020 and 2025. This triangulated design combined local insights with evidence from throughout the world, strengthening the conclusions' validity.

The study was carried out at DGIC, a significant TVET institution in Ethiopia chosen for its applicability to industries like industrial technologies, construction, and renewable energy. In order to integrate theoretical viewpoints with actual institutional experiences, the study used both deductive and inductive methods. A census sampling technique was used to gather primary data from instructors, yielding a total sample size of 126 respondents. Secondary data was gathered from reliable sources, including reports from the World Bank, OECD, International Labor Organization, and UNESCO.

Focus groups, semi-structured interviews, and structured questionnaires were used in data gathering to record both quantitative and qualitative viewpoints. While interviews and focus group discussions (FGDs) offered deeper insights into new skill needs and training obstacles, the questionnaire employed a Likert scale to quantify variables like green skill demand, institutional preparation, and policy influence. Expert reviews, pilot testing, and internal consistency metrics like Cronbach's Alpha were used to guarantee validity and reliability.

While qualitative data was examined using theme coding and pattern recognition, quantitative data was handled using SPSS to produce descriptive statistics, cross-tabulations, and trend analyses. The study used a hybrid forecasting approach that combined sectors demand predictions, stakeholder views, and literature-based trend extrapolation. A structured outlook on future green skill requirements was provided by classifying forecasts into short-, medium-, and long-term periods. Throughout the study, ethical standards were upheld by guaranteeing informed permission, confidentiality, anonymity, and each respondent's voluntary involvement.

7. Result and Discussion

7.1. Respondent Type

Since only instructors from Technical and Vocational Education and Training (TVET) institutions participated in the study, all respondents had a similar professional background and were directly involved in providing vocational education. Instructors can offer useful, experience-based insights about skill shortages, training methods, curriculum relevance, and institutional performance because they are major stakeholders in the implementation of training programs and interactions with trainees. This emphasis guarantees that the information gathered is pertinent and based on actual TVET system operational circumstances.

Simultaneously, employing instructors alone results in a homogeneous group of respondents, which enhances consistency and lowers response variability. However, because it excludes the opinions of other stakeholders like students, employers, and legislators, it also restricts the variety of viewpoints. Although the results are extremely relevant to TVET teaching practices and institutional performance, they could not accurately reflect the larger system and should be interpreted cautiously because of potential biases and the lack of alternative perspectives.

The study relied solely on a single, homogenous group within Dejazmach Geresu Duki Industrial College, as evidenced by the pie chart, which shows that all of the respondents are professors from this institution. Because all participants have comparable jobs, responsibilities, and institutional experiences, this uniformity guarantees consistency in responses. The college's teachers' replies offer useful, experience-based insights regarding training quality, current skill shortages, and institutional difficulties because they are directly involved in training delivery, curriculum implementation, and student skill development. Because the conclusions are based on the professional knowledge of individuals actively involved in the college's TVET system, this enhances their internal validity.

However, there are drawbacks to concentrating only on Dejazmach Geresu Duki Industrial College professors. The results only represent the viewpoint of the instructors and may not accurately reflect the larger institutional or labor market environment due to the lack of other stakeholders, including trainees, administrative staff, industry partners, and legislators.

For instance, students may refer to learning issues, employers may emphasize skill mismatches, and instructors may highlight teaching and resource challenges. As a result, even though the findings are extremely pertinent to college teaching methods, they should be cautiously extrapolated outside of this particular institutional context.

Table 1. *Year of Experience.*

	Frequency	Percent	Valid Percent	Cumulative Percent
3-5	3	2.4	2.4	2.4
6-10	5	4.0	4.0	6.3
>10	118	93.7	93.7	100.0
Total	126	100.0	100.0	

With 93.7% (118 respondents) having more than ten years of experience, the table demonstrates that the great majority of respondents have substantial job experience. On the other hand, only 2.4% (3 respondents) have three to five years of experience, and only 4.0% (5 respondents) have six to ten years. This suggests that the majority of participants have extensive institutional knowledge and long-term exposure to TVET training techniques, as the sample is substantially dominated by highly experienced personnel.

Because replies are mostly based on seasoned professional experience, which can offer more precise and knowledgeable insights regarding training quality, skill gaps, and institutional performance, this distribution enhances the study's credibility. However, the incorporation of new viewpoints, creative ideas, or recent training experiences may be limited by the underrepresentation of less experienced teachers. Because of this, even though the results are reliable and based on knowledge, they could be slightly skewed in favor of the opinions of seasoned specialists.

