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Integrating Digital Innovation and Green Transitions in Shaping the Future of Work: An Integrative Review

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ABSTRACT

The global economy is being reshaped by the intertwined megatrends of rapid digital innovation and accelerating green transitions, which jointly redefine value creation, organisational practices and employment structures, yet research on their labour-market implications remains fragmented, particularly for emerging and developing economies. This study aimed to synthesise multidisciplinary evidence on how these "twin transitions" jointly shape the future of work, identify key workforce transformations, develop integrative themes linking digitalisation and sustainability and derive theoretical, managerial and policy implications for building a future-ready workforce. An integrative literature review was conducted using PRISMA-guided screening of peer-reviewed, Scopus-indexed journal articles published in English. A structured Boolean search yielded 3,483 records; after title/abstract and full-text screening against predefined inclusion/exclusion criteria, 124 studies were retained for analysis (noting that the concluding synthesis reports 120 studies). Using open coding, conceptual clustering and thematic analysis, four interrelated themes emerged. The review advances an integrated framework grounded in Human Capital Theory, Sociotechnical Systems Theory and the Just Transition perspective and concludes that equitable, resilient and sustainable workforce outcomes depend on integrated digital–green strategies rather than single-transition approaches, while highlighting limitations related to secondary evidence, advanced-economy bias, exclusion of grey literature and heterogeneity across definitions and methods.

Keywords: *Digital innovation; Green transitions; Future of work; Workforce transformation; Sustainability; Automation*

1.INTRODUCTION

The global economy is undergoing a profound structural transformation driven by two interrelated megatrends: Rapid digital innovation and Accelerating green transitions. These forces are redefining how value is created, how organisations operate and how work is structured across economies. Digital technologies such as artificial intelligence (AI), automation, cloud computing, big data analytics and digital platforms have become central to productivity growth, innovation and competitiveness (Brynjolfsson & McAfee, 2017; Vial, 2019). At the same time, escalating climate risks and sustainability imperatives have intensified the shift towards low-carbon development pathways, circular economy models and environmentally responsible production systems (Geissdoerfer et al., 2017; Markard et al., 2020).

From an economic standpoint, digitalisation enables firms to optimise processes, reduce transaction costs and develop new business models, thereby reshaping labour demand and occupational structures (Autor et al., 2023). However, digital transformation has also contributed to job polarisation, skills obsolescence and the expansion of non-standard employment arrangements, raising concerns about inequality and workforce resilience (Acemoglu & Restrepo, 2020). Parallel to this, green transitions aimed at decarbonisation and resource efficiency are altering industrial structures and generating demand for sustainability-oriented occupations, particularly in renewable energy,

environmental services and circular manufacturing (Bowen et al., 2018; Vona et al., 2018).

Increasingly, scholars and policymakers recognise that these transitions do not occur independently but intersect in ways that fundamentally shape economic growth and employment outcomes. Digital technologies play a critical enabling role in green transitions by supporting energy efficiency, smart infrastructure, climate-tech innovation and sustainable supply-chain management (Bergman et al., 2022; Chen et al., 2024). Conversely, sustainability objectives are influencing the direction of digital innovation by prioritising environmentally responsible technologies, green data centres and digital governance aligned with environmental, social and governance (ESG) principles (Del Río Castro et al., 2021).

This convergence-commonly conceptualised as the "twin transitions" has emerged as a key policy and research agenda, particularly in discussions on sustainable growth and economic resilience (European Commission, 2022; van der Ven et al., 2023). Twin transitions emphasise the co-evolution of digitalisation and sustainability, highlighting their combined effects on organisational strategies, skill formation and labour-market restructuring. Yet, despite growing attention, academic research remains fragmented. Studies on digital innovation and the future of work often focus on efficiency and automation outcomes, with limited consideration of environmental sustainability. Conversely, green economy research tends to prioritise environmental outcomes and green job creation while underexploring the role of digital technologies in transforming work processes and skill requirements (Köhler et al., 2019).

This fragmentation is particularly pronounced in emerging and developing economies, where digital adoption and sustainability transitions unfold within distinct institutional and socio-economic contexts. Structural constraints such as infrastructure gaps, skills shortages and labour-market informality complicate the alignment of digitalisation and green growth agendas (Altenburg & Rodrik, 2017; Iacobuţa et al., 2022). Consequently, there is a pressing need for integrative analytical frameworks that account for the combined impacts of digital and green transformations on employment, workforce capabilities and inclusive development.

Addressing this gap, the present study undertakes an integrative literature review to systematically examine how digital innovation and green transitions jointly shape the future of work. Drawing exclusively on peer-reviewed, Scopus-indexed literature, the review synthesises multidisciplinary evidence from economics, management, sustainability studies and labour research. By integrating these perspectives, the study moves beyond siloed analyses and develops a holistic understanding of workforce transformation under twin transitions.

Specifically, this review aims to: (i) Synthesise existing research on digital innovation and green transitions in relation to employment and work; (ii) Identify key workforce transformations emerging from their convergence; (iii) Develop integrative themes explaining how twin transitions reshape job structures, skill requirements and organisational demands; and (iv) Derive theoretical, managerial and policy implications for building a future-ready workforce.

While the introduction has established the significance of digital innovation and green transitions as interconnected drivers of contemporary workforce transformation, a deeper theoretical and empirical grounding is required to understand how these forces jointly reshape employment structures, skill formation and organisational practices. Existing research spans multiple disciplinary domains, including economics, management, sustainability studies and labour relations, each offering distinct yet fragmented insights into the future of work. To address this fragmentation and develop an integrated analytical perspective, it is essential to systematically examine the theoretical frameworks and empirical evidence that underpin research on digitalisation, sustainability transitions and labour-market change.

