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Reframing Green Skills Ecosystems in Fragile States: A Case Study of Lebanon's Workforce Transition

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Abstract:

As countries confront environmental and economic crises, the shift to a green economy depends not only on technological innovation but on strategic workforce development. This paper introduces a novel green skills ecosystem framework, integrating institutional theory, education-to-employment pathways, and just transition principles to analyze how countries, particularly fragile states, can build inclusive green labor markets. Using Lebanon as a contextual case study, the paper identifies critical gaps in training access, policy alignment, and governance coordination. By bridging global conceptual insights with national-level dynamics, the research reframes green skills not only as labor market attributes but as systemic capacities essential to equitable and resilient sustainability transitions. The findings offer transferable insights for policy, education reform, and global green skills governance in crisis-affected and developing regions.

Keywords:

Green Economy, Green Skills, Workforce Development, Just Transition, Lebanon

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Introduction

The In recent years, the global push toward sustainability has brought the concept of the green economy to the forefront of academic, policy, and labor market discussions. A green economy emphasizes the need to harmonize economic growth with environmental stewardship and social equity, offering a pathway to address climate change, resource depletion, and economic inequality simultaneously. At the heart of this transition lie green jobs, occupations that contribute directly or indirectly to environmental objectives, and the green skills required to perform them effectively.

As economies shift toward greener models, the demand for a workforce capable of supporting sustainable industries is accelerating. This demand is not only quantitative but qualitative, requiring a rethinking of education systems, vocational training, and employment policies. Yet, the pace of technological change, coupled with evolving environmental regulations, has outstripped the capacity of many educational and labor systems to keep up, resulting in a widening green skills gap. This gap poses a critical challenge to the success and inclusiveness of green transitions worldwide.

While a growing body of literature explores green employment and sustainability-related competencies, there remains a critical gap in linking macro-level green transition theories with country-level workforce realities, especially in fragile or crisis-affected states. Most studies remain either abstractly conceptual or limited to high-income contexts. This study addresses that gap by proposing a green skills ecosystem model that captures the institutional, educational, and policy enablers necessary for inclusive green transitions. It combines global theory with a contextual analysis of Lebanon, providing both analytical depth and empirical relevance.

This study examines the critical role of green skills in enabling a sustainable economic transition, and to assess Lebanon's preparedness in this regard. Specifically, the study addresses three interrelated research questions:

- What are the essential skills and competencies required in the green economy?
- What challenges and gaps exist in aligning education and training systems with green labor market needs?
- How can countries like Lebanon design and implement more effective policies and educational programs to close the green skills gap?

To answer these questions, this study is grounded in an original conceptual framework that integrates institutional theory, sustainability transitions, and the skills ecosystem approach. It views green skills development as a systemic process influenced by the interplay between national policy structures, educational and vocational institutions, and labor market actors, under the broader influence of global climate and economic pressures.

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As illustrated in Figure 1, green skills emerge through three development channels: formal education, vocational training, and informal learning. These pathways are mediated by institutional enablers (policy, education, and labor systems) and constrained by structural barriers such as governance fragmentation, equity gaps, and misalignment with market demand. This conceptual model provides the analytical foundation for the dual-level approach adopted in this study: a global literature review and a contextual analysis of Lebanon.

Figure 1: Institutional Transition Model for Green Skills Development.

The above framework links global sustainability drivers and national workforce development outcomes via institutional enablers, education-employment interfaces, and governance systems. It highlights how green skills are shaped by interactions between training institutions, policy environments, and labor markets, particularly in fragile contexts.

This study makes three original contributions to the literature on green skills and workforce development in the context of sustainability transitions.

First, it introduces a green skills ecosystem model that integrates institutional theory, sustainability transition frameworks, and the skills ecosystem approach. This model conceptualizes green skills as the product of dynamic interactions between education providers, labor market actors, and governance systems.

Second, the study applies this model to the underexplored case of Lebanon, a country experiencing overlapping crises but showing signs of grassroots green transition. This application offers unique insight into green skills development in fragile or crisis-affected states.

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Third, the research bridges conceptual and empirical gaps by connecting high-level sustainability goals to practical, country-specific challenges in education, training, and employment. In doing so, it offers policy-relevant lessons for other developing countries facing similar structural barriers to green workforce readiness.

The conceptual foundation of this study draws from three interrelated theoretical strands:

- Institutional theory (North, 1990; Scott, 2001) provides a lens to examine how formal and informal rules, regulatory fragmentation, and organizational structures influence the capacity of national systems to support green workforce development. Institutions are viewed as both constraints and enablers in shaping how green skills emerge, are recognized, and are supported by policy.
- Sustainability transitions theory (Geels, 2002; Markard et al., 2012) helps frame the green economy as a systemic shift that requires changes not only in technology, but also in education, social practices, and governance structures. Green skills are situated within the broader multi-level transition process involving niche innovations, regime change, and landscape pressures.
- The skills ecosystem approach (Buchanan et al., 2001; Wheelahan et al., 2012) conceptualizes the co-evolution of skills supply and demand through coordinated action among firms, training institutions, government bodies, and labor market intermediaries. This perspective emphasizes the need for alignment between education systems and sectoral labor market needs.

Together, these theories inform the green skills ecosystem model (Figure 1) used to analyze how green jobs are generated, how green skills are developed, and why misalignments persist, especially in fragile and under-governed contexts such as Lebanon.

Literature Review

The literature review is structured to lay the foundation for the proposed green skills ecosystem model. Drawing from the fields of sustainability transitions, institutional theory, and education-labor policy, the review explores the evolution of the green economy concept, defines the scope of green skills, and identifies systemic barriers in workforce development. The synthesis focuses on how skills gaps emerge, how education systems respond, and how governance frameworks enable or constrain inclusive transitions.