Table 2. *Current availability of green skills in Dazazmach Geresu Duki Industrial College.*

Current Availability of green skills in Institution					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Renewable energy skills (solar, wind)	126	1	5	2.73	1.176
Energy efficiency & conservation skills	126	2	4	2.93	0.771
Waste management & recycling skills	126	2	5	3.33	1.144
Sustainable agriculture/urban farming	126	1	4	2.72	1.078
Green construction & eco-building skills	126	1	5	3.06	1.288
Environmental management skills	126	2	5	3.07	1.133
Green ICT/digital sustainability skills	126	1	5	2.79	1.342
N	126				

The findings from Dejazmach Geresu Duki Industrial College indicate that the overall availability of green skills is moderate but uneven, with mean values ranging from 2.72 to 3.33. The highest-rated area is waste management and recycling (Mean = 3.33), followed by environmental management (Mean = 3.07) and green construction (Mean = 3.06). This suggests that the college has made some progress in integrating environmental awareness and basic sustainability practices into its training programs. This aligns with broader African TVET research, which shows that institutions are increasingly incorporating environmental practices such as waste management and resource efficiency as entry points for greening education systems [5, 21]. Similarly, studies confirm that

TVET institutions contribute to sustainable development by promoting environmentally responsible practices and skills relevant to green economies [9, 18]. Therefore, the moderate performance of these areas in the college reflects positive alignment with continental and global trends in TVET reform.

However, critical green skill areas such as renewable energy (Mean = 2.73), sustainable agriculture (Mean = 2.72), and green ICT (Mean = 2.79) are relatively low, indicating significant gaps in advanced and emerging green competencies. This finding is strongly supported by empirical studies in Ethiopia and Africa, which highlight that TVET systems often face limited capacity, inadequate infrastructure, and insufficient funding for advanced green technologies like renewable energy and digital sustainability [15, 25]. Even where initiatives exist such as the Ethiopian Green Energy TVET program, which introduced solar PV training and curriculum development these efforts are typically limited to pilot institutions and not widely scaled across all colleges [3, 8]. Furthermore, research shows that despite policy awareness, challenges such as weak industry linkage, lack of trained instructors, and insufficient investment continue to hinder effective green skill integration in TVET systems [5, 21]. This explains why Dejazmach Geresu Duki Industrial College demonstrates only moderate performance and low scores in key future-oriented skill areas.

Table 3. *Status of Green skill development, skill orientation, curriculum integration and major gaps in Dazazmach Geresu Duki Industrial College.*

Indicator	Category	Frequency	Percent	Valid Percent	Cumulative Percent
Compared to 3 years ago, green skills have	Increased	91	72.2	72.2	72.2
	No change	35	27.8	27.8	100.0
	Total	126	100.0	100.0	
Dominant skill orientation in the college	Traditional Technical Skill	26	20.6	20.6	20.6
	Mixed technical + green skill	74	58.7	58.7	79.4
	Strong green skill integration	18	14.3	14.3	93.7
	Weak green skill integration	8	6.3	6.3	100.0
	Total	126	100.0	100.0	
Green skills integration in curriculum	Low	67	53.2	53.2	53.2
	Moderate	51	40.5	40.5	93.7
	Fully integrated	8	6.3	6.3	100.0
	Total	126	100.0	100.0	
Major gaps in green skills	Lack of renewable energy expertise	59	46.8	46.8	46.8
	Lack of environmental awareness training	16	12.7	12.7	59.5
	Lack of green technology equipment	51	40.5	40.5	100.0
	Total	126	100.0	100.0	

7.2. Overall Improvement in Green Skills But Uneven Development

Dejazmach Geresu Duki Industrial College's TVET systems are gradually becoming more environmentally friendly, as evidenced by the conclusion that green skills have increased (72.2%) from three years ago. The development is still not uniform across all skill categories, though. According to [13, 22], African TVET institutions are progressively incorporating green skills, but growth is dispersed and primarily based on institutional capability rather than systemic reform.

Although the shift is still in its early stages and lacks complete institutionalization, recent data indicates that many African TVET institutions are implementing green practices like waste management and environmental awareness [22, 23]. In a similar vein, research conducted by UNESCO in Ethiopia shows that initiatives to incorporate greening into curricula are still in the pilot stage and have not yet reached full national size [23]. As a result, while the college's improvement is indicative of greater continental success, it also shows that the development of green talents is still in a transitional stage.

7.3. Dominance of Mixed Technical and Green Skills Orientation

The institution is in a hybrid transition stage rather than a fully greenized TVET system, as seen by the predominance of mixed technical + green skill orientation (58.7%). This is in line with UNESCO's findings that, rather than completely converting curricula into green-oriented systems, the majority of TVET institutions in Africa are incorporating sustainability as an add-on [21, 22].

According to recent research, TVET systems around the world are shifting toward "twin transition" models, which combine digital and green competences. However, implementation in Africa is still constrained by institutional capacity and inadequate curriculum reform frameworks [22, 24]. As a result, rather than fully aligning with the demands of the green economy, the college's hybrid orientation represents an early adaptation.

7.4. Low Curriculum Integration of Green Skills

Green skills are not yet methodically included into teaching and learning procedures, as evidenced by the fact that 53.2% of respondents cited low curriculum integration. Recent research demonstrating that TVET institutions in Africa encounter structural obstacles such a lack of curriculum frameworks, insufficient teacher preparation, and a lack of instructional resources for green education provides compelling evidence for this [23].

Effective integration necessitates curriculum restructuring, teacher capacity development, and strong industry linkage, all of which are still lacking in many TVET systems in developing nations, according to a UNESCO handbook on greening TVET [22]. In a similar vein, studies reveal that in the absence of organized curriculum reform, green skills continue to be dispersed and rely more on the initiative of individual teachers than on institutional policies [25]. This explains why the college has a low level of integration.