Accordingly, the following section presents the theoretical background and literature review, synthesising key scholarly contributions relevant to digital innovation, green transitions and their convergence within the context of the future of

work. Drawing on established theories-such as Human Capital Theory, Sociotechnical Systems Theory and the Transition framework-the section critically reviews prior studies to identify dominant themes, conceptual linkages and unresolved gaps in the literature. This structured review provides the conceptual foundation for the integrative analysis undertaken in this study and informs the development of themes that explain how twin transitions are redefining workforce dynamics in pursuit of resilient and sustainable economic growth.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 Theoretical Foundations

Understanding how digital innovation and green transitions jointly shape the future of work requires a robust theoretical grounding capable of capturing technological change, workforce adaptation and sustainability-oriented transformation. Given the complexity and multidimensionality of these twin transitions, a single theoretical lens is insufficient to explain their implications for employment structures, skill formation and organisational practices. Consequently, this study integrates insights from Human Capital Theory, Sociotechnical Systems Theory and the Just Transition framework to develop a comprehensive analytical foundation for examining workforce transformation under conditions of digitalisation and environmental sustainability (Acemoglu & Autor, 2022; Köhler et al., 2021).

2.1.1 Human Capital Theory and Workforce Transformation

Human Capital Theory emphasises that investments in education, training and skill development enhance individual productivity and contribute to economic growth. In the context of digital innovation, this framework has been widely used to explain how technological change increases demand for advanced cognitive, analytical and digital skills, while reducing reliance on routine manual tasks (Acemoglu & Autor, 2022). The diffusion of artificial intelligence, automation and data-driven technologies has intensified skill-biased technological change, reshaping wage structures and occupational mobility across labour markets (Spencer, 2022).

Recent studies extend Human Capital Theory by incorporating sustainability-oriented competencies, arguing that green transitions generate new forms of human capital associated with environmental management, renewable energy systems and circular economy practices (Cohen & Moodie, 2022). These green skills increasingly complement digital capabilities, particularly as digital technologies enable energy optimisation, emissions monitoring and sustainable production processes (Bai et al., 2023). From this perspective, twin transitions amplify the demand for hybrid skill sets that integrate digital literacy with sustainability intelligence, thereby redefining employability and career trajectories (Paiho et al., 2023).

However, scholars have also highlighted the limitations of traditional Human Capital Theory in explaining workforce transformation under twin transitions. Structural constraints such as unequal access to education, digital infrastructure and green training opportunities may prevent large segments of the workforce from acquiring relevant skills, particularly in developing economies (Hirsch-Kreinsen, 2021). Without institutional support and coordinated reskilling strategies, investments in human capital may exacerbate labour-market inequalities rather than promote inclusive growth.

2.1.2 Sociotechnical Systems Theory and the Co-evolution of Technology and Work

Sociotechnical Systems Theory offers a critical perspective for analysing how technological innovations interact with social structures, organisational design and work practices. Rather than viewing technology as an exogenous force, this approach emphasises the co-evolution of technical systems and human agency within broader institutional contexts (Geels, 2020). In studies of digitalisation, sociotechnical perspectives demonstrate that the effects of technologies such as algorithmic management, artificial intelligence and digital platforms depend on how they are embedded in organisational routines and governance frameworks (Spencer, 2022).

Applied to green transitions, Sociotechnical Systems Theory highlights how sustainability-oriented innovations reshape work processes and occupational roles. Digital tools such as smart grids, digital twins and real-time environmental monitoring systems enable organisations to integrate ecological objectives into production and decision-making processes (Paiho et al., 2023). This integration gives rise to hybrid digital-green roles that require workers to manage complex interactions between technological systems and sustainability goals (Bai et al., 2023).

Sociotechnical approaches also draw attention to issues of power, control and worker participation during transition processes. If digital-green innovations are implemented without inclusive design and stakeholder engagement, they may intensify work intensification, surveillance or job insecurity (Hirsch-Kreinsen, 2021). Consequently, Sociotechnical Systems Theory is particularly valuable for analysing how twin transitions can be governed in ways that balance efficiency, environmental performance and decent work outcomes.

2.1.3 Just Transition Framework and Inclusive Workforce Development

The Just Transition framework originates from sustainability and labour scholarship concerned with ensuring that environmental transitions do not disproportionately disadvantage workers and vulnerable communities. It emphasises social dialogue, equity and inclusive policy design in managing structural changes associated with decarbonisation and environmental regulation (Rosenberg & Reckien, 2023). Within the context of green transitions, the framework has been widely used to examine job displacement in carbon-intensive sectors and the creation of new employment opportunities in green industries (Kohler et al., 2021).

As digitalisation accelerates alongside sustainability transitions, the Just Transition framework has gained renewed relevance. Digital technologies can accelerate structural change and alter skill requirements at an unprecedented pace, increasing the risk of exclusion for workers unable to adapt (Spencer, 2022). Scholars argue that without coordinated digital-green reskilling strategies and adequate social protection mechanisms, twin transitions may exacerbate existing labour-market inequalities (Rosenberg & Reckien, 2023).

Integrating the Just Transition perspective with Human Capital and Sociotechnical Systems theories enables a more holistic understanding of workforce transformation under twin transitions. While Human Capital Theory focuses on skill acquisition and productivity outcomes and Sociotechnical Systems Theory highlights system-level interactions between technology and work, the Just Transition framework foregrounds equity, inclusion and governance (Acemoglu & Autor, 2022; Köhler et al., 2021). Together, these frameworks provide a multidimensional theoretical foundation for analysing how digital innovation and green transitions jointly reshape the future of work.