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Conceptual Foundations: Green Economy, Green Jobs, and Green Skills

A green economy is the shift from the conventional economic paradigms and represents an effort toward building sustainability, environment consciousness, and social inclusivity (Schulz & Bailey., 2014). A green economy focuses on aligning economic growth and environmental welfare, acknowledging the interdependence of human wealth as well as environmental prosperity (Fiorino, 2018).

Sustainability is a basic pillar of the green economy (D'amato & Korhonen, 2021). It involves satisfying current needs without endangering the capabilities that the next generations have to meet their demands. This requires sustainable use of natural resources, highlighting an equilibrium between consumption and conservation (Elsawy & Youssef, 2023).

The green economy has another central aspect which is the principle of resource efficiency. This encompasses the rational use of resources to limit waste and emissions (Prokopowicz, 2020). Clean technologies, sustainable production practices, and comprehensive recycling programs are a crucial part of the resource efficiency strategies (Nižetić et al., 2019). Secondly, the character of the green economy is a change from conventional fuels to sustainable energies (Scheer, 2013). The priority on solar, wind, and hydroelectric power leads to a decrease in carbon emissions which is currently one of the pressing issues – climate change (ÓhAiseadha et al., 2020). This change highlights the significance of sustainable energy practices in implementing a green economy.

Unmüßig et al. (2016) identified social equity as the central dimension of green economy This entails ensuring that the gains from sustainable practices are shared fairly among members of society. These are the factors of job generation, availability of clean energy, and social integration that are vital for developing such an inclusive and equitable green economy.

The green economy is propelled by innovation and technology. Efforts of research and development concentrate on green infrastructure along with eco-friendly technologies that help to promote sustainable economic progress. The trends of the green economy are influenced greatly by technological advancements (Capasso et al., 2019).

On the other hand, green jobs are an integral part of the workforce that strives to promote environmental sustainability and support a shift toward a green economy. These job opportunities are known to be directly related to ecological benefits, climate change abatement, and sustainable practices in all sectors (Altenburg & Rodrik 2017; Söderholm 2020).

In the field of green jobs, various positions can be identified which play an essential role in different aspects of environmental conservation and sustainability. Renewable energy occupations, like solar panel installers, wind turbine technicians, and sustainable engineering experts are the cornerstones of

the green job scenery (Jennings,2009; Curtis & Marinescu, 2023). Such roles contribute to fostering clean and sustainable energy initiatives that are essential in reducing reliance on fossil fuel.

Green jobs include sustainable agriculture. Environmental-friendly farming is practiced by professionals dealing with organic agriculture, permaculture practices, and agroecology (Rahmann et al., 2017). By giving priority to biodiversity, reducing the use of harmful chemicals, and implementing sustainable agricultural practices, these people contribute directly to environmental health and resilience (Shroff & Cortés 2020).

Apart from these, green jobs include professionals in areas of sustainable resource management and recycling activities (Saeed, 2019). Such professionals include waste management specialists, recycling coordinators, and circular economy practitioners. These initiatives help reduce the impact on the environment, promote resource use efficiency, and move towards more sustainable consumption.

The importance of green jobs does not only depend on their environmental impact but also on how they contribute to the development of a green economy (Unay-Gailhard & Bojnec, 2019). Such roles ensure the provision for workers needed to actualize sustainable practices in an effort not only to deal with challenges posed by climate change but also to promote economic growth and social equity. With pressure for environmental accountability extending on a world level, the requirement of green jobs is relied upon to expand thus offering concrete possibilities for a sustainable and resilient future (Lee & Tang 2018).

Additionally, green skills represent a particular skillset for knowledge, abilities, and competencies that individuals acquire to perform activities aimed at ensuring environmental sustainability leading to support the aims of a green economy (Pavlova 2018). All these skills are crucial in ensuring that the issues associated with environmental degradation, climate change, and the transition towards sustainability practices across industries are addressed (Vona et al., 2018).

Technical Proficiency in Sustainable Practices (Rodriguez et al., 2018; Pappas et al., 2018): Green skills require extensive knowledge of sustainable practices in certain fields. This can include knowledge about clean energy technologies, green design, and the use of eco-friendly technology. People with green skills have technological proficiency that enables them to make contributions towards programs of developing and implementing sustainable solutions.

Interdisciplinary Knowledge (Kelly et al., 2019; Pavlova, 2019): Green skills are usually transverse, as they require people to add environmental issues in various fields. The interconnectedness between environmental health, economic activities, and social well-being must be understood by professionals. This cross-sectoral approach provides a comprehensive understanding of sustainability problems and solutions.

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Adaptability and Innovation (Ogbeibu et al., 2021; Sharma et al., 2021): In a dynamic environment, green skills focus on adaptability and creativity. People must remain aware of the advances in technology, new environmental regulation trends, and market shifts. Green skills encompass the capacity to innovate and apply new practices that conform to changing sustainability standards.

Resource Management and Conservation (Cabral & Dhar et al., 2019; Cabral & Dhar, 2021): The green skills are resource management and conservation. This includes the ability to apply resource efficiency, minimization of waste, and circular economy principles. Sustainable utilization of resources as well as minimizing an environmental impact is contributed by green skilled professionals.

Communication and Stakeholder Engagement (Vona et al., 2018): Communication is an essential component of green skills, where professionals have to communicate sophisticated environmental ideas to a wide group of stakeholders. It involves collaborating with different communities, policymakers, and businesses to promote dialogue on the meaning of sustainability so that everyone can work together towards maintaining cleanliness.