7.5. Key Gaps: Renewable Energy, Green ICT, and Environmental Training

The significant gaps found, especially the lack of green technology equipment (40.5%) and renewable energy skills (46.8%), are in line with extensive data from around Africa. According to different recent research there is a serious skills shortage in the renewable energy sector due to a lack of contemporary equipment in TVET institutions, poor practical exposure, and insufficient technical training.

According to UNESCO publications, African TVET systems fail to support green technologies like solar energy, energy efficiency systems, and green ICT due to a lack of finance and inadequate infrastructure [21]. Additionally, many institutions lack specialized laboratories and experienced teachers, which severely restricts the development of advanced green capabilities, according to a recent Africa Skills Week report [20].

The lack of training on environmental awareness is also a reflection of larger systemic flaws in integrating sustainability into all academic fields rather than considering it as a standalone topic.

Table 4. *Rate severity of skill gaps.*

Rate severity of skill gaps					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Renewable energy skills	126	1	4	2.67	1.072
Waste management skills	126	1	4	2.28	.786
Sustainable agriculture skills	126	1	4	2.13	.741
Green ICT skills	126	1	4	2.50	1.263
Valid N (listwise)	126				

7.6. Interpretation and Discussion of Results on Severity of Green Skill Gaps

With mean values ranging from 2.13 to 2.67 on a four-point scale, the findings show that the degree of green skill gaps at Dejazmach Geresu Duki Industrial College differs across various competency areas. This indicates a moderate degree of skill deficiency overall, with some areas showing more noticeable gaps than others. Inconsistent skill availability among respondents is also shown by the comparatively greater standard deviations, especially in Green ICT skills (SD = 1.263) and Renewable energy skills (SD = 1.072), which imply unequal

exposure and training opportunities across departments.

7.6.1. Renewable Energy Skills Gap (Mean = 2.67, SD = 1.072)

The skills gap in renewable energy is the most severe. This suggests that respondents believe there is a moderate to severe lack of expertise in solar, wind, and other renewable technologies. This result is consistent with current research on TVET systems in Africa, which shows that training in renewable energy is among the least developed due to inadequate infrastructure and a shortage of qualified instructors.

For instance, the International Renewable Energy Agency highlights that one of the biggest obstacles to the green energy transition in Africa is the severe lack of qualified personnel for solar PV installation and maintenance. Similarly, due to high equipment prices and limited institutional capacity, the majority of TVET institutions in Sub-Saharan Africa have not yet fully integrated renewable energy modules, according to [21]. According to research conducted by Ethiopia's Ministry of Labor and Skills in 2023, the majority of institutions lack the necessary equipment because teaching in renewable energy is still centered in a small number of pilot TVET colleges. Consequently, a wider continental problem in the development of renewable energy skills is reflected in the current finding.

7.6.2. Green ICT Skills Gap (Mean = 2.50, SD = 1.263)

Deficits in digital sustainability capabilities, such as energy-efficient computing, e-waste management, and digital environmental monitoring systems, are shown by the comparatively large gap in green ICT skills. Significant variety among respondents is shown by the high standard deviation, which implies that certain departments may have partial exposure while others may not. This result is in line with recent research demonstrating the ongoing emergence of green digital transformation in TVET. Due to inadequate digital infrastructure and staffing levels, African TVET institutions are falling behind in integrating ICT-based sustainability skills, according to UNESCO [19]. In a similar vein, a World Bank analysis from 2023 points out that most developing economies still have inadequate structures for integrating digitization and environmental sustainability, especially when it comes to vocational training. Consequently, the observed disparity reveals a crucial future-oriented talent gap that may restrict graduates' employability in digital-green businesses.

7.6.3. Waste Management Skills Gap (Mean = 2.28, SD = 0.786)

When compared to other areas, the waste management skill gap is comparatively smaller, indicating that the organization has some awareness or training. The mean, however, still shows a moderate shortfall, indicating that sophisticated approaches (such as recycling systems and circular economy activities) and practical application are still lacking. This conclusion is corroborated by [17], which states that although waste management is the most frequently taught green skill in African TVET institutions, it is frequently restricted to basic awareness rather than the development of technical proficiency. Similarly, study by [12] demonstrates that, because of insufficient facilities, waste management instruction in TVET is usually theoretical and lacks practical application. As a result, the college's moderate gap indicates limited practical implementation but partial integration.

7.6.4. Sustainable Agriculture Skills Gap (Mean = 2.13, SD = 0.741)

Although the value still shows a considerable shortfall, the lowest mean score suggests that sustainable agriculture abilities have the smallest perceived gap. This implies that some fundamental information might be present, perhaps as a result of Ethiopia's TVET systems' heavy emphasis on agricultural education. This result is in line with [2] observation that, in comparison to other green sectors, agricultural TVET programs in Ethiopia and East Africa have comparatively stronger incorporation of sustainability ideas, especially in soil conservation and climate-smart agriculture. But FAO also highlights how underdeveloped advanced sustainable methods like climate-resilient farming and precision agriculture are. Similarly, research by [1] shows that although there are many agricultural TVET programs, they frequently don't use innovation-based teaching methods. As a result, the comparatively smaller gap indicates that training in sustainable agriculture has partially improved but is still inadequately modernized.

