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REVIEW

Mainstreaming green skills in India: Theoretical lenses, institutional mechanisms and challenges in skill development

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ABSTRACT

Developing green skills is critical as a prerequisite for facilitating the transition of India towards sustainability, low carbon emissions and resilience to climate change. With growing international concern over clean energy, ecological sustainability, and circular production, there is no doubt about the importance of acquiring competencies in these areas in India. The current paper is devoted to providing a comprehensive review of existing data on the topic of green skills development in India in terms of concepts, policies, sectors, and institutions. The review is grounded in the context of Sustainable Development Goals (SDGs) by the United Nations, particularly SDG 4 (Quality education), SDG 7 (Affordable and clean energy), SDG 8 (Decent work and economic growth), SDG 9 (Industry, innovation and infrastructure), and SDG 13 (Climate action). It is evident that despite the development of some programs (such as Green Skill Development Programme (GSDP), Greening Framework of NSDC, skilling in renewable energy and waste management) there remain numerous gaps. The challenges lie in regional imbalances and inadequate integration of green-skills competence in order to hinder equal progress. Despite the aforementioned obstacles, there are plenty of opportunities to use public- private partnerships, entrepreneurship among young people, e-learning and transition justice tools. The study concludes with a set of policy recommendations aimed at achieving a coherent, inclusive, future-ready green-skills ecosystem that advances India's progress on the above SDGs. Prioritizing holistic workforce development aligned with climate commitments can help India leverage green skills as a key driver of economic competitiveness, social equity, and long-term environmental stewardship.

KEYWORDS

Green skill; Sustainable Development Goals; Sustainable development; Green job; Renewable; Workforce

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Introduction

Green Skill has gained significant importance from academic and policy interest over the past decade, due to increasing concern over climate change, environmental degradation and a changing labour market. For a growing country like India, sustainability and economic growth are inextricably linked. There is a need for clarity on the concept and application of green skills. According to UNESCO, there is a need for streamlining green skills with Technical and Vocational Education and Training (TVET) [1]. Further, UNESCO added the following terms- environmental literacy, problem-solving and systematic thinking, adaptability in the changing work context, and resource- efficient technical skills, into its definition. The International Labour Organization (ILO) defines Green Skill as the knowledge, abilities, values, and attitudes required to live in, develop, and support a sustainable and resource-efficient society. World Economic Forum defines green skill as the development of competencies that enable individuals and organizations to operate in alignment with global sustainability objectives. Therefore, green skill may be defined as a systematic approach to mould the technical knowhow of the workforce in a manner that suits sustainable development.

Green skills have been categorized by scholars and international organizations into four main interconnected groups. Core technical green skills encompass specialized skills in relation to green technologies usage and maintenance, such as installation and maintenance of solar photovoltaics, battery maintenance of and servicing electric vehicles, energy audit, waste segregation and recycling, as well as water conservation and rainwater harvesting technologies. Transversal and analytical green skills enable sustainable decision-making in different spheres and include environmental monitoring and compliance, resources management, lifecycle analysis, as well as sustainability data-based assessment [2]. Green soft skills and behavioural skills, such as environmental ethics, sustainable consumer behaviour, interdisciplinary collaboration and adaptability in rapidly developing green sectors are now recognized as vital. Lastly, entrepreneurial green skills, becoming ever more relevant in the light of growth of sustainability-driven entrepreneurship in India, help develop innovations in relation to green business models, eco-innovation, social entrepreneurship and green finance literacy. Thus, green skills are not limited only to technical fields and include all types of competences needed for sustainable development [3,4].

Within the Indian case, sustainable economic development is an essential prerequisite for development within the country. Due to the increasing use of renewable energies and environmentally friendly methods of production, there is a need to develop green skills. Green skills refer to technical, managerial, and behavioural skills which integrate environmental sustainability with economic development [5]. There is an increasing body of literature on India's approach towards developing its labour force through policies, training, and the institutional structure [6]. The World Bank revealed that less than 6% of jobs within India are considered green skills, showing the gap between available skills and future demands of the green economy. This gap and the associated urgency in policy terms form the basis of the present study [7].

Based on the above rationale, the present study examines the existing body of knowledge on green skill development within India, highlights gaps and future directions. The present study will examine the current policy framework, sector dynamics, and opportunities and challenges of green skill development within India to support its SDGs commitment.