Green skills play a significant role in ensuring the establishment of a workforce that possesses knowledge about how to make sustainable choices for emerging green economies. In the transformation of industries into environmentally responsible, green-skilled individuals act as agents for change and promote innovation with conditions that favor sustainability principles (Rosenberg et al., 2018).

Educational institutions and training programs are critical in ensuring that people develop green skills (Ramlia et al., 2019). For instance, by providing environmental conservation courses and training modules on renewable energy and sustainable practices these programs help develop a sophisticated workforce that can meet the challenges provided by the green economy (Auktor, 2020).

Opportunities and Constraints in Green Job Creation

Many researchers, such as Arcelay et al. (2021) and Mealy and Teytelboym (2022) focus on the development of industries including renewable energy, eco-construction, and nature conservation. In particular, Ram (2020) highlights the development of qualified professionals in renewable energy technologies; it also observed an increase in demand for solar panel installers and wind turbine technicians.

In addition, as highlighted by Ali et al. (2021), the green economy also serves as a driving force for innovation. Similarly, Ustundag et al. (2018) concur, emphasizing that an experienced and skilled workforce is essential for the transition to sustainability, as it is capable of driving the development and adoption of new technologies. So, the emergence of green jobs is a chance for professionals who have skills in trendy technologies and sustainable approaches to frame a new ecologically sound economy.

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Nevertheless, a closer analysis reveals some weaknesses and intricacies surrounding the potential of green economy jobs. Majid (2020) and Zhang et al. (2021) focus on the importance of sustainable green job creation strategies that are fair to all employers while also advocating for inclusive growth. The authors point out that while some industries might see development, such as renewable energy, others may suffer from displacement. A just transition is essential to prevent the deepening of existing social and economic gaps.

One of the important recurrent themes in literature is a skills gap. As highlighted by Anderson (2017) and Garcia (2019), there also is a specific demand for the relevant skills in the green workforce. This faster pace of technological and practice, innovation presents the challenge for education programs as they have to keep updating with constant upskill requirements. This brings up issues with diversity and accessibility, as some groups may struggle to gain the required green competencies.

Also, the literature warns against over-depending on some sectors, especially renewables. According to Vona et al. (2018), Pavlova (2018), and Cabral and Dhar (2021), renewable energy is integral in the green economy; however, a holistic approach should also be adopted for resilience reasons. Focusing too much on one industry may end up as a weakness, given the fact that global markets are ever-changing and rapidly developing technologically.

Skills Gaps and Capacity Challenges in the Green Economy

One of the recurrent themes in literature is that green skills demand does have a dynamic nature. Some authors point out the fast-changing character of the green economy, which requires periodic recalibration of skill requirements and this is Vona et al. (2018) and Mealy and Teytelboym (2022). This dynamic in turn poses significant challenges for educational institutions and training programs, which find themselves struggling constantly to keep their curricula corresponding with the development of demand from a green workforce.

Philip and Reisch (2018) also point to the importance of interdisciplinary skills. Although proficiency in particular green sectors is important, professionals must also be able to apply environmental considerations through broader lenses. According to the literature, sustainability challenges require individuals with interdisciplinary skills to be better prepared because holistic education is required.

The critical lens is also used towards the problem of inclusivity and equity in terms of green skills accessibility. Scholars like Maclean et al. (2018) contend that the skills gap worsens social inequalities with certain demographic groups having difficulties obtaining appropriate education and training. This leads to issues of green skills development programs accessibility and the possibility of inequalities perpetuation by future emerging green workforce.

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The issue of the 'just transition' arises prominently in discussions about skills deficits. In response to this challenge, authors such as Mercier (2020) and Carley and Konisky (2022) critically examine policy structures and strategies designed to facilitate a fair transition, assessing their effectiveness in mitigating adverse social and economic impacts.

The corporations' role in addressing skills gaps has been examined by scholars such as McGuinness et al. (2018) and Vona et al. (2018). The literature critically evaluates business responsibility to invest in employee training and development, as well as collaboration among academia, industry, and government in developing green skills programs. However, questions are raised about the willingness of private institutions to support a skilled workforce and how partnerships materialize into real skill development attainments.

A distinctive thread in the literature on service delivery focuses on sustainability literacy and behavioral change. For instance, Woltering et al. (2019) and Aust et al. (2020) critically review the effectiveness of educational approaches aimed at promoting sustainability literacy and assess whether these strategies contribute to transformative behavioral change among workers.

In addition, a critical analysis of skill gaps requires distinguishing between global perspectives and local realities. According to Syed and Ozbilgin (2019), as well as Wenhai et al. (2019), regional differences in priorities, environmental challenges, and economic structures lead to varying demands for skills. The literature critically reflects on the influence of global paradigms on green skills development and emphasizes the need for differentiated approaches that account for local contexts.

So, the green economy skills gap literature offers a detailed representation of knowledge on challenges and intricacies associated with generating an adequately qualified labor force. The thematic review sheds light on the complex nature of the skills gap discourse, underscoring adaptive education system workability, inclusive policies implementation, or corporate responsibility assessment. Furthermore, it reveals nuanced understandings of sustainability literacy awareness within relevant private and commercial organizations. Future research directions should focus on the efficacy of specific interventions, policy frameworks, and educational approaches in addressing the targeted skills gaps thereby establishing a more dynamic understanding to develop green skills.

Building on these insights, this study positions the proposed green skills ecosystem model within the existing body of research. It contributes to the literature on sustainability transitions by proposing an integrative conceptual model that positions green skills not merely as individual attributes but as systemic capacities embedded in institutional arrangements. While existing models, such as the International Labour Organization (ILO)'s Just Transition framework, Buchanan et al.'s skills ecosystem theory, and Geels' Multi-Level Perspective (MLP), each address key aspects of green labor market transformation, they do so in partial isolation.

