THE ROLE OF DIGITAL TECHNOLOGIES AND THE GREEN ECONOMY IN PROMOTING EMPLOYMENT IN VIETNAM'S MOUNTAINOUS AREAS: A PLS-SEM APPROACH.

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Abstract

This study examines the role of digital technology in promoting green economic development and job creation in Vietnam's mountainous regions. Drawing on the Technology Acceptance Model, Sustainable Development Theory, Dynamic Capabilities Theory, and the Sustainable Livelihood Framework, the research employs Partial Least Squares Structural Equation Modelling (PLS-SEM) to analyse survey data from 400 respondents, including small and medium enterprises, workers, and local authorities across three mountainous areas. Results indicate that digital technology adoption significantly enhances green economic development (β = 0.320, p < 0.001) and digital entrepreneurship (β = 0.280, p < 0.001), both of which contribute to employment generation. Multi-group analysis highlights gender-based differences, with women showing greater leverage of digital tools for sustainable economic growth. The findings emphasize the need for integrated policies focused on digital infrastructure, capability building, and gender-inclusive strategies to maximise sustainable development outcomes in mountainous regions.

Keywords: Digital technology, Green economy, Job creation, Digital entrepreneurship, Mountainous regions

Introduction

The intersection of digital transformation and sustainable development represents a pivotal shift in contemporary development discourse, particularly for regions confronting geographical marginalisation and socio-economic vulnerabilities (Hu & Zhang, 2024; Wang & Ye, 2024). Vietnam's mountainous regions exemplify these challenges, characterised by distinctive socio-ecological systems, limited infrastructure, and communities whose livelihoods are closely intertwined with natural resource utilisation (Tran, 2023). Within this context, digital technology offers the potential to catalyse green economic development and generate sustainable employment, yet empirical understanding of these processes remains limited.

Globally, the pursuit of the Sustainable Development Goals (SDGs) has elevated the "twin transition"—simultaneous digitalisation and environmental sustainability—as a central strategy for inclusive development (Sun, Liu, & Tansuchat, 2023). Vietnam's national policies,

such as the National Strategy on Green Growth (2021–2030) and the National Digital Transformation Programme, explicitly aim to leverage technological advancements for sustainable economic restructuring (Prime Minister of Vietnam, 2021). However, translating these macro-level policy aspirations into measurable outcomes in mountainous regions remains underexplored, particularly regarding the mechanisms through which digital technology adoption fosters green economic practices and employment creation.

Although the role of digital transformation in sustainable development has received growing scholarly attention, substantial gaps remain concerning the specific pathways through which digital technology promotes green economic development and employment in marginalised geographies. Existing studies largely focus on urban or industrialised contexts (Ma & Lin, 2023; Zhou & Zhang, 2023), leaving unique challenges and opportunities in mountainous regions—such as ethnic minority populations, traditional ecological knowledge, and environmental vulnerability—insufficiently examined. Moreover, the mediating processes translating technology adoption into sustainable employment, as well as the moderating influences of demographic factors, warrant systematic empirical investigation.

This study addresses these gaps by examining three interrelated questions: (1) How does digital technology adoption, supported by infrastructure and organisational capabilities, influence green economic development and digital entrepreneurship in Vietnam's mountainous regions? (2) Through which mechanisms do green economic development and digital entrepreneurship translate into job creation? (3) What role do demographic factors, particularly gender, play in moderating these relationships? Through a multi-theoretical lens and rigorous empirical methodology, this research contributes to both theoretical development and practical policy guidance for sustainable development in marginalised contexts.

Theoretical contributions of this study arise from the integration of four frameworks—Technology Acceptance Model (TAM), Sustainable Development Theory (SDT), Dynamic Capabilities Theory (DCT), and Sustainable Livelihood Framework (SLF)—which collectively enable a comprehensive understanding of the digital–green–employment nexus. Empirically, the study provides evidence from an underrepresented geographical context, utilising advanced statistical techniques to uncover complex relationships and mediating pathways. Practically, the findings offer insights for policymakers and development practitioners seeking to harness digital technologies for inclusive and sustainable outcomes.

The paper is structured as follows: Section 2 presents the theoretical framework and hypothesis development; Section 3 details the methodological approach, including research design, measurement, and analysis; Section 4 reports the empirical findings; Section 5 discusses implications and limitations; and Section 6 concludes with key contributions and avenues for future research.