Table 5. *Which Green skill dominates green jobs.*

In the next 10 years, which green skills will dominate green jobs?				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Artificial intelligence for sustainability	76	60.3	60.3	60.3
Smart renewable energy systems	25	19.8	19.8	80.2
urban sustainability planning	17	13.5	13.5	93.7

In the next 10 years, which green skills will dominate green jobs?				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Green innovation and circular economy design	8	6.3	6.3	100.0
Total	126	100.0	100.0	

According to the results, the majority of respondents (60.3%) strongly believe that artificial intelligence (AI) for sustainability will be the most important green skill for the next ten years. This is followed by smart renewable energy systems (19.8%), urban sustainability planning (13.5%), and green innovation and circular economy design (6.3%). This is a clear anticipation that digital transformation and cutting-edge technologies, especially AI-enabled environmental monitoring, smart energy management, and data-driven sustainability solutions, would be major drivers of future green jobs.

This view is consistent with recent international research that highlights AI's role as a key facilitator of the green transition through energy efficiency, emission reduction, and better environmental decision-making [11, 27]. The International Renewable Energy Agency cites the need for qualified experts in solar, wind, and intelligent grid technologies as a major factor in the expansion of green jobs globally, and this is reflected in the predominance of smart renewable energy systems.

Despite literature emphasizing their significance for long-term environmental resilience and resource efficiency, the comparatively low recognition of circular economy design and urban sustainability planning suggests limited awareness of broader systemic sustainability approaches [17, 22]. Overall, the findings show that respondents are more likely to link future green occupations with high-tech, AI-driven solutions than with comprehensive sustainability systems. This finding both reflects a global change and points to a possible knowledge deficit regarding integrated green economy competencies.

Table 6. *In the next 5 years, which green skills will be most demanded.*

In the next 5 years, which green skills will be most demamnded?				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Solar & renewable energy systems	84	66.7	66.7	66.7
Climate-smart agriculture	16	12.7	12.7	79.4
Waste recycling & circular economy	17	13.5	13.5	92.9
Environmental monitoring & ESG skills	9	7.1	7.1	100.0
Total	126	100.0	100.0	

According to the findings, the majority of respondents (66.7%) believe that solar and renewable energy systems will be the most in-demand green skills over the next five years, followed by waste recycling and circular economy skills (13.5%), climate-smart agriculture (12.7%), and environmental monitoring and ESG skills (7.1%). This implies that the expansion of renewable energy, especially solar technology, is a major focus of short-term green labor market aspirations, reflecting Ethiopia's and Africa's larger energy transition strategy.

This result is in line with recent reports showing that, as investment in off-grid and grid-connected renewable energy projects increases, solar energy installation, maintenance, and system design are among the fastest-growing green job sectors in Sub-Saharan Africa [25]. In line with [17] findings that such skills are still emerging in developing economies, the moderate emphasis on the circular economy and climate-smart agriculture demonstrates recognition of sustainability in production and resource efficiency, even though these areas are not yet seen as dominant job drivers. Despite their growing significance in global green economy frameworks, the comparatively low need for environmental monitoring and ESG skills indicates a lack of understanding of regulatory, reporting, and sustainability governance competences [10, 22]. Overall, the results show that while more general environmental governance and systemic sustainability abilities are still underappreciated, short-term labor market expectations are heavily concentrated on renewable energy technology.

Table 7. Government Green Policies.

Government green policies				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
very high	26	20.6	20.6	20.6
low	32	25.4	25.4	46.0
moderate	24	19.0	19.0	65.1
high	26	20.6	20.6	85.7
very high	18	14.3	14.3	100.0
Total	126	100.0	100.0	

The findings reveal a mixed perception of government green policies, with responses ranging from very high (20.6%) to high (20.6%), moderate (19.0%), low (25.4%), and again very high (14.3%). This suggests that respondents' assessments of the government's commitment to green policies are generally moderate to positive. When taken as a whole, the higher ratings (high and very high) indicate that a considerable percentage of respondents acknowledge strong governmental efforts to promote green transformation, while the presence of a significant low rating (25.4%) reflects perceived gaps in institutional effectiveness and policy implementation.

This conflicting view is in line with recent research that contends that while Ethiopia and many other African nations have created ambitious green economy strategies, such as renewable energy policies and climate-resilient green economy (CRGE) frameworks, their implementation is still uneven because of a lack of institutional capacity, lax enforcement, and inadequate resource allocation [25, 16]. In a similar vein, [17] observes that while many developing nations exhibit strong policy drafting, they struggle to implement green policies in educational and training institutions. In addition, [22] highlights that policy-practice gaps, where knowledge of national goals does not always convert into curriculum modification or skill development, are a significant obstacle to greening TVET systems. Consequently, the results indicate that although government green initiatives are generally regarded as existing and somewhat effective, their actual institutional impact is still uneven and underutilized.