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The green skills ecosystem model developed here advances the field in three ways:

- Synthesis of Multi-Disciplinary Theories: It bridges institutional theory, sustainability transition frameworks, and education-to-employment systems into a single analytical lens.
- Focus on Fragile States: It adapts transition theory to fragile and under-governed contexts, an area largely underexplored in the literature.
- Governance and Equity Emphasis: Unlike earlier models, this framework explicitly highlights governance fragmentation and equity gaps as structural constraints on skills development and green job readiness.

As such, this model reframes green skills not only as outputs of labor market demand but as indicators of institutional resilience and inclusive transition planning. The integrated model provides the conceptual foundation for the methodological design outlined in the following section.

Methods and Data

This study adopts a qualitative, dual-level design: (1) a narrative literature review of global conceptual frameworks and empirical studies on green jobs and skills, and (2) a contextual case study of Lebanon.

The first component of the methodology is a structured narrative literature review of scholarly publications, international policy reports, and institutional documents. Sources were selected from peer-reviewed journals, working papers, and publications by international organizations such as the ILO, UN agencies, and the World Bank. This review focuses on several interconnected themes central to the understanding of sustainable economic transformation. It begun by exploring the definitions and key dimensions of the green economy, green jobs, and green skills, establishing a conceptual foundation for subsequent analysis. The literature review forms the theoretical and conceptual foundation of the current study, enabling the identification of core competencies, global barriers, and potential strategies relevant to green labor markets.

The second component of the study presents an in-depth contextual analysis of Lebanon as a national case, offering a concrete illustration of how a country grapples with simultaneous socio-economic crises and emerging opportunities in the green economy. This case study is developed through a comprehensive analysis of secondary data sources, including national policy documents and development strategies, reports and datasets from international organizations such as the International Labour Organization (ILO), United Nations High Commissioner for Refugees (UNHCR), and Union for the Mediterranean – Chamber of Commerce and Industry (EMME-CCI), as well as various Lebanese ministries. In addition, academic studies focusing on Lebanon's labor market, energy transition, and environmental education provide further depth to the analysis.

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The Lebanese case is organized around three key analytical axes. First, it explores the sectoral potential for green job creation in fields such as renewable energy, green construction, and sustainable agriculture. Second, it examines the educational and vocational training programs that support the development of green skills, identifying both progress and existing gaps. Third, it analyzes structural challenges that hinder effective implementation, including policy fragmentation, unequal access to resources and opportunities, and weak institutional coordination.

This case study was analysed using qualitative content analysis. Policy documents, sectoral reports, and academic studies were coded thematically according to the components of the proposed green skills ecosystem model. Coding categories reflected institutional enablers, skills development pathways, and governance barriers relevant to green workforce readiness. Themes emerging from Lebanon's data were then compared with the global literature review to identify convergences, divergences, and context-specific factors. This approach allowed for a systematic alignment of national evidence with international frameworks without imposing external assumptions.

This twofold methodological approach, combining a comprehensive literature review with an in-depth national case study, directly addresses the study's three research questions. The literature review serves to identify the essential skills and competencies required in a green economy (RQ1) while also highlighting global challenges related to aligning labor market demands with existing education and training systems (RQ2). Complementing this, the case study of Lebanon provides empirical insight into how these global challenges are experienced and interpreted within a specific national context. It offers context-specific evidence that informs the design of targeted policy interventions and educational reform strategies aimed at fostering green skills development (RQ3).

By integrating conceptual exploration with grounded contextual analysis, this mixed-method approach ensures both analytical breadth and empirical depth. It enables the study to contribute meaningfully to theoretical debates on sustainability transitions while also informing practical discussions on workforce development in low and middle-income countries.

Results

Green Job Prospects in Lebanon's Transition Economy

Despite its unique economic and environmental circumstances, Lebanon offers a range of green economy jobs providing both direct and indirect support to sustainable solutions (EMME-CCI 2022).

For instance, the overall findings of the ILO (2019) report on the future of green jobs in Lebanon indicate that there is considerable job creation potential in going green in Lebanon. As new environmentally sustainable technologies and practices are introduced and adopted, new job opportunities across all the

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studied sectors are expected to appear. Already several green jobs exist in all the studied sectors, including in renewable energies and energy-efficient appliances, organic agriculture and integrated pest management, green construction as well as in several green waste management activities, such as sorting, composting, and recycling. If an enabling environment is created to advance the transition towards a green economy, several further green job opportunities in these activities can be created. Recent empirical evidence from Lebanon confirms these prospects, highlighting both sectoral demand and major misalignments in education and training systems (Bellakhal et al., 2025)

One key dimension of Lebanon's transition toward a green economy lies in the direct jobs generated from green energy. Lebanon holds significant potential for direct employment opportunities generated by the expansion of green energy initiatives as reported by UNHCR (2019 and 2022). With a focus on renewable energy sources, and jobs in the installation and maintenance of solar panels. This was mainly motivated and supported after the economic crisis when the Lebanese started to drastically install solar panels. This has, for instance, encouraged many students to pursue passes related to electrical engineering, and electric and renewable energy businesses are flourishing.

Therefore, skilled technicians, solar engineers, and wind energy specialists are crucial in harnessing Lebanon's ample sunlight and wind resources. Additionally, the establishment of green power plants, dedicated to solar and wind energy production, opens avenues for plant operators, maintenance personnel, and project managers, contributing directly to the country's renewable energy ambitions.