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2. Theoretical Background and Hypotheses Development

2.1 Theoretical Foundations

The interplay between digital technology, green economic development, and employment generation necessitates a multi-theoretical approach capturing individual, organisational, and systemic dynamics. This study integrates four complementary frameworks to develop a holistic understanding of these relationships within Vietnam's mountainous regions.

2.1.1 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), provides foundational insights into the determinants of individual technology adoption. TAM posits that behavioural intention to adopt technology is primarily influenced by two cognitive beliefs: Perceived Usefulness (PU)—the degree to which technology is believed to enhance performance—and Perceived Ease of Use (PEOU)—the degree to which technology is perceived as effortless (Venkatesh & Davis, 2000). In the context of green economic activities, PU reflects beliefs regarding digital tools' capacity to improve sustainable agricultural practices, facilitate market access for eco-friendly products, or enhance resource management efficiency (Chen & Lu, 2016). PEOU is particularly salient in mountainous regions due to digital literacy constraints and infrastructure limitations (Anthony & Petersen, 2022).

Applying TAM to digital technology adoption for green economic development highlights important contextual dependencies. While the potential benefits of digital tools—such as precision agriculture for resource efficiency or e-commerce platforms for organic products—may be apparent, the perceived ease of use depends on enabling conditions, including quality digital infrastructure, culturally appropriate training, and interfaces designed for local languages and contexts (Pikkarainen, Pikkarainen, Karjaluoto, & Pahnila, 2004). Consequently, evaluating digital adoption requires attention not only to adoption rates but also to the conditions that facilitate meaningful engagement with digital technologies for sustainable development.

2.1.2 Sustainable Development Theory (SDT)

Sustainable Development Theory (SDT) provides the normative foundation for this study, emphasising development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). SDT's tripartite structure—encompassing economic sustainability, social equity, and environmental protection—aligns closely with Vietnam's conceptualisation of the green economy as articulated in national policy documents (Prime Minister of Vietnam, 2021). By advocating integrated and systemic approaches, SDT offers a framework to understand how digital technologies can simultaneously enhance economic efficiency, environmental stewardship, and social inclusion (Souad, 2023).

In Vietnam's mountainous regions, SDT principles are particularly salient due to the deep interdependence between local livelihoods and ecological systems. Digital technologies can facilitate sustainable development by enabling economic activities compatible with environmental conservation while ensuring equitable benefit distribution (Masyuk, Bushueva,

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Li, & Bogomolov, 2024). Moreover, the notion of a "just transition" embedded in SDT highlights the importance of addressing potential disruptions to traditional livelihoods caused by digital-enabled green economic transformation, emphasising inclusive strategies for vulnerable populations (Pociovălişteanu et al., 2015).

2.1.3 Dynamic Capabilities Theory (DCT)

Dynamic Capabilities Theory (DCT) explains how organisations and communities develop competencies to thrive under rapidly changing conditions (Teece, Pisano, & Shuen, 1997). DCT identifies three core processes: sensing (recognising opportunities and threats), seizing (mobilising resources to exploit opportunities), and reconfiguring (adapting capabilities to maintain competitiveness). In the digital-green economy context, these processes manifest as recognising sustainable market opportunities through digital platforms, creating digital entrepreneurship ventures addressing environmental challenges, and continuously integrating emerging technologies into green business models (Pavlou & El Sawy, 2011).

In mountainous regions, DCT underscores the critical role of ecosystem-level factors. The ability to sense opportunities depends not only on individual skills but also on digital infrastructure, access to market information, and supportive policies (Magistretti, Pham, & Dell'Era, 2021). Seizing opportunities requires access to finance, technical support, and market networks, which may be limited in remote areas. Thus, digital capabilities should be considered within the broader enabling environment that facilitates or constrains their development and application (Ma & Lin, 2023).

2.1.4 Sustainable Livelihood Framework (SLF)

The Sustainable Livelihood Framework (SLF) provides a people-centred approach to understanding how digital interventions influence rural livelihoods (Khosla, 2001). SLF identifies five forms of capital—human (skills and knowledge), social (networks and trust), natural (environmental resources), physical (infrastructure), and financial (monetary resources)—which together offer a comprehensive lens for assessing digital technology's impacts. For example, digital tools can enhance human capital through skills training, expand social capital via online networks, strengthen physical capital through connectivity infrastructure, and improve financial capital access via digital financial services (Hrustek, 2020).

