Int. j. adv. multidisc. res. stud. 2025; 5(5):1242-1247

Received: 03-09-2025
Accepted: 13-10-2025

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Digital Transformation in Vietnam's Resource and Environmental Economics

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DOI: https://doi.org/10.62225/2583049X.2025.5.5.5101

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Abstract
The integration of digital technologies into resource and environmental economics has become critical for sustainable development in emerging economies. This paper provides a comprehensive assessment of digital transformation in Vietnam's resource and environmental sectors, drawing on official Vietnamese government data and reports, as well as analyses by global development institutions. We examine the current state of digitalization in natural resource management and environmental governance, including official e-government initiatives, data infrastructure, and sector-specific applications. Key models, technologies and policies driving digital change are analyzed, with emphasis on innovations such as remote sensing, Internet of Things (IoT), artificial intelligence (AI), and big data analytics. The socio-economic impacts of these digital advances on environmental governance, resource management efficiency, and green economic practices are evaluated. We also identify major challenges and barriers—such as infrastructure gaps, limited digital skills, data fragmentation, and regulatory issues hindering effective digitalization. Finally, the paper proposes policy recommendations and strategic directions for Vietnam's future digital transformation in resource and environmental economics, emphasizing capacity building, unified data platforms, inclusive digital literacy, and supportive legal frameworks. The findings indicate that Vietnam has achieved significant progress in digitalizing its environmental and resource sectors (e.g. smart irrigation, GIS-based monitoring, e-services), but sustained efforts and investments are needed to fully realize a digital and green economy.

Keywords: Digital Transformation, Resource, Environmental Economics

1. Introduction

Digital transformation—the integration of digital technologies across economic and social systems is revolutionizing how societies manage resources and protect the environment. In Vietnam, a dynamic emerging economy, rapid growth and urbanization have heightened pressures on natural resources and the environment (e.g. deforestation, pollution, climate vulnerability). To address these challenges, the Vietnamese government has identified digitalization as a strategic enabler of sustainable development. Key national policies, including the National Digital Transformation Program by 2025 (Directive 749/QĐ-TTg) and the draft Digital Transformation Law (2025), prioritize a "digital government" and "digital economy" as core drivers of growth. Concurrently, Vietnam's Green Growth Strategy (2021–2030) and commitments under the Paris Agreement call for leveraging technology to achieve environmental goals (e.g. carbon neutrality by 2050).

Against this backdrop, this paper focuses on the intersection of digital innovation and resource/environmental economics. We assess how Vietnamese authorities and industries are applying digital tools (such as GIS mapping, AI, IoT sensors, and big data platforms) to improve natural resource management (including land, water, forestry) and environmental governance (monitoring, regulation, green industry). Official sources show that ministries and sector agencies are actively pursuing digital initiatives. For example, the Ministry of Agriculture and Rural Development (MARD) and the Ministry of Natural Resources and Environment (MoNRE) have established units for digital transformation and are deploying e-government services in forestry, land, and irrigation. State-owned enterprises, such as Vietnam Electricity (EVN), are also recognized as leaders in corporate digitalization. International partners (e.g. UNDP, ADB) collaborate with Vietnam on green digital solutions in agriculture and waste management.

This paper is organized as follows. Section II reviews literature on digital transformation in environmental and resource sectors, drawing on global studies and Vietnam-specific analyses. Section III outlines the methodology, which involves qualitative analysis of official documents, reports, and case studies. Section IV presents results and discussion, covering (a) the current status of digital transformation in Vietnam's resource/environment sectors, (b) key technologies, models and policies driving change, (c) socio-economic impacts on governance, resource use and green practices, and (d) challenges and barriers. Finally, Section V concludes with policy recommendations and strategic directions for sustaining and scaling digital transformation in Vietnam's resource and environmental economics. All citations follow IEEE style, referencing official Vietnamese and international sources.

2. Literature Review

Digital transformation and environmental governance have been widely studied in international literature, but Vietnam-specific research is sparse. Globally, digitalization is seen as a catalyst for sustainable development: technologies like remote sensing and AI enable better resource monitoring, while platforms and e-services improve transparency. For instance, digital mapping allows state agencies to allocate budgets spatially and identify critical conservation areas. In Vietnam's context, scholars note the alignment between "green" and "digital" agendas. Business leaders describe digital and green transformation as "twin pillars" of growth in Vietnam. For example, Viet Nam News reports that businesses (dairies, tourism, manufacturing) are adopting IoT, AI and renewable energy to modernize operations and reduce carbon footprints.