2.2 Digital Innovation and the Future of Work

Digital innovation has emerged as a central force reshaping the nature, organisation and governance of work across economies. Advances in artificial intelligence, automation, robotics, cloud computing and digital platforms are transforming production systems, labour processes and employment relations, leading to profound changes in job design, skill demand and workforce structures (Brougham & Haar, 2021; Frank et al., 2019). Unlike earlier waves of technological change, contemporary digitalisation is characterised by its speed, scope and capacity to substitute for both routine manual and cognitive tasks, thereby intensifying labour-market restructuring.

A substantial body of literature highlights the reconfiguration of occupational structures driven by digital technologies. Automation and AI adoption have been associated with the decline of routine-intensive occupations and the expansion of high-skill, technology-intensive roles, particularly in data analytics, software development and digital services (Nedelkoska & Quintini, 2018). At the same time, digitalisation has contributed to employment growth in complementary occupations requiring problem-solving, creativity and socio-emotional skills that are less susceptible to automation (Manyika et al.,

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2017). This dual dynamic has reinforced job polarisation, with growing disparities between high- and low-skill workers across sectors and regions.

Beyond task substitution, digital innovation has fundamentally altered how work is organised and managed. Algorithmic management systems increasingly govern task allocation, performance evaluation and labour control in platform-based and digitally mediated work environments (Kellogg et al., 2020). While such systems can enhance efficiency and flexibility, they also raise concerns related to worker autonomy, surveillance and employment precarity (Wood et al., 2019). The expansion of gig and platform work exemplifies these tensions, offering income opportunities and labour-market access while simultaneously challenging traditional employment protections and social security frameworks.

Digital innovation has also reshaped skill formation and lifelong learning requirements. Scholars emphasise that digital transformation necessitates continuous upskilling and reskilling, as technological competencies rapidly become obsolete (Carnevale et al., 2020). In addition to technical digital skills, workers increasingly require transversal competencies such as adaptability, critical thinking and digital collaboration capabilities (OECD, 2020). The uneven distribution of these skills across populations contributes to digital divides, reinforcing inequalities between firms, regions and demographic groups (Cirillo et al., 2021).

From an organisational perspective, digital innovation enables new business models and forms of value creation, including platform ecosystems, remote work arrangements and digitally enabled global value chains (Autio et al., 2021). The COVID-19 pandemic accelerated the adoption of remote and hybrid work, demonstrating both the resilience-enhancing potential of digital technologies and the challenges associated with digital fatigue, work-life boundary blurring and unequal access to digital infrastructure (Messenger, 2020). These developments underscore that digitalisation reshapes not only employment outcomes but also workers' lived experiences and well-being.

Recent literature increasingly situates digital innovation within broader societal and sustainability contexts. Scholars argue that digitalisation should not be evaluated solely in terms of productivity gains, but also in relation to its social consequences, including job quality, inclusiveness and long-term employability (Berg et al., 2018). This perspective aligns with calls for responsible digital transformation, emphasising governance frameworks that balance technological efficiency with decent work principles and social protection (De Stefano, 2016).

Despite extensive research on digital innovation and the future of work, gaps remain in understanding how digital transformation interacts with other structural transitions, particularly environmental sustainability. Much of the existing literature examines digitalisation in isolation, without accounting for how sustainability imperatives shape digital adoption or how digital technologies enable green transformations. This limitation reinforces the need for integrative approaches that examine digital innovation as part of broader twin transitions influencing economic resilience and workforce evolution.

2.3 Green Transitions and Sustainability-Oriented Employment

Green transitions have become a central pillar of contemporary economic restructuring as governments, firms and societies respond to climate change, environmental degradation and resource scarcity. These transitions involve a systematic shift toward low-carbon energy systems, sustainable production and consumption patterns and circular economy models, with far-reaching implications for labour markets and employment structures (Markkanen & Anger-Kraavi, 2019). Unlike incremental environmental reforms, green transitions entail structural transformation across sectors, fundamentally altering skill demand, occupational composition and workforce dynamics.

A growing body of literature examines the employment effects of green transitions, particularly the emergence of green jobs-defined as occupations that contribute directly to environmental protection, climate mitigation and resource efficiency (UNEP et

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al., 2022). Empirical studies suggest that green transitions generate employment opportunities in renewable energy, energy efficiency, environmental services, sustainable agriculture and waste management, while simultaneously reducing labour demand in carbon-intensive industries such as fossil fuels and heavy manufacturing (Bowen & Kuralbayeva, 2015; Popp et al., 2020). This dual process of job creation and destruction underscores the transformative, rather than additive, nature of green employment.

Beyond job quantity, scholars increasingly emphasise the qualitative transformation of work associated with sustainability transitions. Green employment often requires new technical competencies related to environmental monitoring, life-cycle assessment, sustainable design and regulatory compliance, as well as transversal skills such as systems thinking and stakeholder engagement (Strietska-Ilina et al., 2018). As a result, green transitions are closely linked to changing skill ecosystems, necessitating coordinated investments in education, vocational training and lifelong learning (Janser, 2018).

Recent research also highlights the heterogeneity of green employment outcomes across regions and sectors. While advanced economies tend to benefit from early investments in renewable energy and clean technologies, developing economies face distinct challenges related to financing constraints, institutional capacity and workforce preparedness (Pegels et al., 2020). In many cases, informal employment dominates environmentally sensitive sectors, complicating the implementation of sustainability standards and decent work principles (Basu et al., 2023). These disparities raise concerns about uneven development trajectories and the risk of excluding vulnerable workers from the benefits of green growth.