The justification for such a review becomes stronger considering

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the increasing number of publications related to green skills training, which have been ignored in the original research. Internationally, according to Safee and Kosnan, in their review of the TVET literature through a narrative review, the development of green skills in higher education is being constrained by inconsistencies in the definition of green skills, misalignment between academia and industry, as well as pedagogical barriers such as large class sizes and assessment practices leaving no room for personalized and practical learning experiences - barriers very similar to those observed for India in this paper [7]. In particular, as far as India is concerned, Suresh Kumar and Shobana review the history of the country's initiatives in green education and the problems associated with the incorporation of sustainable development into the educational system, while Bongirwar and Das illustrate with the example of architectural education how NEP 2020 provides an opportunity for the embedding of green considerations into professional curricula [9,10]. Beyond education, literature that is relevant to this study includes the analysis of the National Green India Mission Scheme and the constraints that hinder green entrepreneurship in Umajyothi and Surendran, the proposal of an Indian state-level workforce ESG and decarbonization strategy for India in comparison to its G20 and BRICS peers by Pasupuleti, the discussion of the role of AI in overcoming the problem of outdated curricula and inequality of access to green-skills training via TVET in Subrahmanyam, and the recommendation of green skills integration into education as climate action in Kaushiva [10-13]. It should be noted that the issues raised in this literature, namely curriculum, capacity and definition issues discussed for India below, are relevant to the body of literature as well [14].

Research Gaps

Even with increased emphasis on green skills development in India both through policy and scholarship, several gaps continue to exist within research. The majority of studies on green skills have tended to be focused on renewable energy and waste management, yet other important sectors such as construction, manufacturing, agriculture, and e-mobility have not received adequate attention in empirical investigations. Green skills competency mainstreaming through education and vocational training has not been comprehensively studied, particularly with regard to the framework of the curriculum and its market relevance. Much of the literature tends to offer only descriptive and thematic analyses without comparative and longitudinal insights into sectoral performance. The impact of green skills framework in relation to marginalized groups and promotion of just transition in carbon-heavy regions, including coal mining areas, has not been explored. Information on green occupations in the labour market, changes in skill gaps and wage outcomes is still missing, and existing reports do not feature strong data or comparisons across various sectors. Finally, there is a need for a comprehensive evaluation of green skilling initiatives undertaken by the government of India such as GSDP and NSDC's Greening Framework.

Research Methodology of the Study

Given the requirement of a transparent and reproducible research base outlined above, an approach of Systematic Literature Review (SLR) methodology is adopted in the current study. This includes following PRISMA guidelines for a scoping-style SLR as per its general principles. Below follows the description of three phases of the research methodology namely search strategy, screening and selection, and thematic synthesis.

Search strategy

A systematic review of research papers from a range of database sources including Google Scholar, Scopus, and government/institutional websites was carried out employing the keywords such as “green skills”; “development of green skill in India”; “present status of green skill in India”; “Skill Council for Green Jobs in India”; and “India's policy on green skill”. This included employing the above keywords separately and in Boolean combination (for instance, "green skill" AND "India" AND "policy") [16,17].

Screening and selection criteria

Records that were located through the searching process were screened in two rounds. In the title/abstract round, sources were included if they covered green skills, green jobs, or any workforce development in India related to sustainability issues; sources related to green economy in international perspective without reference to India were not included, as well as sources that were just promotional web pages. In the full-text round, the remaining sources, which consisted of academic papers in journals and books, policy papers by governmental institutions and multilateral/industry organizations' reports, were selected based on their relevance to the four key themes of analysis: theoretical framework, institutional and policy instruments, sector-specific factors, and gaps/barriers.

Evidence extraction and thematic synthesis

Peer-reviewed journal articles, book chapters, policy frameworks and reports by the government that have been selected at the end of screening were fully read and the evidence extracted using a common template that included the theoretical approach used, the institutions and policies highlighted, the sectors addressed and any barriers, gaps or opportunities identified. The extracted evidence was then thematically synthesized rather than a narrative synthesis of the sources being performed so as to build the framework used in sections Theoretical lenses underpinning green skills to Key Gaps, Opportunities and Policy Recommendations of this paper whereby the theoretical approaches, institutional approaches, sectoral issues, and barriers mentioned below are all backed up by the keyword-based evidence base that has been compiled.

Theoretical Lenses Underpinning Green Skills

Drawing on the evidence base assembled through the systematic review described in . Research Methodology of the Study, the importance of green skills can be viewed from the following three theoretical standpoints.