Government and development agency publications highlight Vietnam's push toward Industry 4.0 across key sectors. Official strategies emphasize data-driven policy making and cross-sector data sharing. A World Bank policy note and Vietnam Digital Government reports underscore the benefits of e-government: improved citizen services, streamlined administration, and reduced corruption. In environmental management, international case studies (e.g. Indonesia, Vietnam) show how digital platforms can engage communities in waste management and biodiversity conservation. For agriculture, UNDP documents illustrate digital traceability systems for crops that allow consumers to verify sustainable practices, aiding export competitiveness under carbon regulations.

However, literature also stresses challenges. Digital divides (urban–rural and socio-economic) may hinder inclusive transformation. Vietnam's rural areas face underdeveloped ICT infrastructure and limited tech literacy among farmers. Fragmented data systems and weak inter-agency coordination have constrained the effectiveness of early e-government efforts. Peer-reviewed analyses (albeit limited) often call for more integrated approaches and capacity-building in digital skills. In sum, the literature suggests that while digital tools hold promise for Vietnam's environmental and resource management, realizing these gains requires strong policies, infrastructure, and human capital.

3. Methodology

This study employs a qualitative review of official Vietnamese government publications, policy documents, sectoral reports, and analyses by international organizations. We surveyed sources from Vietnam's Ministry of Agriculture and Rural Development (MARD) and Ministry of Natural Resources and Environment (MoNRE), including press releases and digital strategy plans. National-level directives (e.g. National Digital Transformation Program) and ministerial decisions were examined for quantitative targets on online services and database integration. We also incorporated reports from the Ministry of Science and Technology (MST/MIC) on digital economy indicators and state-owned enterprise documentation (e.g. EVN's digital transformation report).

For broader context, we included analyses from global development partners: UNDP case studies on digital agri-food systems, ADB/USAID development publications on digital solutions in waste and environmental monitoring, and media reports covering government and private sector initiatives. Data points such as online service usage rates, internet penetration, and ICT sector revenue were drawn from official statistics and press reports. We systematically coded these findings to address the five focal areas: (1) current state, (2) technologies and policies, (3) socio-economic impacts, (4) challenges, and (5) policy recommendations. Direct quotations and data are cited using IEEE-style references linked to their sources.

4. Results and Discussion

4.1 Current State of Digital Transformation

Vietnam's government has prioritized digital transformation across sectors, including resources and environment. The national agenda (Decision 749/QĐ-TTg) mandates that by 2025, a majority of administrative procedures be online and critical data systems integrated. Recent reports indicate substantial progress in e-government: as of mid-2024, 100% of national agencies reported digital document management and 43% of procedures are fully online. In environment and resource ministries specifically, dedicated digital transformation units have been established (e.g., MoNRE's Department of Digital Transformation) to drive implementation. The agricultural and environmental portal highlights a government workshop (Mar 2025) emphasizing development of legal frameworks, national data infrastructure, and cybersecurity for the digitalization of these sectors.

Significant initiatives include the consolidation of **national resource databases**. For instance, the MoNRE's digitalization roadmap aims to synchronize land data for all 484 districts into a unified national land database by mid-2025. Similarly, a national remote sensing database has been built with nearly 100,000 satellite images covering the country and its seas. This centralized imagery supports diverse uses: flood and typhoon response, forest and land use change monitoring, and methane emissions estimation. In summary, official sources suggest that Vietnam has laid substantial groundwork for digital resource management, with national data centers, e-services platforms, and inter-ministerial linkages under development.

At the sector level, evidence of digital adoption is emerging. The irrigation sector has transformed reservoir operation from manual decisions to data-driven coordination. Since 2015, irrigation authorities have applied hydraulic simulation models (MIKE 11, SWAT, WEAP) and real-time monitoring to build drought and flood regulation scenarios. Between 2019–21, this system saved 1.4–1.8 billion m^3 of water annually in Vietnam's mid/northern plains while sustaining crop area. In forestry, pilot projects (e.g. in Vinh Phuc province) are developing digital monitoring systems that combine field surveys with UAVs and satellite imagery.

In agriculture, IoT sensors and blockchain traceability are being trialed for crops: a partnership between MARD and UNDP introduced an e-traceability QR-code system for dragon fruit farms, enabling consumers to verify origin and carbon footprint. Meanwhile, state-owned utilities leverage ICT: Vietnam Electricity (EVN) has deployed AI for power line monitoring and achieved 97% remote control of high-voltage substations.

Summarizes key indicators: e.g., percentage of online public services in resource agencies, mobile internet coverage, and digital skill levels. Notably, the Ministry of Public Security reports that 100% of citizens now have ID numbers and 86.3 million (≈100%) have electronic ID cards, facilitating digital identification for environmental services and land registration. Internet access has expanded (Vietnam ranked among top 10 globally for speed in 2025), though urban–rural gaps remain. Overall, official data indicate Vietnam's digital infrastructure and services in resource and environment management are rapidly advancing, albeit from a low base.