SLF's emphasis on vulnerability is particularly relevant in mountainous regions facing environmental risks, market volatility, and seasonal fluctuations. Digital technologies can mitigate vulnerability by providing early warning systems, access to market information, and opportunities for income diversification (Yuan, 2024; Kosasih & Sulaiman, 2024). However, the digital divide represents a new form of vulnerability, as limited access to technology and skills can exacerbate existing marginalisation. Consequently, inclusive approaches that ensure equitable access and capability development are essential for realising digital technologies' full potential (Riaz et al., 2024).

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2.2 Hypotheses Development

2.2.1 Digital Technology Adoption and Green Economic Development

The link between digital technology adoption (DTA) and green economic development (GED) is grounded in TAM's adoption mechanisms and SDT's sustainability imperatives. When individuals and enterprises perceive digital technologies as useful for implementing greener practices and relatively easy to use, adoption likelihood increases, enabling more sustainable economic activities (Davis, 1989; Venkatesh & Davis, 2000). Empirical studies indicate that digital transformation enhances green total factor productivity by improving resource efficiency, reducing emissions, and facilitating circular economy practices (Lu, Muhamad, & Hanafiah, 2025).

In mountainous regions, digital technologies can act as "green nudges," making sustainable practices more accessible and their benefits more observable. For instance, smart farming applications provide real-time information to optimise resource use, while energy monitoring tools highlight tangible environmental and economic gains (Galán-Díaz, Edwards, Nelson, & van der Wal, 2015). Additionally, digital platforms enable remote producers to reach environmentally conscious consumers and premium markets (Huda et al., 2024).

H1: Digital technology adoption positively influences green economic development in Vietnam's mountainous regions.

2.2.2 Digital Technology Adoption and Digital Entrepreneurship

The theoretical relationship between DTA and digital entrepreneurship (DE) is supported by TAM's perceived usefulness construct and DCT's focus on capability development. Digital technologies reduce traditional barriers to entrepreneurship—lowering capital requirements, expanding market access, and enabling flexible business models—thus democratising entrepreneurial opportunities (Nambisan, 2017). This effect is particularly significant in geographically isolated regions where physical market access is constrained (Satalkina & Steiner, 2020).

The realisation of digital entrepreneurship potential depends on overcoming digital divide challenges. While digital tools theoretically allow individuals in mountainous regions to access global markets, such benefits require sufficient infrastructure, digital skills, and supportive ecosystems (Raja, Prasetya, Setiawan, & Bachtiar, 2024). Empirical evidence indicates that under enabling conditions, DTA catalyses entrepreneurial activity through improved opportunity recognition, reduced transaction costs, and enhanced business model innovation (Driņķe et al., 2024).

H2: Digital technology adoption positively influences digital entrepreneurship in Vietnam's mountainous regions.

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2.2.3 Digital Infrastructure and Green Economic Development

Digital infrastructure (DI) constitutes the foundational architecture enabling digital transformation for sustainable development. From an SDT perspective, robust DI supports the deployment of digital solutions for environmental monitoring, resource optimisation, and the diffusion of green innovation (Li & Diao, 2025). Empirical studies show that investments in digital infrastructure significantly reduce carbon emissions by enhancing urban green innovation and environmental awareness (Sun, 2023).

DI affects GED both directly—through green technology implementation—and indirectly—by facilitating knowledge exchange and market access for sustainable products. Smart grids support renewable energy integration, and broadband connectivity enables precision agriculture and sustainable supply chain management (Lu & Muhamad, 2025). However, the environmental impact of DI itself necessitates attention to "green digital infrastructure" powered by renewable energy and designed sustainably (Ma & Lin, 2023).

H3: Digital infrastructure positively influences green economic development in Vietnam's mountainous regions.

2.2.4 Digital Infrastructure and Digital Entrepreneurship

Within the Dynamic Capabilities Theory (DCT) framework, digital infrastructure (DI) provides the foundational resources that entrepreneurs utilise to identify and exploit digital opportunities. Empirical evidence highlights that digital connectivity is a prerequisite for digital venture creation and scaling (Elshaiekh, Al-Hijji, Shehata, & Alrashdi, 2023). In geographically isolated mountainous regions, DI enables location-independent enterprises and access to broader markets, mitigating traditional constraints on entrepreneurship (Li, Ge, & Fan, 2024).

Nevertheless, infrastructure alone is insufficient; complementary factors such as entrepreneurial skills, financial access, and institutional support are essential. Broadband availability creates potential that must be activated through human capital development and ecosystem support (Upadhyay, Upadhyay, & Dwivedi, 2022). Consequently, infrastructure impacts must be understood within the broader context of regional entrepreneurial ecosystems.

H4: Digital infrastructure positively influences digital entrepreneurship in Vietnam's mountainous regions.