Table 8. Climate Change Pressure.

Climate change pressure				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Very low	17	13.5	13.5	13.5
low	32	25.4	25.4	38.9
moderate	34	27.0	27.0	65.9
high	18	14.3	14.3	80.2
very high	25	19.8	19.8	100.0
Total	126	100.0	100.0	

With responses ranging from very low (13.5%) to low (25.4%), moderate (27.0%), high (14.3%), and very high (19.8%), the results show that respondents view climate change pressure as generally moderate but becoming more significant. The majority falls into the moderate group, indicating that while the effects of climate change are already apparent in the institutional and operational environment, they are not yet widely felt at an extreme level. But when the high

and very high replies are combined (34.1%), a sizable portion of respondents acknowledge that climate change is putting significant pressure on the environment, indicating rising environmental stress and awareness of climate-related issues.

This pattern is in line with recent research highlighting the growing climate variability in Sub-Saharan Africa, including rising temperatures, erratic rainfall, and resource stress, all of which have an immediate impact on agriculture, education, and technical training systems [4, 25]. According to [17], developing economies are experiencing increased pressure from climate change, especially in sectors related to agriculture and energy, which are extremely susceptible to changes in the environment. According to [22], training programs must incorporate climate resilience and adaptation skills due to TVET institutions' growing exposure to climate stresses. Consequently, the results indicate that although the pressure from climate change is not always seen as severe, it is already a major and expanding factor affecting institutional knowledge and the requirement for the development of green capabilities.

Table 9. *Industry Transformation.*

Industry transformation					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	very low	25	19.8	19.8	19.8
	low	24	19.0	19.0	38.9
	moderate	42	33.3	33.3	72.2
	high	17	13.5	13.5	85.7
	very high	18	14.3	14.3	100.0
	Total	126	100.0	100.0	

According to the findings, respondents believe that industry transformation is generally at a moderate stage. The largest percentage of responses (33.3%) fall into this group, followed by very low (19.8%), low (19.0%), high (13.5%), and very high (14.3%). This distribution indicates that although some industrial transformation progress is acknowledged, it is not yet seen as completely developed or pervasive. While the combined low and very low responses (38.8%) show that many still perceive limited transformation within their operational context, the high and very high responses (27.8%) show that a significant portion of respondents acknowledge ongoing structural changes in industry, particularly linked to technological upgrading and green transition processes.

This result is in line with recent research that contends that many developing economies are still in an intermediate stage of industrial transformation, marked by the gradual adoption of digitalization, energy-efficient practices, and green production systems rather than extensive industrial restructuring [11, 25]. In a similar vein, [16] notes that while African industries are making a "dual transition" toward both digital and green economies, development is unequal because of inadequate infrastructure, low investment, and weak innovation ecosystems.

TVET institutions are essential in promoting industrial transformation through skill development, according to [22]. However, in many situations, there is still a lack of alignment between training systems and changing industrial needs. Consequently, the results indicate that industry transformation is beginning to take shape but has not yet reached its full potential, indicating a transitional stage in which opportunities and structural limitations coexist.

Table 10. *Technological Advancement.*

Technological advancement					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	very low	8	6.3	6.3	6.3
	low	16	12.7	12.7	19.0
	moderate	33	26.2	26.2	45.2

Technological advancement					
		Frequency	Percent	Valid Percent	Cumulative Percent
	high	34	27.0	27.0	72.2
	very high	35	27.8	27.8	100.0
	Total	126	100.0	100.0	

According to the findings, the majority of respondents reported very high (27.8%) and high (27.0%) levels of technical advancement in their context, followed by moderate (26.2%), low (12.7%), and very low (6.3%). increasingly over half of the respondents (54.8%) acknowledge significant technical advancement, indicating that digitalization and contemporary technologies are becoming increasingly apparent in institutional and industrial processes. Overall, this distribution demonstrates a definite move toward favorable opinions. The existence of a sizable intermediate group, however, also suggests that this progress is still uneven and not entirely unified across all domains.

This result is consistent with recent international and regional research showing that digital tools, automation, and smart systems are driving a rapid but unequal technological revolution in developing economies. For example, according to the World Bank (2023), digital transformation is growing quickly in African countries, especially in the fields of education, energy, and industry, but it is still limited by gaps in infrastructure and unequal access.

In a similar vein, the [11] highlights that while many institutions are still in the intermediate phases of adoption, technology innovation is becoming increasingly important to productivity and green transition processes. TVET systems are starting to incorporate cutting-edge technology like artificial intelligence (AI), the Internet of Things (IoT), and digital learning platforms, according to [23]. However, the degree of integration differs greatly throughout institutions. As a result, the results indicate that while technological progress is robust and expanding, it is nevertheless marked by uneven development and partial integration, indicating a period of transitional digital transformation.