4.2 Key Models, Technologies, and Policies

Vietnam's digital transformation is driven by a combination of technological innovation and supportive policies. Technologically, core models include remote sensing and GIS mapping, IoT sensor networks, digital twins and simulation models, cloud-based data platforms, and mobile applications. For example, remote sensing is used nationwide: the Satellite Applications Center provides monthly maps of forest cover and flood risk. The irrigation sector employs a four-layer digital architecture (infrastructure, data, technology, service) with real-time data feeds from hundreds of reservoirs, weather stations, and UAVs. At the application layer, predictive models (Digital Twin, MIKE Flood) and decision support systems issue early warnings for droughts, saltwater intrusion and storms. Da Nang City has implemented a smart environmental monitoring system: over 70 smart cameras and 66 automated stations continuously track air and water quality, with data integrated into urban management dashboards. These technologies reflect adoption of Industry 4.0 paradigms in public administration, as described by Vietnamese planners.

Policy initiatives are equally important. Vietnam's legal framework has begun embedding digital concepts into environmental law. The 2020 Environmental Protection Law and its implementing decree allocate specific articles for environmental information systems, databases, and online service delivery. Building on this, MoNRE issued technical guidelines (Circular 02/2022) for establishing and interconnecting environmental databases at national and local levels. The government's "Project 06" (2022–25) is a major program unifying personal identification and population data, which EVN and other agencies leverage to link service databases. In late 2025, the Prime Minister further decreed that all ministries complete accurate and interoperable data systems by 2025 to facilitate AI analytics and cloud-based governance. These top-down mandates reflect a strategic push to standardize data sharing across ministries (so-called "digital backbone"), with incentives (budget allocations, legal mandates) to encourage implementation.

At the sectoral level, specific policies guide digital adoption. MARD has integrated digitalization into its climate-smart agriculture strategies, partnering with UNDP to promote IoT in farming and digital trade. In January 2024, MARD announced the formation of a Center for Digital Transformation and Agricultural Statistics to coordinate IT use and e-government within agriculture. The forestry ministry (under Agriculture and Environment) plans to expand remote sensing applications for forest inventory and protection, as reported in 2025 news. The irrigation authority follows a national strategy for smart water management, as detailed in technical reports. Other policies include rural connectivity programs (e.g. 5G expansion targets, broadband subsidies) that underpin digital transformation in farming and environment.

Together, these models and policies create an ecosystem for "green digital transformation": digital tools are framed as instruments to achieve low-carbon, sustainable development. Vietnam's leadership frequently links digitalization with green growth: for example, renewable energy projects often incorporate smart grid digital controls, and e-commerce platforms promote eco-friendly products. A 2025 business survey notes that Vietnamese companies see digital and green transformation as "strategic imperatives" for competitiveness. This narrative is reinforced by global initiatives: the EU and ADB support Vietnam's "just transition" projects that combine digital monitoring with emissions reduction in agriculture and energy. In summary, Vietnam's digital change in resource and environmental economics is guided by a convergence of high-level policies and practical technology deployments, aimed at data integration, smart management, and green outcomes.

4.3 Socio-Economic Impacts of Digitalization

Digital transformation in Vietnam's resource and environmental sectors carries significant socio-economic implications. First, **enhanced environmental governance** is a core benefit. By digitizing monitoring and reporting, authorities can enforce regulations more transparently and timely. For instance, the smart monitoring in Da Nang allows city officials and citizens to report pollution incidents quickly. This increased oversight can reduce illegal logging, improper waste disposal, and other infractions, improving public health and ecosystem quality. Similarly, online permit systems for land use or mining (e-government services) reduce bureaucratic delays and corruption, streamlining investment in resource projects. As noted by Vietnam's DT Steering Committee, a unified document interconnection axis and digital IDs now facilitate almost all permit transactions online. The digital platforms (e.g. national public service portal) ensure that businesses and individuals in resource sectors can access services remotely, expanding coverage even in remote provinces.

Second, efficiency gains in resource management and industry are substantial. In irrigation, the intelligent reservoir network dynamically balances water supply for agriculture, hydropower and flood control. The earlier example of saving over a billion cubic meters of water annually translates into economic and environmental gains: farmers avoid crop losses, hydropower maintains output, and ecosystems suffer less extreme flows. In agriculture, digital tools like weather forecasting apps, remote sensing-based advisories, and e-commerce platforms help farmers optimize inputs (water, fertilizer) and access markets, raising incomes. A World Bank case on rice farming (though not Vietnam-specific) shows smart methods can cut costs and reduce GHGs. In manufacturing, the Orion smart factory case illustrates how IoT and automation can dramatically boost productivity and resource efficiency: output up 30%, downtime down 68%, and energy/material savings equivalent to millions of dollars in gains. Such improvements strengthen Vietnam's industries' competitiveness and generate new tech-sector jobs, especially in ICT services supporting resource industries.