In parallel, indirect jobs within companies committed to green solutions are contributing to the diversification of the green job market in Lebanon.

Businesses adopting eco-friendly practices, such as sustainable construction firms, waste management companies, and green technology providers, create demand for a range of professionals. Architects and engineers specializing in green building standards, waste management specialists, and experts in circular economy practices find opportunities to contribute to sustainable business practices. Moreover, professionals in marketing, finance, and project management roles within these green-committed companies play pivotal roles in steering the adoption of sustainable strategies, contributing indirectly to the green economy (El-Daghar et al., 2022; Saad et al., 2022).

Key Economic Sectors Driving Green Employment

The prospect of a sustainable future for Lebanon sprang from the daunting challenges in economic, financial, and environmental statuses that took root mainly due to its intrinsic need to maintain sustainable solutions.

The main sectors that are flourishing and expected to flourish in the next few years are:

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- Renewable Energy Sector: Rooftops, warmed by the sun invite solar PV installation and maintenance technicians to make homes and industries cleaner. Skilled wind turbine technicians keep these towering giants spinning, while energy auditors diagnose energy hogs and retrofit specialists transform buildings into models of efficiency. Therefore, as Lebanon chases ambitious renewable energy targets, expect a surge in demand for solar engineers and project managers for large-scale solar farms, battery storage specialists to tame renewable energy's intermittency, and meteorologists and wind resource analysts to pinpoint the perfect windswept spots for future turbines (Elmustapha, H., & Hoppe, 2020; Moore & Collins, 2020).
- Green Buildings and Construction: Green architects and engineers weave sustainability into the fabric of buildings, optimizing energy efficiency and water conservation (Faour et al., 2020). Skilled hands of insulation technicians and green materials manufacturers translate blueprints into reality. This sector promises a bright future for circular economy specialists who guide businesses towards minimizing waste and reusing resources (Scholz & Fink, 2022). Expect rising demand for green building material producers specializing in sustainable bricks, recycled insulation, and bio-based construction elements (Sshibani et al., 2021).
- Sustainable Agriculture and Waste Management: The land needs competent organic farmers and agroecologists who look after healthy soil and varied habitats. Composting and the production of biofertilizers guarantee new life for waste, while workers involved in collecting wastes and recyclables ensure that resources are reused instead of being thrown away. Thus, in the context of Lebanon’s pursuit of sustainable practices, there will emerge possibilities for precision agriculture specialists who utilize technology to drive efficient use and regenerative agricultural expertise where soil fertility, as well as biodiversity, is restored. Waste management systems design and innovative recycling technologies will be in high demand as the circular economy continues to grow

Supportive Collaborations and Legal Frameworks

Cross-sector collaboration and innovation reflect the convergence of direct and indirect jobs in Lebanon’s green economy. Practitioners of environmental impact assessment, climate adaptation strategies, and sustainable urban planning are integral to ensuring that diverse industries adopt green principles. Collaborations between traditional sectors and emerging green businesses generate hybrid roles that combine expertise from multiple domains, yet these initiatives remain under-supported by both government and private-sector actors (Bou Karroum, 2020).

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Policy advocacy and environmental consulting have also emerged as specialized roles essential to the country's green transition. Pro-sustainability professionals contribute to shaping the legal framework by promoting sustainable laws and regulations. Because eco-friendly practices form the foundation of long-term sustainability, the expertise offered by environmental consultants positions them as critical advisors for businesses and governmental bodies seeking to navigate sustainable development (EMME-CCI, 2022).

Sector	***Skills Needed***	***Current Gaps***	***Governance Barrier***
Renewable Energy	Solar panel installation, system maintenance, energy auditing	Training mostly informal, lack of certification	Absence of national certification authority
Green Construction	Eco-design, energy-efficient retrofitting, sustainable materials	Limited specialized training; low green material access	No enforcement of green building codes
Sustainable Agriculture	Organic farming, agroecology, precision agriculture	Curricula outdated, weak practical exposure	Fragmented roles between agriculture/environment ministries
Waste Management	Recycling operations, composting, circular economy planning	Few structured training programs; informal work	Weak cross-sectoral coordination

Table 1: Mapping Green Skills Gaps in Lebanon's Key Sectors.
Source: The Authors, based on EMME-CCI (2022), UNHCR (2019, 2022), Bellakhal et al. (2025), Makdissi et al. (2024).

The above provides an overview of the wide variety of existing and future sustainable environment employment opportunities in Lebanon. This movement allows people with high levels of proficiency who have a desire to contribute towards environmental sustainability and lead fulfilling professional lives.

University-Level Green Education in Lebanon

As the green wave sweeps through Lebanon's universities, diverse programs and degrees designed to equip the students with competencies required by this vastly developing sector are being introduced. Here's a glimpse into some of the exciting options available:

- Renewable Energy: As Lebanon continues its transition toward sustainable energy sources, universities across the country are responding by offering specialized programs in renewable energy. At the American University of Beirut (AUB), the Master of Science in Environmental Sciences and Management with a focus on Renewable Energy Engineering provides a comprehensive curriculum covering solar, wind, and other clean energy technologies. The program prepares students for diverse careers in project development, system design, and energy policy analysis. Similarly, the Lebanese University (LU) offers a Master of Science in Renewable Energy Systems, which emphasizes the technological

aspects of solar, wind, biomass, and geothermal energy. Through lab-based instruction and field projects, students acquire valuable hands-on experience in the sector. At Université Saint-Joseph (USJ), the Master of Science in Clean Energy and Sustainable Design adopts a holistic approach, blending knowledge of renewable energy systems, energy efficiency, and sustainable architectural design. The program encourages students to develop innovative, environmentally responsible solutions to today's energy challenges.