Table 11. *International Green Standards.*

International green standards					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	very low	25	19.8	19.8	19.8
	low	24	19.0	19.0	38.9
	moderate	17	13.5	13.5	52.4
	high	34	27.0	27.0	79.4
	very high	26	20.6	20.6	100.0
	Total	126	100.0	100.0	

The findings indicate that respondents' perceptions of the level of worldwide green standards are generally moderate to high, with the highest percentage stating high (27.0%) and very high (20.6%) levels, followed by low (19.0%), very low (19.8%), and moderate (13.5%). In their institutional or industrial setting, over half of the respondents acknowledge a strong influence or understanding of worldwide environmental and sustainability norms, according to the combined high and very high responses (47.6%). Nonetheless, a sizable percentage of low and very low responses (38.8%) suggests that adherence to, awareness of, or use of such standards is not yet entirely uniform across all domains, suggesting inconsistent alignment with international green frameworks.

This result is in line with recent research that demonstrates that although global sustainability reporting frameworks and ISO 14001 environmental management systems are having an increasing impact on developing countries, their adoption is still uneven and incomplete. Due to a lack of institutional capacity and regulatory enforcement, many institutions in poor

nations are still in the early phases of implementing international environmental norms, according to [17]. In a similar vein, [11] observes that while global sustainability norms are increasingly influencing corporate and educational practices, there are still implementation gaps, especially in lower-income economies where compliance costs and technical competence are scarce.

TVET institutions are gradually being exposed to global green standards through curriculum reform and international alliances, although complete integration into training systems is still evolving, according to [22]. As a result, the results indicate that while worldwide green standards are becoming more widely acknowledged and partially integrated, their application is still inconsistent and in transition, necessitating further institutional alignment and capacity building.

Table 12. *The Institution is ready to supply future green skills.*

the institution is ready to supply future green skills					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	strongly disagree	16	12.7	12.7	12.7
	disagree	18	14.3	14.3	27.0
	neutral	41	32.5	32.5	59.5
	agree	43	34.1	34.1	93.7
	strongly agree	8	6.3	6.3	100.0
	Total	126	100.0	100.0	

The findings show that respondents' opinions of the institution's preparedness to provide future green skills are somewhat favorable but ambiguous. While lower percentages stated strongly disagree (12.7%), disagree (14.3%), and highly agree (6.3%), the greatest percentage of respondents chose "agree" (34.1%), followed by neutral (32.5%). Overall, this distribution shows that while a sizable part of respondents think the institution is somewhat prepared, a sizable portion are unsure or doubtful, suggesting that preparedness is not yet entirely institutionalized or consolidated.

This result is consistent with recent research that highlights the fact that many TVET institutions in developing nations are still in a transitional stage of green skills preparedness, where structural constraints coexist with policy goals and incomplete implementation. While TVET institutions are increasingly expected to provide future-oriented green capabilities, many still lack the infrastructure, qualified teachers, and updated curricula necessary to adequately meet this need, according to [22]. Similarly, the [25] notes that inadequate teacher capacity development, poor industrial connections, and low equipment investment frequently impede African TVET systems' ability to create green skills. Additionally, [17] emphasizes that institutional preparedness for green transformation depends on both policy commitment and practical implementation capacity, which varies throughout institutions. As a result, the results indicate that although the institution shows some developing preparedness for the supply of green skills in the future, this preparedness is still incomplete, unpredictable, and needs to be strengthened through curriculum reform, capacity building, and resource investment.

Table 13. *Curriculum Supports green job preparation.*

The curriculum supports green job preparation					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	disagree	26	20.6	20.6	20.6
	neutral	57	45.2	45.2	65.9
	agree	35	27.8	27.8	93.7

The curriculum supports green job preparation				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
strongly agree	8	6.3	6.3	100.0
Total	126	100.0	100.0	

The findings show that respondents' perceptions of whether the curriculum promotes green job preparedness are generally moderate but substantially ambiguous. Neutral was chosen by the greatest percentage of respondents (45.2%), followed by agree (27.8%), disagree (20.6%), and strongly agree (6.3%). The majority of neutral responses indicate that many respondents are unsure about the breadth, consistency, or visibility of green content within the curriculum, even though a sizable portion of respondents (34.1% combined agree and strongly agree) believe that the curriculum helps prepare learners for green jobs. This suggests that while green job preparation exists, it is not yet fully integrated or acknowledged in every program.

This finding is consistent with recent literature which shows that although many TVET curricula in developing countries are gradually being revised to include sustainability and green competencies, the integration process remains partial and inconsistent. [22] reports that curriculum greening is one of the slowest areas of TVET reform, mainly due to inadequate instructional materials, limited teacher preparedness, and weak curriculum design frameworks. Similarly, the [25] emphasizes that in many African TVET systems, green skills are often included as supplementary content rather than fully integrated into core training programs, which limits their visibility and effectiveness in preparing graduates for green jobs. UNEP (2023) further highlights that effective green job preparation requires competency-based curriculum redesign aligned with labor market demands, which is still underdeveloped in many institutions. Therefore, the findings suggest that the curriculum in the institution is partially supportive of green job preparation, but its effectiveness is constrained by limited integration, weak implementation depth, and insufficient clarity among stakeholders.