2.2.5 Digital Capability and Green Economic Development

Digital capability (DC) encompasses the skills, knowledge, and organisational competencies required to leverage digital technologies for value creation. From a DCT perspective, DC enables firms and individuals to sense environmental opportunities, seize them through green innovation, and reconfigure resources to sustain competitiveness (Zhang & Meng, 2023). The translation of digital tools into green economic outcomes relies on the capacity to strategically and innovatively apply these technologies (Kai, Lin, Yuan, Hui-tao, & Zhang, 2023).

Empirical research indicates that organisations with advanced digital capabilities achieve higher green innovation efficiency, suggesting DC serves as a critical mediator between technology availability and sustainable outcomes (Fan, 2024). In mountainous regions, digital capabilities allow integration of local ecological knowledge with modern sustainability practices, generating unique value propositions in green markets (Xu, Hou, & Zhang, 2022).

H5: Digital capability positively influences green economic development in Vietnam's mountainous regions.

2.2.6 Digital Capability and Digital Entrepreneurship

The relationship between DC and digital entrepreneurship (DE) reflects the multidimensional competencies required in the digital era. Beyond technical proficiency, digital entrepreneurship necessitates capabilities in opportunity recognition, digital marketing, data analytics, platform navigation, and adaptive learning (Lu, Muhamad, & Hanafiah, 2025; Magistretti, Pham, & Dell'Era, 2021). These capabilities allow entrepreneurs to identify market gaps, develop innovative solutions, and scale ventures within digital ecosystems.

In mountainous regions, where formal education and training opportunities may be limited, digital capability development is critical for entrepreneurial success. Evidence suggests that holistic capability development, encompassing both technical and entrepreneurial skills, significantly enhances venture creation and performance (Xu, Hou, & Zhang, 2022).

H6: Digital capability positively influences digital entrepreneurship in Vietnam's mountainous regions.

2.2.7 Green Economic Development and Job Creation

The theoretical basis linking green economic development (GED) and job creation lies in SDT's social sustainability dimension, which emphasises decent work and livelihood improvement (Topgül, 2015). Green economic transformation inherently involves industrial restructuring, generating employment in renewable energy, sustainable agriculture, eco-tourism, and environmental services (Ren, 2023). Global projections estimate that the green economy transition could generate 15–60 million additional jobs, particularly in labour-intensive sectors relevant to rural areas (Yakymchuk & Rataj, 2024).

However, job creation depends on the type of green initiatives and local context. Labour-intensive activities such as organic farming, community-based conservation, and sustainable handicrafts offer more inclusive employment than capital-intensive renewable energy projects (Yakymchuk & Rataj, 2024; Pociovălişteanu et al., 2015). Additionally, workforce development is necessary to equip local populations with the skills required for emerging green jobs.

H7: Green economic development positively influences job creation in Vietnam's mountainous regions.

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2.2.8 Digital Entrepreneurship and Job Creation

Digital entrepreneurship contributes to employment both directly within ventures and indirectly across broader ecosystems. Due to its scalability and relatively low capital requirements, DE can generate rapid employment when ventures achieve market traction (Sartono et al., 2023). Moreover, the expansion of digital enterprises stimulates demand for complementary services such as logistics, content creation, and digital marketing, creating indirect jobs along the value chain (Solaja et al., 2025).

In mountainous regions, the employment impact of DE is contingent upon enabling conditions, including connectivity, digital skills, and market access. When these conditions are met, digital entrepreneurship offers alternatives to urban migration, allowing skilled individuals to create location-independent businesses while remaining in their communities (Li, Ge, & Fan, 2024).

H8: Digital entrepreneurship positively influences job creation in Vietnam's mountainous regions.

2.2.9 Mediating Role of Green Economic Development

GED serves as a mediator in the relationship between digital technology adoption (DTA) and job creation, representing the indirect pathway through which technology adoption generates employment (Kai et al., 2023). Digital tools facilitate sustainable production, market access for green products, and efficient resource management, generating economic value that sustains and expands employment (Solaja et al., 2025).

The effectiveness of this mediation depends on whether digital adoption leads to labour-intensive or capital-intensive green initiatives. In mountainous regions, initiatives leveraging local resources, knowledge, and labour are more likely to create inclusive employment opportunities (Li, Ge, & Fan, 2024).

H9: Green economic development mediates the relationship between digital technology adoption and job creation in Vietnam's mountainous regions.