- Green Buildings and Construction: In response to growing demand for sustainable infrastructure, Lebanese universities are also launching programs centered on green building and sustainable construction. Beirut Arab University offers a Master of Engineering in Sustainable Design and Construction, which equips students with the expertise to design energy-efficient buildings, apply water conservation strategies, and select environmentally responsible construction materials. At the Holy Spirit University of Kaslik, the Master of Science in Sustainable Architecture and Landscape focuses on integrating sustainability principles into architectural and landscape design. The program seeks to balance the built environment with natural ecosystems, using resources wisely and creatively; moreover, this university offers an undergraduate program, a Bachelor of Science in Environmental Engineering with a concentration in Sustainable Buildings, that lays a solid foundation in engineering while emphasizing green design. These programs prepare students to meet the challenges of environmentally conscious construction and to lead Lebanon's future in sustainable urban development.
- Sustainable Agriculture and Waste Management: Sustainable agriculture and waste management are critical components of Lebanon's green economy, and academic institutions are beginning to provide specialized training in these areas. At the American University of Beirut, the concentration in Sustainable Agriculture and Food Systems within the Master of Science in Environmental Science and Management explores sustainable farming techniques, food security, and agroecology. This program empowers students to tackle major environmental and agricultural challenges through innovative and responsible practices. The Lebanese University complements this effort with its Master of Science in Sustainable Agriculture and Rural Development, which emphasizes eco-friendly farming practices that also support the economic resilience of rural communities. Université Antonine contributes to the waste management field with a Bachelor of Science in Environmental Management specializing in Waste Management. This undergraduate program trains students to manage waste effectively through reduction, recycling, reuse, and composting strategies. These offerings reflect the growing recognition of agriculture and waste management as vital sectors for Lebanon's sustainable development.

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While the growing number of green-focused academic programs in Lebanese universities signals an important and commendable shift toward sustainability, this evolution is still in its early stages and faces several limitations. Although these programs provide students with essential knowledge and technical skills, their alignment with actual labor market demands and national policy frameworks remains inconsistent. Moreover, gaps persist in funding, interdisciplinary integration, and institutional support for applied research and innovation. These issues mirror broader regional trends, as higher education institutions across the MENA region continue to face barriers in fostering academic entrepreneurship and innovation in sustainability fields (Achkouty et al., 2024).

In many cases, the connection between academic training and real-world employment opportunities in the green economy is not yet fully established. Therefore, while these educational initiatives represent a positive step toward building a skilled green workforce, they must be complemented by stronger collaboration between universities, the private sector, and public institutions to ensure that green education translates into meaningful employment and systemic transformation. The road toward a fully integrated green skills ecosystem in Lebanon is promising, but it still requires coordinated effort, investment, and long-term strategic planning.

Public Sector Initiatives and Vocational Training in Green Education

While Lebanon's Ministry of Education has begun to revise its national curriculum to more thoroughly incorporate green concepts, dedicated courses targeting green professions remain scarce. Nonetheless, key initiatives reflect early progress in embedding sustainability in education (ILO, 2022; Mehe, n.d.):

- Green Seeds in the Curriculum: One such initiative is the Environmental Education Project, launched in 2005, which integrates environmental education across primary, secondary, and vocational education levels. This program introduces students to fundamental environmental issues and promotes awareness of sustainable practices and responsible resource management. By weaving environmental content into various subjects and school activities, the project fosters ecological consciousness from an early age.
- In parallel, the Ministry of Education has partnered with UNESCO to implement Education for Sustainable Development (ESD) within the national curriculum. The objective of this initiative is to equip learners with the knowledge, competencies, and values necessary to contribute effectively to sustainable development. Through ESD frameworks, students are encouraged to think critically, consider long-term impacts, and take proactive roles in their communities' environmental and social well-being. These curricular reforms, though still evolving, mark an important foundation for building green literacy among Lebanon’s youth and preparing future professionals for emerging green sectors.

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- Vocational Training Blossoms: In addition to curriculum reform, vocational training has emerged as a vital pathway for preparing a workforce aligned with the demands of the green economy. The Ministry of Education, in collaboration with technical and vocational institutes, has launched several training programs aimed at equipping students with practical skills for green jobs. Among these, the Renewable Energy Technician program trains students in the installation, maintenance, and repair of renewable energy systems, including solar panels and wind turbines. Another key offering is the Energy Auditor program, which prepares individuals to evaluate the energy performance of buildings and propose improvements for energy efficiency.

Furthermore, the Organic Agriculture Technician program introduces trainees to sustainable farming techniques, soil conservation, and organic crop management, while the Waste Management Technician program focuses on practices such as waste collection, recycling, composting, and sorting methods. These programs reflect a growing recognition of the need to align vocational education with green market opportunities.

Beyond the public sector, private institutions and NGOs are also active in promoting green vocational training. For instance, Beit el Baraka offers hands-on training in composting, organic farming, and environmental stewardship, empowering participants with skills applicable to community-based sustainability efforts. Similarly, Arcenciel has developed comprehensive training modules in waste management, recycling operations, and environmental awareness. These complementary efforts by the government, private sector, and civil society together help cultivate a generation of technically skilled professionals equipped to support Lebanon's transition to a green economy.

While this study focuses on Lebanon, a brief comparison with Tunisia provides a useful contrast in green skills governance within the MENA region. Tunisia, unlike Lebanon, has established national skills councils and sectoral forecasting mechanisms that guide TVET adaptation to labor market shifts (Bellakhal et al., 2025). Though both countries face economic hardship and fragmented policy implementation, Tunisia's structured institutional response has enabled better alignment between training supply and green sector demand. This contrast underscores the relevance of the green skills ecosystem model in diagnosing not just systemic barriers but also institutional levers for policy reform.