The literature further suggests that green transitions reshape organisational strategies and human resource practices. Firms increasingly integrate environmental objectives into core business functions, leading to the creation of roles related to sustainability management, ESG reporting and environmental compliance (Guerci et al., 2020). Such roles often require cross-functional expertise that bridges technical environmental knowledge with managerial and strategic capabilities. This organisational shift reflects a broader reorientation of value creation toward long-term ecological and social performance rather than short-term economic gains.

Scholars caution against overly optimistic assumptions regarding the employment benefits of green transitions. Without supportive policy frameworks, green job creation may be insufficient to offset job losses in declining sectors, resulting in regional unemployment and social dislocation (Markkanen & Anger-Kraavi, 2019). Consequently, the effectiveness of green transitions in promoting inclusive growth depends on complementary labour-market policies, social dialogue mechanisms and targeted reskilling initiatives (Pegels et al., 2020). This insight reinforces the relevance of just transition principles in aligning environmental objectives with social equity.

Despite the expanding literature on green employment, research remains fragmented with respect to its interaction with digital innovation. Many studies examine sustainability-oriented employment independently of technological change, overlooking how digital tools enable environmental monitoring, efficiency improvements and new forms of green work. This gap limits understanding of how green transitions interact with digitalisation to produce hybrid skill requirements and novel occupational profiles, underscoring the need for integrative analyses of twin transitions.

2.4 Convergence of Digital and Green Transitions (Twin Transitions)

Recent scholarship increasingly conceptualises digital innovation and green transitions as mutually reinforcing processes rather than independent pathways of economic transformation. This convergence, commonly referred to as the “twin transitions” highlights how digital technologies enable sustainability-oriented change while environmental imperatives shape the direction and governance of digitalisation (Del Rio Castro et al., 2021; Lange et al., 2023). Within the context of the future of work, twin transitions provide a critical analytical lens for understanding how technological

and ecological transformations jointly reconfigure labour markets, organisational practices and skill ecosystems.

Digital technologies play a central enabling role in advancing green transitions by enhancing resource efficiency, reducing emissions and supporting sustainable production systems. Empirical studies demonstrate that technologies such as the Internet of Things (IoT), artificial intelligence, blockchain and digital twins facilitate real-time monitoring of energy use, predictive maintenance and optimisation of supply chains, thereby reducing environmental footprints (Bai et al., 2024; Ciarli et al., 2021). These applications not only improve environmental performance but also transform work processes, creating demand for hybrid roles that combine digital expertise with sustainability knowledge.

Sustainability imperatives increasingly influence the trajectory of digital innovation. Firms and policymakers are directing digital investments toward climate-tech solutions, green data infrastructure and environmentally responsible digital governance frameworks (Lange et al., 2023). This shift reshapes organisational strategies and labour demand by prioritising digital applications aligned with environmental, social and governance (ESG) objectives. As a result, new occupational profiles-such as sustainability data analysts, smart-energy system managers and digital ESG specialists are emerging at the intersection of digital and green domains (Cecere et al., 2022).

The twin transitions literature further highlights the transformation of skill requirements and workforce competencies. Rather than treating digital and green skills as distinct categories, recent studies emphasise the growing importance of integrated or hybrid skill sets that combine digital literacy, environmental awareness and systems-level thinking (Laar et al., 2022). Workers are increasingly expected to interpret sustainability data, operate digitally enabled environmental management systems and contribute to organisational climate strategies. This integration challenges traditional education and training models, which often separate technical and environmental skill development.

From a labour-market perspective, twin transitions intensify both opportunities and risks. On the one hand, they create new employment opportunities in climate-tech, smart manufacturing, sustainable mobility and digital public services (Ciarli et al., 2021). On the other hand, they may exacerbate skill mismatches and inequalities if reskilling systems fail to keep pace with rapidly evolving demands (Laar et al., 2022). Scholars caution that without coordinated digital-green workforce policies, the benefits of twin transitions may be unevenly distributed across regions, sectors and social groups (Cecere et al., 2022).

Governance and policy alignment emerge as critical mediating factors in shaping workforce outcomes under twin transitions. Research emphasises the need for integrated policy frameworks that simultaneously address digital innovation, sustainability goals and labour-market inclusion (Del Rio Castro et al., 2021). Such frameworks support investments in digital-green skills, promote responsible technology adoption and ensure that workforce transformation aligns with broader societal objectives, including decent work and social equity.

Despite the growing recognition of twin transitions, the literature remains fragmented and unevenly developed. Many empirical studies focus on technological or environmental outcomes without systematically examining labour-market implications. Moreover, evidence from developing economies remains limited, constraining understanding of how institutional contexts shape digital-green convergence. These limitations underscore the need for integrative reviews that synthesise multidisciplinary evidence and identify common patterns, gaps and future research directions concerning the future of work under twin transitions.

The preceding theoretical background and literature review synthesised multidisciplinary scholarship on digital innovation, green transitions and their convergence as twin transitions shaping the future of work. By integrating insights from economics, management, sustainability studies and labour research, the review highlighted key workforce transformations, emerging hybrid skill requirements

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and persistent research gaps-particularly the fragmented treatment of digital and green transitions and the limited empirical evidence from developing economies. These gaps underscore the need for a systematic and integrative methodological approach capable of consolidating diverse strands of literature into a coherent analytical framework. Accordingly, the following section outlines the research methodology adopted in this study, detailing the review design, data sources, search strategy, screening procedures and analytical techniques used to ensure transparency, rigour and replicability.