Human capital theory

According to Human Capital Theory proposed by Becker, the acquisition of skills would enhance productivity, economic output, and national competitiveness [18]. So far as the green context is concerned: Economically, the payoffs of investments in green skills include job creation in renewables, waste management, and EVs. Through efficient resource utilization, the skilled workers reduce deterioration in the environment. Greater skill levels would also enable the countries to compete in green value chains internationally. As such, green skilling represents both an economic imperative and a development opportunity for India, which faces persistent problems of youth unemployment and skill mismatches.

Ecological modernization theory

The theory of Ecological Modernization by Mol and Spaargaren was based on the belief that environmental protection and economic growth are not mutually exclusive [19]. It holds technological innovation as a driving force toward a “win–win” situation. Green skills, in this context, enable adoption of cleaner technologies; eco-innovation for manufacturing and industry; sustainable production and consumption and integration of policy across the economic and environmental fields. This becomes all the more relevant as India scales up on renewable energy, electric mobility, and sustainable urbanization.

Sustainable development paradigm

Green skills are core to achieving a number of the SDGs within India's policy formulation. The following explanation given below summarizes how each of the SDGs central to this review is operationalized through green skilling.

Under SDG 4, Quality Education, and more precisely target 4.7, by which green skills are integrated into curricula and lifelong learning to

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equip learners with the knowledge, skills, values, and attitudes required to bring about sustainable development and protect the environment. Among these, according to UNEVOC and the AESA Network, such competencies involve but are not limited to awareness of sustainability, resource management, and climate literacy within both formal and non-formal settings [1,20].

In relation to SDG 7 i.e. Affordable and Clean Energy, empowers labour forces and entrepreneurs to undertake initiatives to grow renewable energy fields, develop technical areas related to solar power, wind energy and other energy-efficient technologies. According to UNDP, and Greenly Earth, building the competencies of workers in the use of renewables and energy planning provides India with affordable and low-carbon power [21,22].

Talking about SDG 8, which is decent work and economic growth, pertains to vocational and technical education, which targets educating youth in a manner to create green jobs in sectors related to waste management, eco-tourism and sustainable agriculture. It ensures inclusive growth, decent conditions of work, and contributes to the transition away from high-carbon sectors.

In connection to SDG 9, i.e. Industry, Innovation and Infrastructure, green skills need to develop the workforce with the capacity to design sustainable infrastructure, innovate environmentally friendly products, and develop models for a circular economy. According to Greenly Earth, this drives resilient, sustainable industrialization in line with national priorities [22].

Finally, SDG 13, climate action, requires a labour force that is well-trained in climate mitigation, adaptation, and disaster resilience. Some of these green skills are related to environmental monitoring, carbon auditing, and policy analysis, which will be required to meet the commitment under the Paris agreement and NDCs for positioning human capital in responding effectively to climate change. The development of green skills thus contributes to a whole-of-society transition towards sustainability.

Global frameworks informing green skill development

Global frameworks are an essential component in the development of country-level strategies capable of driving the transformation of the workforce through green skills development frameworks. The former provides the guidelines, targets, and platforms for cooperation that underpin national strategies and facilitate their implementation at the level of qualifications, standard-setting, and skills development policies in support of international obligations such as the UN Sustainability Development Goals, the Paris Agreement, and the ILO standards.

United Nations Sustainable Development Goals (SDGs)

The 2030 Agenda for Sustainable Development and SDGs offer a broad perspective from which green skills can be developed to support various areas of growth. For instance, goal 4 (Quality Education) includes targets, indicators, and education-related policies that provide a framework for promoting inclusive and equitable education with an emphasis on sustainability-related knowledge and skills as stipulated in target 4.7. Meanwhile, goal 7 (Affordable and clean energy) and 8 (Decent work and economic growth) emphasize the need to develop a workforce that supports renewable energy initiatives, industries, and jobs, while goal 13 (Climate action) calls for strengthening through green skill development programs to build capacities for addressing climate change issues [21,23].

Paris Agreement and climate commitments

Paris Agreement acknowledges the need for capacity building as an important element in accomplishing emissions reductions goals through improved Nationally Determined Contributions (NDC). It also highlights the relevance of capacity building in facilitating countries in adopting new technologies, raising energy efficiency and building adaptive capacity to climate change. Accordingly, many countries have emphasized the development of green skills in their climate commitments, thereby helping international cooperation in training efforts, expertise and readiness of workforces [20].