Discussion

The findings of this study reveal a multidimensional and evolving landscape for green jobs and green skills, shaped by global sustainability imperatives and complex national realities.

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Reframing Skills as a Strategic Pillar for Green Transitions

Green skills are no longer peripheral to the labor market; they are increasingly recognized as strategic assets for national development, particularly within the context of climate adaptation, environmental regulation, and inclusive economic recovery. Global literature underscores that technical proficiencies, such as those in renewable energy and green construction, must be complemented by cross-cutting competencies like interdisciplinary thinking, adaptability, and systems-oriented problem solving. These results align with global studies that pair sector-specific skills with transversal competencies and extend them by specifying constraints distinctive to fragile systems.

Lebanon's trajectory reveals both opportunities and constraints in this regard. The country has experienced a spontaneous expansion in renewable energy, particularly in solar power, as a bottom-up response to the protracted national electricity crisis. This pattern is consistent with niche-led diffusion under strong landscape pressures in sustainability transitions, while weak regime institutions keep diffusion informal.

However, in the absence of formal training programs, certification systems, and regulatory oversight, this growth remains fragile. Without institutional support, these green jobs risk remaining informal, hazardous, and inaccessible to many segments of society, thus limiting the long-term potential of Lebanon's green transition.

The Structural Skills Gap: A Double Vulnerability

The international literature identifies the skills gap as one of the most persistent barriers to achieving green transitions, manifesting both quantitatively and qualitatively (Vona et al., 2018; Pavlova, 2018). Quantitatively, there are simply not enough trained workers available to meet the growing demand in green sectors. Qualitatively, even those workers present often lack the interdisciplinary and adaptive skills necessary to respond to evolving sustainability requirements. Lebanon reflects both of these dimensions acutely. Framed against skills-ecosystem research, this HE–TVET–industry disconnect reflects coordination failures among providers, employers, and regulators in fragile contexts.

Although several universities, including the Lebanese University, American University of Beirut, and Université Saint-Joseph, have initiated green-oriented academic programs, these remain largely urban-centric and disconnected from real-time labor market needs. Technical and Vocational Education and Training (TVET) programs in renewable energy and waste management exist but suffer from outdated equipment, low enrollment, and weak connections to private industry. As a result, Lebanon is unable to generate a green-skilled workforce that is both technically competent and socially inclusive. This challenge is compounded by the broader effects of Lebanon's economic collapse, which have deeply affected the operational capacities and training investments of local SMEs (Makdissi et al., 2024).

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This skills mismatch is compounded by the broader governance crisis. Fragmentation across ministries, particularly those responsible for education, labor, and energy, has prevented the development of a unified national skills strategy. The absence of a coordinated roadmap for green skills development, coupled with minimal inter-ministerial collaboration, severely hampers the creation of a coherent and responsive workforce development system.

Policy and Market Disjunctures: The Risks of Spontaneity

A significant insight drawn from this research is the lack of alignment between organic, market-driven green job creation and the state's capacity to regulate and support this growth. In Lebanon, the rise of solar energy employment is largely driven by individual and private-sector responses to the chronic energy crisis. While this underscores citizen resilience and entrepreneurial agility, it also points to the dangers of unregulated market spontaneity.

According to Carley and Konisky (2020), green employment must be anchored in the principles of a "just transition" to avoid deepening social and economic inequalities. In Lebanon, the lack of certification pathways, labor protections, and inclusive training structures exposes green workers to precarious conditions. Without proactive state interventions, this spontaneous job growth could entrench existing disparities, particularly for vulnerable groups such as rural youth, women, and displaced populations. Ensuring equitable participation in the green economy thus requires deliberate policy action, targeted investments in skills, and safeguards that protect workers' rights and promote social cohesion. Our evidence supports just-transition findings that unregulated green growth can reproduce inequality, and contributes a fragile-state case showing how absent certification and protections deepen precarity.

The Role of Educational Institutions: Promise and Limitations

Lebanese educational institutions are beginning to play a more active role in the country's green transition. Universities and vocational schools have introduced programs across areas such as renewable energy systems, green building practices, and sustainable agriculture. These developments signal a growing recognition of the green economy's demands. Yet, the pace and reach of this educational reform remain insufficient. Chronic underfunding, faculty shortages, and an overreliance on theoretical instruction continue to undermine the effectiveness of these institutions.

Moreover, there is a consistent gap between academic training and real-world application. As noted in international research (Ogbeibu et al., 2021; Ramlia et al., 2019), the absence of soft skills development, such as teamwork, communication, and leadership, combined with limited opportunities for experiential learning, renders many graduates ill-prepared for the dynamic needs of green industries. In Lebanon, the lack of formal linkages between universities, technical schools, and the private sector means that green education is often delivered in a vacuum. Additionally, the neglect of soft skills such as

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communication, adaptability, and teamwork in most training programs undermines workforce readiness for green sectors, as these skills are shown to significantly affect organizational performance (Makdissi et al., 2024).

Mechanisms like green skills councils, sectoral training boards, and joint curricula development remain underutilized, limiting the ability of educational institutions to produce job-ready green professionals. This is consistent with international practice where inter-ministerial task forces and skills councils improve alignment; Lebanon's gap helps explain why efforts remain projectized.