Table 14. *What strategies are most effective?*

Which strategies are most effective?					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Curriculum redesign	75	59.5	59.5	59.5
	Industry partnership (green sectors)	26	20.6	20.6	80.2
	Equipment modernization	17	13.5	13.5	93.7
	Green innovation labs	8	6.3	6.3	100.0
	Total	126	100.0	100.0	

According to the results, the majority of respondents (59.5%) believe that curriculum revision is the best way to support the development of green skills. Green innovation laboratories (6.3%), equipment modernization (13.5%), and corporate alliances with green sectors (20.6%) come next. Overall, the results indicate that when addressing the gaps in green skills, stakeholders should give more weight to structural modifications in curriculum frameworks and teaching material than to innovative or infrastructure-based solutions. The prevalence of curriculum reform emphasizes the idea that integrating sustainability and labor market-relevant green competences into training materials is the first step toward effectively transforming TVET systems.

Recent research that highlights curriculum reform as the cornerstone of greening TVET systems provides substantial support for this conclusion. According to [22], integrating sustainability competences into curriculum rather than treating them as supplemental modules is crucial for the successful integration of green skills. In a similar vein, the [25] contends that the most economical and scalable approach to enhancing workforce preparedness in developing nations is curriculum restructuring in line with the objectives of the green economy.

This perspective is further supported by [17], which claims that curriculum transformation has a greater impact when paired with competency-based training strategies that take into account actual labor market demands.

The constraints seen in African TVET institutions, where limited institutional-industry links limit practical exposure to developing green technology, are reflected in the comparatively lower emphasis on industry collaborations and innovation laboratories [11, 22]. Similarly, the low priority given to equipment modernization indicates that respondents may view infrastructure investment as significant but secondary to curriculum change, despite research demonstrating that both updated curricula and sufficient practical facilities are necessary for effective green skills training. Consequently, the results show that while a variety of approaches are pertinent, curriculum redesign is thought to be the most important starting point for enhancing the development of green skills, with supporting roles for industry engagement, infrastructure enhancement, and innovation ecosystems.

8. Overall Forecast of Green Skill Demand

The overall results show that Dejazmach Geresu Duki Industrial College's green capabilities are growing but are still uneven, indicating that Addis Ababa is presently undergoing a transition to a green economy. Although the growth of green skills (72.2%) demonstrates encouraging momentum, the system is nevertheless immature due to ongoing deficiencies in important competency categories. According to this tendency, the demand for green skills in the future is likely to grow gradually rather than drastically. According to recent research [25, 22], many African nations are heading toward a green transition stage where demand is driven by growing industries rather than fully developed green sectors. As a result, the overall prediction points to an increasing but uneven need for green skills that is influenced by sectors development and institutional preparedness.

8.1. Short-Term Forecast (Next 5 Years): Renewable Energy Dominance

As seen by the highest response rate (66.7%), the results clearly show that solar and renewable energy systems will dominate the demand for green skills in the near future. This indicates that renewable energy technology, specifically solar installation, maintenance, and system operation, will play a major role in the immediate future of green jobs in Addis Ababa. Ethiopia's larger energy transformation plan and growing investments in off-grid and grid-connected renewable technologies are in line with this. Due to increased energy consumption and climate pledges, the fastest-growing green employment sector in Africa is renewable energy, according to supporting literature [7, 25]. TVET is therefore the most important skill area for rapid workforce growth, as the short-term prognosis indicates that graduates will mostly be employed in jobs related to renewable energy.

8.2. Medium-Term Forecast (5–10 Years): Digital-Green Convergence

The results also show that green jobs will be dominated by artificial intelligence for sustainability in the next ten years (60.3%), indicating a significant movement toward digital-green convergence. This implies that cutting-edge technology like artificial intelligence (AI), smart energy systems, and data-driven environmental management will play a bigger role in future green jobs. This illustrates a structural shift in which environmental solutions become increasingly mechanized and digitalized. By increasing energy efficiency, lowering emissions, and optimizing resource use, AI is emerging as a key driver of sustainability, according to recent worldwide research [10, 27]. Additionally, [22] emphasizes the growing significance of the "twin transition," which integrates green and digital capabilities. As a result, the medium-term prognosis indicates a change from jobs in physical renewable energy to more sophisticated, technologically advanced sustainability roles.

8.3. Skill Gap and Supply Risk Forecast

The examination of skill gaps indicates ongoing deficiencies in waste management, green ICT, sustainable agriculture, and renewable energy. These gaps suggest that future demand will probably outpace present supply, which could lead to a labor market mismatch. The largest disparity in green ICT and renewable energy indicates that educational institutions are not yet ready to provide the advanced technical skills needed by developing green businesses. This is in line with international data demonstrating that, as a result of poor infrastructure and insufficient training capacity, many African TVET systems experience severe shortages of experts in digital sustainability and renewable energy technicians [7, 22]. Therefore, unless specific initiatives are put in place to improve training systems, the forecast indicates an increasing danger of skills mismatch.