International Labour Organization (ILO) guidelines

ILO makes recommendations to assist in ensuring effective just transition through decent work and inclusive skill development in the new green economy. Moreover, ILO assists countries in integrating green skills development into national VET system through technical assistance, reports and guidelines, and addresses social protection issues concerning the labour market [3].

UNESCO-UNEVOC and global TVET initiatives

UNESCO-UNEVOC promotes green skills development in education and training systems around the world. The global network provides country-level systems with assistance in supporting sustainable development through TVET. Through frameworks, UNESCO-UNEVOC helps establish long-term and visionary national strategies on green TVET.

Multilateral and other regional partnerships

The international frameworks created by the World Bank, the International Renewable Energy Agency, and other regional organizations encourage green skill development through financing, research, and policy advisory services. These partnerships, which have both regional and global reach, allow the transfer of knowledge and creation of infrastructure that is necessary for the global success of green skilling [22,23].

Overall, these international frameworks provide the necessary drive, funding, and guidelines for countries to establish green skills which will match the workforce abilities with the goals of sustainability and the environment.

Rationale for green skills in India

Economic and climate authority: With the growing awareness on environmental sustainability, the economic development of India is also twining with it. As the country aims for ambitious climate targets, for instance, India's NDC under the Paris Agreement, will need to develop a workforce that can enable green growth. Kelkar asserts that India's demographic advantage must be converted to a demographic dividend and that green competencies be built into those skill development systems [5]. The Ham et al. shows that many green jobs in India are concentrated in more economically prosperous states, suggesting inequality in regional green transitions [6]. Accordingly, there is need that green skills provider may widen access to green job opportunity and strive to enable regional equitable transitions.

Policy and institutional drivers: The Indian government has introduced policy measures to support green skills development, viz. the GSDP under the Ministry of Environment, Forest and Climate Change (MoEFCC) is a key initiative that aims to train and develop youth in areas like biodiversity conservation, waste management, and environmental monitoring [23]. More recently, this initiative has been reaffirmed and expanded, while, the Ministry of New and Renewable Energy (MNRE) runs a Human Resources Development (HRD) scheme from 2021 to 2026 to establish renewable energy training through short-term programs, fellowships, and infrastructure development (MNRE, n.d.) [24-26]. This shows the dedication and commitment of the Government to long-term trainings in green sectors.

Just transition and social equity: A just transition, which means moving to a green economy without leaving parts of the workforce behind, is a major concern in the discussion about green skilling. A recent report by Sattva Consulting and the Skills Council for Green Jobs finds that although India could create up to 35 million green jobs by 2047, there are systemic issues like policy gaps, funding shortages, infrastructure challenges, and the exclusion of vulnerable groups. These findings emphasize the need for green skilling to be inclusive and socially fair [27,28]

Relevance of green skills in emerging economies of India

Firstly, to yield a higher demographic dividend in India, there is a need for skilling of more than 400 million workers by 2030. This will

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India prepare to meet the challenges in the changing world. Secondly, accessibility to structured skilling pathways by the high level of informality category is required as more than 80% of the workforce in India are in this category. Thirdly, sectoral transformation in renewable energy, green buildings, agroecology, and EVs are creating new jobs and to meet this rising job market there is requirement of developing green skill. Fourthly, due to climate vulnerability, India requires adaptation skills due to rising concern related to global warming, changing climatic conditions, and water scarcity. Fifthly, as a matter of policy commitments, particularly, with reference to Net Zero Target-India by 2070, 500 giga watt renewable energy target by 2030, India requires a green-skilled workforce in millions. Therefore, green skills are the backbone of India's transition into a sustainable, climate-resilient, economically competitive future

Institutional and Policy Frameworks for Green Skilling in India

National Skill Development Corporation (NSDC) greening framework

NSDC's Greening Framework for Skill Development provides the outline for integrating green knowledge, methods, and tools into already existing vocational training and job profiles. Therefore, the framework advocates for "greening of competencies in existing job profiles" with the aim of reducing environmental impact in the labour market as a whole. This makes sense because it means green elements can be retrofitted to already existing skill programmes instead of building entirely new ones from scratch. This trajectory is consistent with more recent sector reporting on India's green-skilling ecosystem [29].