Cross-Sector Synergies and Missed Opportunities

The success of green transitions depends not only on individual sectoral advancements but on cross-sectoral collaboration. International experiences show that institutionalized partnerships, linking infrastructure, labor, education, and environmental agencies, can significantly boost the scale and effectiveness of green job creation (Auktor, 2020; UNIDO, 2020). Countries that establish national green economy task forces or inter-ministerial coordination bodies often exhibit stronger employment outcomes and more cohesive sustainability strategies.

While various NGOs and international bodies such as UNHCR and EMME-CCI have launched green job training initiatives, these efforts tend to remain project-based and disconnected from national development plans. The result is a proliferation of isolated success stories without systemic transformation. Programs often lack continuity, scalability, and impact assessment, making it difficult to build a resilient and integrated green workforce.

This situation presents a significant missed opportunity. The Lebanese government has the potential to act as a central orchestrator, harmonizing education reform, labor market intelligence, and sectoral investment around a shared vision for green growth. Without such coordination, promising initiatives will remain fragmented and unable to catalyze long-term, sustainable change.

The Way Forward: Building an Inclusive and Resilient Green Workforce

Overall, our findings converge with prior prescriptions on policy coherence, TVET modernization, and labor-market intelligence, while contributing a governance-sensitive blueprint for fragile contexts.

To fully realize the potential of green jobs in Lebanon, a multi-pronged approach is needed. First, policy coherence and inter-ministerial coordination must be prioritized through the development of a national green skills strategy that integrates climate goals with economic recovery plans. This strategy should clearly define institutional roles and align educational pathways with sectoral demand.

Second, vocational and applied training institutions require urgent modernization. This includes upgrading infrastructure, revising curricula, and fostering strong partnerships with the private sector to

ensure that training is both relevant and responsive. Third, inclusivity must be embedded in all workforce development efforts. This entails scaling up gender-sensitive and geographically distributed training programs that provide equitable access for all social groups, particularly those historically marginalized. Moreover, integrating financial literacy into green training can increase SME resilience in times of economic and environmental uncertainty (Makdissi et al., 2025).

Furthermore, national labor observatories or skill intelligence platforms should be established to monitor labor market trends and align educational outputs with green economy needs. Lastly, universities and training centers must adopt innovative curricula that emphasize interdisciplinary learning, systems thinking, and hands-on problem solving, skills that are critical for addressing complex sustainability challenges.

Lebanon's transition to a green economy is not solely a matter of technological adaptation or economic restructuring, it is a question of governance, equity, and societal vision. To build a truly inclusive and resilient green workforce, the country must invest not only in skills but also in institutions, policies, and social frameworks that support long-term sustainability and shared prosperity.

The green skills ecosystem model proposed in this study offers a transferable framework for analyzing the institutional architecture of workforce readiness in fragile states.

Policy-wise, it offers a roadmap for countries with fragmented systems to operationalize green human capital strategies.

Key actions include: establishing inter-ministerial coordination bodies, developing sector-based training roadmaps, aligning curricula with climate targets, and ensuring inclusive access to green training across gender and geography. Future applications of this model can support comparative research across regions facing complex crises.

Conclusion

The transition to a green economy constitutes not only an environmental imperative but a structural reconfiguration of labor markets, education systems, and governance frameworks. This study has examined the central role of green skills in enabling such a transition, situating its analysis at the intersection of global sustainability discourse and Lebanon's national context. Through a comprehensive narrative literature review and a contextualized country case study, the study has provided a multilayered understanding of the competencies required for green jobs, the barriers to skills alignment, and the policy frameworks necessary for an inclusive and resilient workforce transformation.

At the global level, the findings confirm that green skills extend beyond technical proficiencies to encompass interdisciplinary knowledge, adaptability, innovation, and stakeholder engagement. These

competencies are increasingly indispensable across sectors such as renewable energy, sustainable agriculture, construction, and circular economy models. However, the persistent skills gap, exacerbated by uneven access to training, weak institutional coordination, and limited employer engagement, poses a critical constraint on the scalability and equity of green job creation.

The Lebanese case substantiates these challenges while also demonstrating context-specific dynamics. Although the spontaneous growth of solar energy jobs and the proliferation of green academic programs point to latent potential, the lack of systemic planning, inclusive access, and state-led coordination undermines long-term sustainability. The country's fragmented governance, underfunded education systems, and absence of national skill forecasting mechanisms hinder its ability to leverage the green transition as a vector for recovery and resilience.

This study makes three core contributions to the literature. First, it reconceptualizes green skills as a multidimensional construct essential for structural transformation in both advanced and developing economies. Second, it offers a rare integration of global trends with a granular national case study in a lower-middle-income context, addressing a gap in comparative green economy research. Third, it presents actionable insights into the institutional, educational, and policy reforms required to operationalize green skills frameworks at the national level.

The implications of this research are both theoretical and practical. Theoretically, it invites a rethinking of human capital development within ecological macroeconomic models, highlighting the need to integrate labor dynamics more explicitly into environmental transition frameworks. Practically, it calls for the establishment of green skills governance mechanisms, such as national task forces, green jobs observatories, and competency-based curricula, capable of aligning education supply with labor market demand in dynamic sustainability sectors.

Future research should focus on three key areas: (1) empirical evaluations of green training program outcomes in developing economies; (2) comparative analyses of green skills integration across TVET, higher education, and informal learning systems; and (3) the role of private sector coalitions and industry associations in shaping inclusive green labor markets. Longitudinal studies tracking the evolution of green employment patterns in response to policy changes would also enrich the evidence base.

A green transition without a green-skilled workforce is not only incomplete, it is unsustainable. Countries like Lebanon, facing compounding crises, must view the development of green human capital not as a peripheral policy option but as a central pillar of national resilience. Only through coherent, inclusive, and forward-looking education-to-employment systems can the promise of the green economy be fully realized.

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