8.4. Institutional Readiness and Supply Constraints

The results also demonstrate that, with a high percentage of ambivalent responses, institutional preparedness to provide future green skills is moderate but uncertain. This suggests that even while the institution has started incorporating green talents, it is still not entirely prepared to handle future demand. This uncertainty is exacerbated by problems including poor industrial connectivity, insufficient equipment, and restricted curricular integration. This is consistent with recent research

that contends structural constraints, rather than a lack of policies, frequently hinder TVET preparation in poor nations [22, 25]. According to the estimate, institutions may find it difficult to satisfy the demands of the future green labor market if they do not make substantial investments in curriculum reform and capacity building.

9. Policy and System-Level Outlook

The results also show conflicting opinions of the government's green initiatives and mild climate pressure, suggesting that although policy frameworks are in place, their application is still uneven. As a result, there is a growing need for green skills but inconsistent institutional and policy support. According to research, there is a continuing gap between the development and implementation of green policies in many African nations, especially in the areas of education and training [16, 17, 22] Emphasizes that improved coordination between national policies and TVET curricular revisions is necessary for a sustainable green transition. As a result, the system-level perspective indicates that while policy support is present, it has not yet been fully converted into successful skill development results.

10. Integrated Forecast Model for Addis Ababa Green Jobs

The results allow for the projection of Addis Ababa's future green employment market into three phases. Demand will concentrate on jobs related to renewable energy, such as solar technicians and energy system installers, in the near future (0–5 years). Demand for smart energy systems, urban sustainability planning, and environmental monitoring positions will change in the medium term (5–10 years). Over the next ten years or more, the market will shift toward smart city engineering, circular economy design, and advanced AI-driven sustainability roles. This gradual shift is consistent with a global trend in which economies gradually transition from low-tech green technologies to highly digitalized sustainability systems [25, 27].

11. Conclusion

This study looked at Dejazmach Geresu Duki Industrial College's green talent development, skill shortages, institutional preparedness, and future demand for green jobs. The results show that the institution is presently in a transitional stage of integrating green capabilities, with some progress made but still large structural and competency gaps. While advanced fields like renewable energy, green ICT, and sustainable agriculture continue to be weak, green skills like waste management, environmental management, and green construction exhibit modest progress. This unequal progress is a result of poor technology infrastructure, inadequate training resources, and restricted curricular integration.

Although the study's preponderance of seasoned teachers offers reliable, practice-based insights, the absence of various stakeholders implies that the results mostly represent internal institutional viewpoints rather than the larger TVET ecosystem. Despite this drawback, the data unequivocally demonstrates that the development of green skills is growing but has not yet reached complete institutionalization.

Regarding future labor market trends, the report indicates a shift toward digital-green convergence, with renewable energy systems driving need for green jobs in the medium term and AI-based sustainability solutions driving demand in the long run. However, institutional preparedness is now only moderate, and respondents' perceptions of the curriculum's support for preparing students for green jobs are still ambiguous and weak. If corrective action is not taken, this mismatch between growing demand and constrained institutional capability raises the possibility of a future skills shortage.

Overall, the study finds that although Dejazmach Geresu Duki Industrial College is moving closer to greening its TVET programs, the system is still in the early stages of transformation, marked by uneven implementation, partial integration, and a lack of readiness for the demands of the emerging green economy.

12. Recommendations

Based on the results, a number of important suggestions are made to improve the development of green talents and match the organization with the demands of the labor market in the future.

First, a thorough curriculum overhaul that methodically incorporates green skills into all technical and vocational programs should be the college's top priority. To guarantee that all graduates gain important sustainability skills, green competences should be integrated into core training modules rather than being viewed as optional content. This will assist in closing the existing gap between the requirements of green jobs and curriculum material.

Second, investing in state-of-the-art equipment and labs is necessary to enhance practical training, especially in the areas of environmental management systems, green ICT, and renewable energy technologies. Theoretical knowledge cannot be successfully converted into employable skills without sufficient resources and facilities.

Third, in order to boost practical exposure, internship possibilities, and labor market alignment, the institution should strengthen its partnerships with industry, particularly with businesses in the green sector. Training programs will reflect the technological and environmental demands of the actual world if there is strong industrial collaboration.

Fourth, specific capacity-building initiatives for educators should be put into place, with an emphasis on cutting-edge green technology including solar energy systems, artificial intelligence for sustainability, circular economy strategies, and

climate-smart agriculture. To keep instructors abreast of global green trends, they must engage in ongoing professional development.

Fifth, in order to ensure that national green economy plans are successfully transformed into institutional practices, policymakers and TVET administrators should collaborate to develop policy implementation mechanisms. This includes improved structures for accountability, monitoring, and money distribution.

Lastly, in order to prepare students for future changes in the labor market, the institution should encourage awareness and integration of advanced green skills like AI-based sustainability and smart energy systems. This will assist in bridging the gap between the output of present training and the new global trends in green jobs.

Abbreviations

TVET	Technical and Vocational Education and Training
DGIC	Dazazmach Geresu Duki Industrial College
FAO	Food and Agricultural Organizations
FGD	Focal Group Discussion
AI	Artificial Intelligence
ICT	Information Communication Technology
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
MoE	Ministry of Education
UNDP	United Nations Development Programme
OECD	Organization for Economic Co-Operation and Development

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Conflicts of Interest

The authors declare that there is no conflict of interest.

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