Skill Council for Green Jobs (SCGJ)

SCGJ also has a crucial role in operationalizing green skills across industries. On April 2, 2025, an MoU between the SCGJ and WRI India was inked, under which the former proposes to map skill gaps, design curricula, and offer access to green skilling. Evidently, the collaboration will aim at under-represented communities, women, and micro-enterprises, especially focusing on inclusivity in green skill initiatives. Bishnoi and Rai describe SCGJ at work recognizing non-formal green skills among MSME workers employed within the sectors of waste management and renewable energy [30]. It presents formal certification of such skills helps validate the experience of the workers, enhances their employability, and brings into alignment the MSMEs' practices with environmental objectives.

Ministry of New and Renewable Energy (MNRE) HRD programme

Among the government-initiated interventions institutionalizing various components of renewable energy training are the MNRE HRD Scheme for short-term trainings, internships, fellowships, capacity building, and infrastructure. This scheme aims at bringing in or establishing a pipeline of professionals qualified in solar, wind, bioenergy, and energy storage-related sectors. This public effort goes toward providing steady and scalable infrastructure for skilling in green jobs.

Collaboration and knowledge partnerships

This cooperation between NSDC and WRI India is an exemplary model of strategic collaboration in 2025 between government-linked skilling institutions and NGOs that conduct research to design training modules suitable for the market. This shows evidence of need of green skilling, responding to emerging demands across sectors. Comparable industry-facing initiatives – for example, the trend analysis reported in LinkedIn's Green Skills Report – similarly point to intensifying employer demand for verified green competencies, reinforcing the case for such partnerships [31].

India's international commitments on the Paris Agreement, SDGs, UNFCCC frameworks, ILO guidelines, and G20 mandates prove to be a strong catalyst for green skill development. They influence not only national policies but also industry demands, training curricula, funding priorities, and preparedness of the workforce. As global climate commitments get stronger and economic transitions toward sustainability gather speed, India's green-skilling of its workforce will become imperative for meeting international expectations with the objective of inclusive and sustainable development.

Sectoral Dynamics of Green Skills in India

Skill development for greening in India is not homogenous; it requires separate competencies for different sectors. Based on the literature, a few key sectors have been identified where green skilling is of utmost importance

Renewable energy sector

The key sectors that contribute most to the potential of green jobs are renewable energies, especially in solar, wind, and bioenergy. MNRE has institutionalized training through its Human Resource Development or HRD scheme. The required skills in the sector are installation, operation, and maintenance, energy auditing, and grid integration. Bishnoi and Rai discuss how labour within the renewable energy value chain, specifically in the fields of solar energy and small-scale waste-to-energy enterprises, obtain green skills through non-formal learning and how SCGJ works for their certification [30]. This strengthens the argument that there indeed is a dire need for recognized pathways for informal green workforces. This sits alongside recent demand-side estimates suggesting robust hiring growth for renewable-energy-linked green roles [32].

Waste management and circular economy

Waste management is another important industry that has joined in. A case study by Bishnoi and Rai says SCGJ took up the cause of upskilling waste-managing MSMEs in the process of recycling, reuse, and waste-to-energy [30]. Training encompasses safe handling, segregation, bio-methanation, and circular economy practices under both technical and managerial green competencies.

Agriculture and sustainable farming

There are also competencies in resilient climate farming, irrigation skills to consume less water, organic farming methods, and soil health management. Certain specific empirical studies on green skills in agriculture in India are few and far between when compared with energy or waste sectors. However, the policy discourse already discussed, for example, World Bank, underlined training in sustainable practices for farmers and agricultural workers [6].

Green construction and green manufacturing

A workforce sensitive to the principles of sustainability is needed for green building technologies, energy-efficient materials, green architecture, and eco-friendly manufacturing processes. Sector-specific literature on green skills in Indian construction and manufacturing remains limited; however, NSDC's Greening Framework supports the greening of existing job profiles in construction and services through the embedding of environmentally sustainable methods, a trend corroborated by recent industry commentary on green-skills adoption in the building sector [33-35].

Barriers in Green Skill Development in India

Green skill development has considerable ground still to cover; several barriers continue to obstruct its growth. Consistent with the search themes used to assemble the evidence base in research methodology of the study– particularly the keywords “present status of green skill in India” and “India's policy on green skill” – these barriers cluster into four categories:

Policy and institutional barriers

The policy landscape for green skill development in India continues to be fragmented, replete with gaps. House shows that, according to the

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Sattva–SCGJ report, one of the biggest barriers is a lack of policy coherence-skills policy is very often in silos where different ministries and agencies are not aligned properly, which results in fragmenting funds and duplication of project work [36]. The same report brings out the continued infrastructure deficits, including a shortage of training centres specializing in green technologies. Vulnerable groups, such as women and marginalized castes, are conspicuous by their absence owing to insufficient outreach and culturally relevant content.