3. RESEARCH METHODOLOGY

3.1 Research Design

This study adopts an integrative literature review methodology to synthesise and critically evaluate existing research on digital innovation, green transitions and their combined implications for the future of work. Integrative reviews are particularly suitable for complex and emerging research domains, as they allow for the inclusion of diverse theoretical perspectives, empirical findings and methodological approaches (Whittemore & Knafl, 2005). Unlike traditional systematic reviews that often focus narrowly on specific research questions or methods, integrative reviews facilitate the development of new conceptual insights by combining evidence across disciplines.

Given the multidisciplinary nature of twin transitions-spanning economics, management, sustainability and labour studies-this approach enables a holistic examination of workforce transformation while identifying patterns, contradictions and knowledge gaps across the literature (Snyder, 2019). The methodology aligns with the study's objective of developing integrative themes that explain how digital and green transitions jointly reshape employment structures, skill requirements and organisational practices.

3.2 Data Sources and Search Strategy

The literature search was conducted using major academic databases: Scopus, which is widely recognised for the comprehensive coverage of high-quality and peer-reviewed research. These databases were selected to ensure the inclusion of rigorously reviewed and internationally recognised scholarly publications relevant to the study's scope.

A structured search strategy was employed using Boolean operators and keyword combinations related to digitalisation, sustainability and workforce transformation. The search was limited to peer-reviewed journal articles published in English to maintain academic quality and consistency.

Database	Keywords
Scopus	(TITLE-ABS-KEY (future AND of AND work) AND TITLE-ABS-KEY (digital AND innovation) AND TITLE-ABS-KEY (artificial AND intelligence) AND TITLE-ABS-KEY (sustainability))

3.3 Inclusion and Exclusion Criteria

To ensure relevance and quality, explicit inclusion and exclusion criteria were applied. Studies were included if they:

1. Examined digital innovation, green transitions or their intersection;
2. Addressed employment, skills, workforce transformation or organisational implications;
3. Were peer-reviewed journal articles indexed in Scopus.
4. Provided conceptual, empirical or policy-relevant insights related to the future of work.

Studies were excluded if they:

1. Focused solely on technical aspects without workforce implications;
2. Lacked relevance to digital or sustainability transitions;
3. Were non-peer-reviewed sources such as reports, editorials or conference abstracts; or
4. Duplicated findings from already included studies.

3.4 Screening and Selection Process

The screening process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodological transparency and replicability (Page

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et al., 2021). An initial search yielded 3483 records, which were screened based on titles and abstracts to remove irrelevant and duplicate studies. Full-text screening was then conducted to assess eligibility against the inclusion criteria.

Following this multi-stage screening process, a final sample of 124 studies was retained for in-depth analysis. This rigorous selection procedure ensured that the review captured high-quality and thematically relevant literature while minimising selection bias.

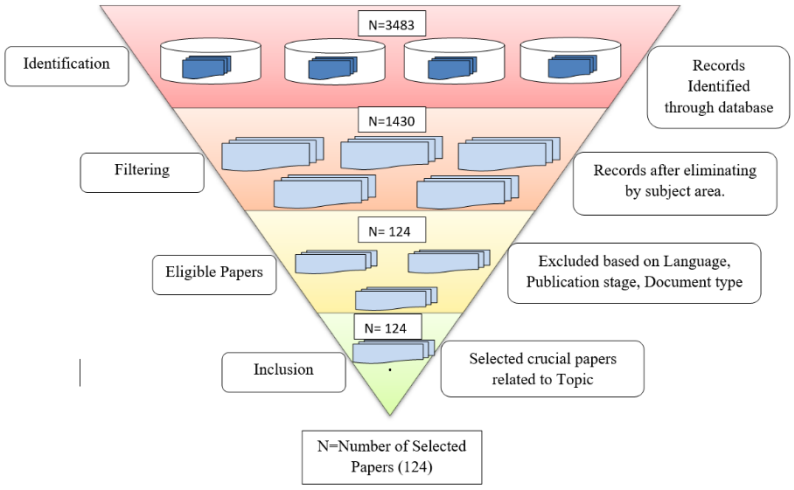

Figure 01: PRISMA Flow chart

3.5 Data Analysis and Synthesis

The selected studies were analysed using a combination of coding, conceptual clustering and thematic analysis. An initial open-coding process was used to identify recurring concepts related to digital innovation, sustainability transitions and workforce outcomes. These codes were then grouped into higher-order categories through iterative comparison and refinement (Braun & Clarke, 2019).

The analytical process resulted in the identification of four integrative themes that capture the multifaceted impacts of twin transitions on the future of work. This thematic synthesis enabled the development of an integrated framework linking digital technologies, green transitions, skill formation and labour-market dynamics, thereby addressing the study's research objectives.

4. RESULTS / FINDINGS

The integrative review of 124 Scopus-indexed studies revealed four dominant and interrelated themes that explain how digital innovation and green transitions jointly reshape the future of work. These themes capture structural changes in workforce models, the emergence of sustainability-oriented employment, the convergence of digital and green transformations and the role of policy and governance in mediating workforce outcomes. Together, they provide a comprehensive understanding of labour-market transformation under twin transitions.

4.1 Digital Innovation Reshaping Workforce Models

The first theme highlights the profound impact of digital innovation on workforce structures, job design and employment relationships. Across the reviewed studies, digital technologies particularly artificial intelligence, automation, robotics and data analytics were found to significantly alter task composition within occupations, leading to the reconfiguration of traditional job roles (Frey & Osborne, 2017; Arntz et al., 2020). Routine and repetitive tasks are increasingly automated, while non-routine cognitive, analytical and interactive tasks gain prominence.