2.2.10 Mediating Role of Digital Entrepreneurship

Digital entrepreneurship also mediates the relationship between DTA and job creation, based on TAM's adoption mechanisms and DCT's capability perspective. Technology adoption provides the tools and perceived benefits necessary for venture creation, which subsequently generates employment (Sartono et al., 2023; Satalkina & Steiner, 2020).

The effectiveness of this mediation relies on the strength of the entrepreneurial ecosystem, including access to finance, mentorship, market linkages, and supportive policies. In mountainous regions, strengthening these ecosystem elements is essential for realising the employment potential of digital ventures (Khan, Ahmad, & Khan, 2025).

H10: Digital entrepreneurship mediates the relationship between digital technology adoption and job creation in Vietnam's mountainous regions.

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Methodology

This study employed a quantitative research design using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine the relationships between digital technology, green economic development, and job creation. PLS-SEM was chosen due to its suitability for exploring complex models with multiple constructs, robustness with moderate sample sizes, and effectiveness in handling formative measures (Hair, Risher, Sarstedt, & Ringle, 2019). A cross-sectional survey design was applied across three mountainous regions of Vietnam—Northwest (Lai Chau, Dien Bien, Son La), Northeast (Ha Giang, Cao Bang, Bac Kan), and Central Highlands (Kon Tum, Gia Lai, Dak Lak)—selected for their geographical isolation, high poverty levels, ethnic diversity, and active digital transformation initiatives.

The study targeted three key stakeholder groups: SMEs engaged in agriculture, tourism, handicrafts, and services; workers including farmers and artisans; and local government officials involved in economic development. A stratified random sampling strategy yielded a final sample of 400 respondents (150 SME representatives, 200 workers, 50 officials), ensuring representativeness across the regions. Measurement instruments were adapted from validated scales and contextualised for the local setting. Constructs included Digital Technology Adoption (Davis, 1989; Venkatesh, Morris, Davis, & Davis, 2003), Digital Infrastructure (World Bank, 2020; Nguyen, Pham, & Le, 2021), Digital Capability (Teece, Pisano, & Shuen, 1997; ITU, 2021), Green Economic Development (UNEP, 2011; Tran, Nguyen, & Le, 2022), Digital Entrepreneurship (Ajzen, 1991; Hoang, Nguyen, & Pham, 2023), and Job Creation (ILO, 2019; Pham, Nguyen, & Tran, 2022).

Data were collected between January and March 2024 through face-to-face interviews, with surveys translated and back-translated for accuracy and cultural sensitivity. Reliability and validity were confirmed via Cronbach's alpha, composite reliability, AVE, and HTMT ratio assessments (Henseler, Ringle, & Sarstedt, 2015). Structural relationships were evaluated using path coefficients, bootstrapping (5,000 subsamples), effect sizes, and model fit indices (SRMR, NFI, R^2). Multi-group analyses assessed gender-based differences, and control variables including respondent type, region, age, education, and prior digital experience were included to isolate the effects of primary constructs (Hair et al., 2019).

Conclusion

This investigation provides robust empirical evidence that digital technologies serve as significant catalysts for green economic development and employment generation in Vietnam's mountainous regions when supported by adequate infrastructure and capabilities. The successful validation of the integrated multi-theoretical framework demonstrates the value of synthesising individual adoption, organisational capability, sustainable development, and livelihood perspectives to understand complex development phenomena.

The identification of green economic development and digital entrepreneurship as significant mediating pathways between digital technology adoption and job creation offers crucial insights for development theory and practice. These findings suggest that digital technologies

generate employment not through direct effects but by enabling economic transformation processes that subsequently create opportunities.

The research's practical contributions include evidencebased guidance for policymakers designing digital transformation initiatives in geographically marginalised regions. The emphasis on integrated approaches addressing infrastructure, capabilities, and sustainable economic opportunities, combined with attention to genderdifferentiated impacts, provides a foundation for more effective and inclusive development programming.

Looking forward, this research establishes a foundation for continued investigation into digital-green transitions in challenging contexts. The validated theoretical framework and methodological approach can be adapted for other geographical regions and development contexts, contributing to broader understanding of how digital technologies can support sustainable and inclusive development in an increasingly connected yet unequal world.

The imperative for sustainable development in the face of climate change and digital transformation makes understanding these relationships increasingly critical. As demonstrated in Vietnam's mountainous regions, digital technologies hold significant potential for facilitating environmentally sustainable economic development whilst generating meaningful employment opportunities. Realising this potential requires coordinated attention to infrastructure development, capability building, and inclusive programming that ensures the benefits of digital-green transitions reach those who need them most.

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