One of the weak points of integrated policymaking and program implementation, highlighted during the Partnership for Action on Green Economy (PAGE) readiness assessment, is the weak cross-ministerial coordination [38]. The small social safety net for green workers also means that vulnerable groups are exposed during sector transitions. Partnership for Action on Green Economy, 2023. In this respect, according to CAG India, 2025, the absence of universally accepted definitions on green jobs is combined with inadequate and poorly targeted funding, thus restricting the development and scalability of green skills initiatives. The Organisation for Economic Co-operation and Development reaches a similar conclusion, noting that workforce-competency initiatives for green jobs remain constrained by this same lack of coordinated funding and definitional clarity [39].

Social inclusion and gender

Social equity underpins the development of sustainable green skills but remains problematic. A number of projects, however, including those by GIZ India, have had considerable success with the development of TVET modules for women and other marginalized groups by adapting curricula and modes of delivery to meet the needs of these groups-for example, flexible scheduling, materials in local languages, and availability of women trainers [40].

These disparities persist at the regional level as well. Quoting Bala, the unequal distribution of green jobs across India's vast geography deepens labor market inequalities, often compounded in places where green infrastructure remains underdeveloped [41]. In that light, a need exists for targeted skilling programs in order to foster meaningful inclusion in the first place in regions or groups that are underrepresented.

Awareness and demand-supply mismatch

Despite this being a growing sector, awareness of green skills and jobs among the youth and the general population is low, as it is with other green industries. According to Environmental Defense Fund, though many young people are informed about climate change, few of them can specify any particular green role or even where to go for training. Such a mismatch between the available job opportunities and awareness among the youth minimizes the available talent pool for the green sectors [42].

This gets further exacerbated with the rapid evolution of industries: according to Team Lease, often, skilling efforts are unable to keep pace with sectoral demand in renewables, hence leading to an unfilled green job vacancy and a missed opportunity for the young job seeker.

Institutional capacity

The institutional capacity for green skill training remains underdeveloped in relation to the needs of an ambitious green transition agenda of India. As the ILO says, in 2023, most TVET institutions are without certified trainers, poorly equipped, and have outdated curricula that weaken the employability prospects of graduates. Modern green labs, a prerequisite for giving hands-on training in solar, EVs, and waste management, are highly inadequate.

According to Industrial Extension Bureau (iNDEXTb) the initiative at the Centre of Excellence proposes dedicated facilities with advanced equipment, upskilling of faculty, and quality assurance systems. As a matter of fact, such investment might alter the landscape and spur higher levels of competence and credibility in green sector training.

Key Gaps, Opportunities and Policy Recommendations

These challenges, identified in barriers in green skill development in India, can be summarized in the form of gaps, opportunities and policy recommendations in a coherent manner rather than being listed separately

Key gaps

Green-related notions are not part of regular education at schools and universities; training, even if it exists, does not keep up with new technologies and by the time students graduate their knowledge becomes obsolete. This issue is exacerbated by insufficient numbers of qualified trainers and specialized infrastructure for the purpose of providing high-quality skilling programs, as well as by significant regional differences, as urban areas receive more training than small towns and rural regions. Youth and informal sector employees have insufficient awareness of existing programs and demands of the industry, while investments in green skills do not match the requirements, and informal skills cannot be certified.

Opportunities and future directions

In light of the above gaps, there are many opportunities to develop green skills through India's sustainability transition. Renewable energy, e-mobility and waste management are all developing rapidly and creating jobs, and the NSDC-WRI MoU shows how this can be done in a scaling way based on evidence-based alignment of curricula with industry. Digital/blended learning approaches can help reach disadvantaged groups in rural areas through green skilling online courses/training, and assistance with youth entrepreneurship initiatives in green technologies, recycling and conservation start-ups will help to grow the economy sustainably. Reskilling programs for just transitions of industries dependent on sunset industries, such as coal, are going to become increasingly necessary as India's energy mix changes, and the development of a set of national standards on green skills competency based on state-level Centers for Research, Innovation and High-Quality Training would facilitate quality assurance and labour mobility within the green economy.