Empirical evidence indicates that digitalisation contributes to occupational polarisation, characterised by the expansion of high-skill, high-wage roles and the persistence of low-skill service

jobs, alongside the decline of middle-skill occupations (Goos et al., 2014; Arntz et al., 2020). This restructuring intensifies demand for advanced digital competencies, including programming, data interpretation and digital problem-solving, while simultaneously marginalising workers lacking access to reskilling opportunities.

In addition to altering task structures, digital innovation reshapes employment relationships and organisational control mechanisms. Algorithmic management systems increasingly govern performance monitoring, work allocation and evaluation, particularly in platform-mediated and digitally enabled workplaces (Meijerink & Bondarouk, 2021). While such systems enhance efficiency and flexibility, they also raise concerns regarding job security, autonomy and worker well-being, underscoring the uneven social consequences of digital workforce transformation.

4.2 Green Transitions and Sustainability-Oriented Job Creation

The second theme focuses on employment dynamics emerging from green transitions. The reviewed literature consistently demonstrates that sustainability-driven policies and investments generate new forms of employment in renewable energy, energy efficiency, sustainable construction, environmental services and circular economy activities (Consoli et al., 2016; Popp, 2019). These green jobs are not confined to niche sectors but increasingly permeate traditional industries undergoing decarbonisation and ecological restructuring.

However, the findings also reveal that green transitions entail significant job displacement, particularly in carbon-intensive sectors such as fossil fuels, mining and heavy manufacturing (Spencer et al., 2018). The net employment effects of green transitions therefore depend on the pace of transition, sectoral composition and the availability of reskilling pathways. Studies emphasise that green job creation alone is insufficient to ensure inclusive growth without complementary labour-market and social policies (Klenert et al., 2018).

Sustainability-oriented employment is associated with evolving skill requirements. Green jobs increasingly demand interdisciplinary competencies combining technical environmental knowledge, regulatory awareness and systems thinking (Consoli et al., 2016). This transformation highlights the importance of coordinated education and training systems capable of supporting workforce adaptation to environmentally driven structural change.

4.3 Convergence of Digital and Green Transformations: Emergence of Hybrid Roles

The third theme captures the convergence of digital innovation and green transitions, giving rise to hybrid digital-green roles and integrated skill profiles. A growing number of studies document how digital technologies enable sustainability outcomes by supporting energy optimisation, emissions tracking, smart manufacturing and climate-tech innovation (Zhang et al., 2022; Chien et al., 2021). This convergence transforms work processes and creates demand for roles that integrate digital expertise with sustainability objectives.

Examples of emerging hybrid roles identified in the literature include sustainability data analysts, smart-grid engineers, digital environmental auditors and ESG analytics specialists (Zhang et al., 2022). These occupations require workers to navigate complex technological systems while interpreting sustainability metrics and contributing to organisational climate strategies. As a result, traditional distinctions between “digital jobs” and “green jobs” are increasingly blurred.

The findings further indicate that hybridisation intensifies skill mismatches, as education and training systems often lag behind rapidly evolving labour-market demands (Chien et al., 2021). Without integrated digital-green skill frameworks, organisations face talent shortages that constrain the effective implementation of twin transitions. This insight reinforces the importance of aligning workforce development strategies with technological and environmental transformation agendas.

4.4 Policy, Governance and Workforce Inclusion

The fourth theme emphasises the critical role of policy and governance in shaping workforce outcomes under twin transitions. The reviewed studies consistently highlight that market forces

alone are insufficient to ensure equitable and inclusive workforce transformation (Klenert et al., 2018). Instead, coordinated policy interventions are required to align digital innovation and green transitions with social and employment objectives.

Effective governance frameworks support workforce inclusion by promoting access to reskilling opportunities, strengthening social protection systems and addressing regional and sectoral disparities (Spencer et al., 2018). Policy alignment with Sustainable Development Goals (SDGs) and just transition principles is particularly important in mitigating inequality and ensuring that vulnerable workers are not disproportionately affected by technological and environmental change.

The literature underscores the importance of institutional coordination across education systems, labour-market policies and industrial strategies (Meijerink & Bondarouk, 2021). Countries and organisations that adopt integrated digital–-green workforce strategies are better positioned to harness the economic and social benefits of twin transitions while minimising adverse labour-market outcomes.

5. DISCUSSION

This integrative review sought to examine how digital innovation and green transitions jointly shape the future of work by synthesising multidisciplinary evidence across economics, management, sustainability and labour studies. The findings reveal that workforce transformation under twin transitions is neither linear nor technologically deterministic but mediated by skill ecosystems, organisational practices and institutional frameworks. This section interprets the key results in light of existing theory, situates the study's contributions within broader academic debates and highlights how twin transitions redefine contemporary understandings of work, employment and economic resilience.

5.1 Reinterpreting Workforce Transformation Through the Lens of Twin Transitions

The findings confirm that digital innovation and green transitions are deeply interconnected processes that collectively reshape job structures, skill requirements and employment relations. While prior research has examined digitalisation-driven automation or sustainability-oriented job creation in isolation, this review demonstrates that their convergence generates qualitatively distinct workforce outcomes. In particular, the emergence of hybrid digital-green roles supports recent arguments that technological and environmental transformations should be analysed as co-evolving systems rather than parallel trends (Lange & Santarius, 2020).

From a theoretical perspective, this integration extends Human Capital Theory by illustrating how skill-biased technological change is amplified under twin transitions. Workers are increasingly required to possess not only advanced digital competencies but also sustainability-oriented knowledge and systems thinking capabilities. This finding aligns with emerging evidence that future employability depends on hybrid skill portfolios that cut across traditional occupational boundaries (Deming & Noray, 2020). Consequently, workforce transformation under twin transitions is better understood as a process of skill recombination rather than simple skill upgrading.