Policy recommendations

Turning these potentialities into reality will depend on an effective and integrated policy ecosystem of education, industry, climate finance, and governance that will not only enable the labour force to prepare itself for new green industries but will also provide a just transition for the workforces impacted due to the changing climate and economic conditions. There are five key priorities.

First, there needs to be coherence and integration in policy because of the fragmented approach to the green-skills policy in education, environment, labour, and industry. The scaling up of green skills involves articulation of the national policies like National Education Policy and National Skill Development Mission and climate policies like NAPCC; coherence of laws and targets in different ministries will ensure uniform standards and facilitate cross-sector cooperation thus enhancing implementation, promoting accountability, and linking skill development to India's transition to low carbon development [1,2].

Second, there are various ways in which incentives for the industry to become involved in areas such as renewable energy, circular economy, green building, and electric mobility can be accelerated, including the use of tax rebates, salary grants for green apprenticeship training, preferential financing, and publicly funded green-skills training, which is made mandatory [3]. This would, in turn, incentivize companies to invest in upskilling, thus reducing the prevalence of skill mismatches, and helping to foster a green competitive economy [5].

Third, labour market data systems need to be developed in order to fill the gap in the general lack of intelligence about new green jobs and skills shortages, as well as transition trends. A Green Labour Market Information System, drawing on data from training providers, sector

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skill councils, and national surveys, will contribute to evidence-based policymaking, future anticipation of skill needs, curriculum alignment with employers' needs, and intervention targeting the most vulnerable groups in the population.

Fourth, connecting climate finance with green-skilling programs – which ensures that nationally and internationally funded programs as well as privately funded programs include a budget for skill acquisition and transitions of workforce – will ensure that marginalized communities benefit economically from the low-carbon development path by linking projects in renewable energy, adaptation, and resilience to green-skilling activities in order to improve technical skills, increase technology uptake, and develop green economies.

Finally, proper mechanisms for monitoring and evaluation that track relevance of training, learning outcomes, job placements, and absorption by sectors, including factors such as impact on reduction of carbon emissions, transition preparedness, and utilization of skills, are crucial for continuous improvement and accountability.

Conclusion

The concept of green skills is at the junction of economic ambitions and environmental responsibilities of India. Whether it is the Paris Agreement or India's NDCs, green skills are essential for the shift of India towards clean energy, circular economy, sustainable agriculture and eco-industries. This paper shows that although India has taken several steps in acknowledging the need for green skills through national policies, sector-specific approaches and collaborations, the current ecosystem of green skills lacks integration and suffers from uneven development.

Green skills have not been adequately incorporated into school and higher education curriculums which limits early exposure and proper development of foundational skills. There is always a mismatch between the needs of industries and what the training institutes are able to provide with their limited faculty strength, dated training curriculum and non-recognition of informal sector skills.

One more issue of concern is social equity: without interventions of specific character India faces an unbalanced green transition that will benefit only the most advanced regions and communities, with lack of labour market information, unclear allocation of climate finance and inadequate monitoring system hindering India's capability of developing its green labour force.

However, despite these shortcomings, there are immense opportunities: demographic dividend, the rising renewable energy sector, the rise of electric mobility, climate-smart agriculture and increased sustainability globally together present a conducive space for massive green skilling programs. Public-private collaborations, e-learning and just transition models can be instrumental in providing context-specific solutions for disadvantaged areas, and standardized national certifications as well as coordinated policies can contribute to the mobility and effectiveness of such an initiative even further. Thus, green skills become not only the answer to climate change challenges but the path to transformative economy. India can therefore establish a workforce that will be able to support the country's demand for green skills and help the country grow sustainably, while protecting the environment.

Data Availability Statement

No new datasets were generated or analyzed during this study. The article is based exclusively on published literature, government reports, institutional publications, and publicly available secondary sources, all of which are appropriately cited in the reference list. Therefore, data sharing is not applicable to this article.

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Authors Contributions

Dr. Kuldeep Goala: Conceptualization; Literature Review; Methodology; Data Curation; Formal Analysis; Writing – Original Draft; Visualization; Project Administration.

Dr. Yarso Awungshi: Conceptualization; Supervision; Validation; Critical Review and Editing; Interpretation of Findings; Writing – Review & Editing.

Both authors have read and approved the final manuscript and agree to be accountable for all aspects of the work.

Conflict of Interest

The authors declare that they have no known financial interests, competing interests, personal relationships, or affiliations that could have appeared to influence the work reported in this paper.

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