5.2 Organisational and Labour-Market Implications

The results further suggest that twin transitions fundamentally alter organisational strategies and labour-market dynamics. Digital technologies enable firms to embed sustainability objectives into core operations, transforming performance metrics, managerial practices and job design. This integration supports sociotechnical perspectives emphasising that technology adoption reshapes work through organisational choices rather than technical necessity alone (Orlikowski & Scott, 2016). The review indicates that firms adopting integrated digital-green strategies are more likely to develop new occupational roles and internal labour markets oriented toward long-term sustainability goals.

At the labour-market level, the findings highlight both opportunities and risks. While twin transitions create new employment opportunities in climate-tech, smart manufacturing and sustainable services, they also intensify skill mismatches and employment insecurity for workers in declining

sectors. This duality reinforces concerns that uncoordinated transitions may exacerbate inequality and social exclusion (ILO, 2021). The results therefore support calls for proactive labour-market institutions capable of managing structural change through reskilling, job-matching mechanisms and social protection.

5.3 Equity, Inclusion and Just Transition Considerations

A key contribution of this review lies in demonstrating that workforce outcomes under twin transitions are highly contingent on governance and policy alignment. The findings reinforce the relevance of the Just Transition framework by showing that technological and environmental transformations can compound risks for vulnerable workers if equity considerations are not embedded in transition strategies. This insight echoes recent research emphasising that digitalisation can deepen labour-market segmentation when combined with weak institutional support (Rodrik & Stantcheva, 2021).

5.4 Contribution to Future-of-Work and Sustainability Literature

By synthesising fragmented strands of research, this study advances future-of-work scholarship in three key ways. First, it conceptualises twin transitions as a unified analytical framework that captures the interaction between digitalisation and sustainability, addressing a significant gap in existing literature. Second, it identifies hybrid digital-green skills as a defining feature of emerging labour markets, extending theoretical debates on skill-biased technological change. Third, it situates workforce transformation within broader discussions on sustainable development and economic resilience, aligning labour-market analysis with ecological and social objectives. Overall, the discussion underscores that the future of work cannot be understood through single-transition narratives. Instead, it requires integrative perspectives that account for technological, environmental and social dynamics simultaneously.

6. IMPLICATIONS

The findings of this integrative review have significant implications for theory development, managerial practice and public policy in the context of twin transitions. By demonstrating how digital innovation and green transitions jointly reshape workforce structures and skill ecosystems, this study provides insights that extend beyond sectoral or disciplinary boundaries. The following subsections outline the key implications for advancing future-of-work scholarship and informing decision-making in organisations and policy institutions.

6.1 Theoretical Implications

From a theoretical standpoint, this study contributes to the future-of-work and sustainability literature by advancing an integrated twin transitions perspective. Existing theories of technological change and employment have largely focused on digitalisation as an independent driver of workforce transformation. The findings of this review suggest that such single-transition frameworks are increasingly insufficient, as sustainability imperatives fundamentally influence the direction, application and outcomes of digital innovation (Pfeiffer et al., 2022).

First, the results extend Human Capital Theory by highlighting the emergence of hybrid digital-green skill configurations. Rather than viewing digital and green skills as separate domains, the evidence indicates that employability increasingly depends on the ability to combine technological competencies with sustainability-oriented knowledge and systems thinking (Green et al., 2023). This insight calls for theoretical models that conceptualise skill formation as a dynamic and integrative process shaped by multiple structural transitions.

Second, the findings reinforce and expand sociotechnical perspectives by demonstrating that workforce outcomes under twin transitions are contingent on organisational and institutional design choices. Digital technologies do not automatically generate sustainable or inclusive employment outcomes; instead, their effects are mediated by governance structures, organisational strategies and labour-market institutions (Benitez et al., 2020). This underscores the need for theory-building efforts that explicitly incorporate sustainability objectives and social equity considerations into analyses of digital work systems.

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Finally, the study strengthens the relevance of the Just Transition framework by situating it within a digitally enabled economy. The compounded effects of automation and decarbonisation suggest that future theoretical work must integrate technological change more explicitly into just transition debates, particularly in relation to skill displacement, employment quality, and social protection (Newell & Mulvaney, 2019).

6.2 Managerial Implications

For managers and organisational leaders, the findings highlight the strategic importance of aligning digital transformation initiatives with sustainability goals and workforce development strategies. Firms pursuing digitalisation without considering environmental and social dimensions risk creating skill bottlenecks, workforce resistance and reputational challenges (Brock & von Wangenheim, 2019). Conversely, organisations that integrate digital and green objectives are better positioned to develop resilient business models and future-ready workforces.

One key managerial implication concerns talent management and skill development. The emergence of hybrid digital-green roles requires organisations to rethink traditional job classifications, recruitment practices and training programmes. Managers should invest in continuous learning systems that support cross-functional skill development, enabling employees to operate digital technologies while contributing to sustainability objectives (Dubey et al., 2021). Partnerships with educational institutions and training providers can play a critical role in building these capabilities.

6.3 Policy Implications

At the policy level, the results underscore the need for coordinated digital-green workforce strategies that align economic, environmental and social objectives. Policymakers should move beyond fragmented policy approaches that separately address digital skills, climate action, employment and instead adopt integrated frameworks that reflect the interconnected nature of twin transitions (Mazzucato & Perez, 2023).

Education and training systems play a central role in this process. Public investment in digital and sustainability education-spanning formal schooling, vocational training and adult learning-is essential for reducing skill mismatches and ensuring broad-based workforce participation in emerging labour markets (CEDEFOP, 2022). Policies that support lifelong learning and targeted reskilling for displaced workers are particularly important in mitigating the distributional impacts of automation and decarbonisation.

The findings highlight the importance of social protection and labour-market institutions in promoting inclusive transition outcomes. Strengthening unemployment insurance, job-matching services, and regional development policies can help buffer workers and communities affected by structural change (OECD, 2023). For developing economies, international cooperation and development finance can support investments in digital infrastructure and green industries, enabling more equitable participation in global twin transitions.

7. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

While this integrative review provides a comprehensive synthesis of existing research on digital innovation, green transitions and their convergence in shaping the future of work, several limitations should be acknowledged. Recognising these limitations is essential for contextualising the findings and identifying meaningful avenues for future research.

7.1 Limitations

First, the study is constrained by its reliance on secondary data drawn from published literature. Although the integrative review methodology enables the synthesis of diverse theoretical and empirical insights, it does not allow for causal inference or direct observation of workforce dynamics. As a result, the findings reflect patterns and interpretations present in the existing literature rather than primary empirical evidence of worker or organisational behaviour (Booth et al., 2021).

Second, despite the inclusion of multidisciplinary studies, the reviewed literature remains geographically skewed toward advanced economies, particularly Europe and North America. This bias

reflects broader trends in academic publishing and limits the generalisability of findings to developing and emerging economies, where institutional contexts, labour-market structures and digital infrastructure differ substantially (Galgóczi, 2021). Consequently, workforce outcomes under twin transitions in low- and middle-income countries may be underrepresented in this review.

Third, the review focuses primarily on peer-reviewed journal articles, excluding grey literature such as policy reports, industry publications and practitioner studies. While this approach ensures academic rigour and quality, it may overlook emerging practices and policy innovations that have not yet been extensively documented in scholarly outlets (Donthu et al., 2021). This limitation is particularly relevant in fast-evolving domains such as digitalisation and climate-related employment.

Finally, although the study adopts a thematic synthesis approach, the heterogeneity of methodologies and conceptual frameworks across the reviewed studies presents challenges for integration. Differences in definitions of digital innovation, green jobs and sustainability outcomes may introduce interpretive inconsistencies that cannot be fully resolved through qualitative synthesis alone.

7.2 Future Research Directions

Building on these limitations, several avenues for future research emerge. First, there is a strong need for empirical studies examining twin transitions in developing and emerging economies. Longitudinal and mixed-method research designs could provide deeper insights into how digital and green transformations interact with informal labour markets, skill systems and institutional capacity in diverse socio-economic contexts (Galgóczi, 2021).

Second, future research should prioritise longitudinal analyses of skill formation and career trajectories under twin transitions. Existing studies largely adopt cross-sectional approaches, limiting understanding of how workers acquire, recombine and adapt digital-green skills over time. Long-term studies could shed light on employment stability, wage dynamics and intergenerational effects associated with hybrid skill development (McKinsey Global Institute, 2021).

Third, there is scope for advancing theoretical integration by developing formal models that explicitly link digitalisation, sustainability transitions and labour-market outcomes. Such models could extend existing theories of technological change and just transition by incorporating environmental constraints and governance mechanisms, thereby enhancing explanatory and predictive power (Gao et al., 2022).

Fourth, future studies should explore sector-specific dynamics of twin transitions. Comparative research across sectors such as energy, manufacturing, agriculture and digital public services could reveal how technological and environmental pressures interact differently across production systems and occupational structures. This would support more targeted policy and managerial interventions.

Finally, greater attention should be paid to the social and ethical dimensions of workforce transformation under twin transitions. Research examining issues such as job quality, worker voice, algorithmic governance and gender and regional inequalities would deepen understanding of how digital-green transformations can be aligned with inclusive and decent work objectives (Vallas & Schor, 2020).

8. CONCLUSION

This integrative review set out to examine how digital innovation and green transitions jointly shape the future of work, responding to the growing recognition that contemporary economic transformation is driven by multiple, interconnected forces. By synthesising evidence from 120 Scopus-indexed studies across economics, management, sustainability and labour research, the study demonstrates that digitalisation and environmental sustainability are not parallel trajectories but mutually reinforcing processes that collectively redefine workforce structures, skill requirements and organisational strategies.

From a theoretical perspective, this study contributes to future-of-work scholarship by advancing a twin transitions framework that integrates insights from Human Capital Theory, Sociotechnical Systems Theory, and the Just

Transition perspective. This integrative approach moves beyond single-transition narratives and provides a more comprehensive understanding of how economic growth, technological progress and environmental responsibility intersect. By situating workforce transformation within broader debates on sustainable development and economic resilience, the study aligns labour-market analysis with ecological and social priorities.

The review also underscores the central role of governance, institutions and policy coordination in shaping workforce outcomes under twin transitions. Digital innovation and green transitions do not automatically yield inclusive or equitable employment outcomes; rather, their effects are mediated by education systems, labour-market institutions and organisational practices. Integrated digital-green policies, inclusive reskilling strategies and robust social protection mechanisms are therefore essential for ensuring that workforce transformation contributes to resilient and sustainable growth pathways (World Economic Forum, 2023).

In conclusion, this study demonstrates that redefining growth in the twenty-first century requires an integrated understanding of how economy, society and sustainability interact through twin transitions. By consolidating fragmented strands of research into a unified analytical framework, the paper offers timely insights for scholars, policymakers and practitioners seeking to navigate the complex challenges of workforce transformation. As economies continue to confront rapid technological change and escalating environmental pressures, adopting integrative perspectives such as the one advanced in this study will be critical for shaping a future of work that is productive, inclusive and environmentally sustainable.

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