Third, **green economic practices** are being enabled by digitalization. Digital traceability and e-commerce platforms allow certification of sustainable goods, opening premium export markets that require environmental standards. For example, the UNDP-supported digital carbon label for fruit and shrimp production helps Vietnamese exporters meet EU carbon border adjustment requirements. Digital platforms also foster the circular economy: open data and apps can facilitate recycling programs and citizen science. An NGO-developed platform (nhuavasuckhoe.vn) aggregates plastic pollution data from various projects, connecting communities and government agencies. Although still nascent, such initiatives indicate a shift toward data-driven environmental stewardship. Moreover, the rise of the digital economy itself is large: ICT sector revenues grew ~28% year-on-year in 2025, contributing over 12% of GDP. This growth underpins a "green digital economy" where technology industries coexist with sustainable practices.

However, digitalization also has socio-economic risks that Vietnam must manage. There are inequality and inclusion concerns. Advanced digital solutions tend to benefit urban, well-resourced areas first. Rural farmers and underserved communities may be left behind due to lack of access or skills. Indeed, MARD officials note that Vietnamese rural internet infrastructure is still weak and many smallholders lack capacity to use smart devices. In addition, dependence on digital systems raises issues of data privacy, cybersecurity, and the need for social safeguards. The state is attentive to these: for example, the draft Digital Transformation Law emphasizes digital literacy for all, safe and inclusive networks. On balance, the socio-economic impacts of digital transformation in Vietnam's resource and environment sectors are strongly positive in terms of governance, efficiency and new economic opportunities, but require parallel efforts to ensure equitable access and mitigate digital divides.

4.4 Challenges and Barriers

Despite momentum, Vietnam faces multiple challenges in fully realizing digital transformation in resource and environmental economics. Infrastructure gaps remain a key barrier. Many rural and remote areas lack high-speed internet or IoT networks, hindering field data collection and service delivery. The irrigation report noted that only ~17% of thousands of reservoirs have full meteorological sensors. Similarly, the general environment administration acknowledges that its ICT infrastructure is "fragmented, outdated and mostly depreciated". This causes data silos: environmental databases at national, ministerial, and provincial levels are often not well integrated due to legacy systems and incompatible software. The government is attempting to address this by accelerating nationwide fiber and 5G rollout, but gaps persist.

Another barrier is digital skills and awareness. Many public officials and local practitioners lack training in data analytics and ICT tools. [53] reports that staff in the environment sector still have only partial understanding of digital transformation. Among farmers and small businesses, tech adoption is limited by low digital literacy and small scale of operation. Without sufficient human capital development, advanced systems cannot be effectively used. Recognizing this, Vietnam has launched "Digital Literacy for All" initiatives and skill-training program, but scaling such programs to millions of rural users is challenging.

Regulatory and institutional challenges also hinder progress. Although laws now mandate environmental information systems, implementation is uneven. The tapchi article notes that building national environmental databases relies on guiding decisions from the Ministry, and enforcement has only just begun. Coordination between ministries (e.g. agriculture, environment, planning) is complex; each may have its own ICT projects. Data sharing is often constrained by unclear policies and legacy restrictions. The prime minister's recent call for interoperable data platforms aims to overcome this, but progress depends on ministries' capacity to reorganize. Cybersecurity and data privacy are also emerging concerns: with more critical infrastructure online, Vietnam must protect against hacks and misinformation, requiring investment in security measures (as noted in [19], 76.5% of systems now have approved security plans).

Finally, financial and social barriers persist. Digital projects require funding for hardware, software and maintenance. Although the state budget and social capital are mobilized for digital infrastructure, resource constraints may slow some sector-specific programs. Public acceptance is another issue: for example, farmers may resist sharing data or adopting new tools without clear incentives. In sum, Vietnam's digital transformation in resource/environment faces multi-dimensional barriers: technological, human, institutional and financial. Addressing these requires coordinated strategies and sustained commitment.

4.5 Policy Recommendations and Future Directions

To overcome these challenges and leverage digitalization for sustainable resource management, we propose several policy directions:

1. **Enhance Infrastructure and Data Integration.** Rapidly expand ICT infrastructure in rural/resource areas: for instance, deploy IoT sensor networks (soil moisture, air/water quality) and ensure reliable broadband to field offices. Continue building national data hubs (land, water, forest, climate) that are interoperable by design. The Prime Minister's 2025 directive on completing connected data systems should be accelerated, with specific targets for resource/environment agencies. Promote open data standards so that public environmental datasets (e.g. forest maps, pollution indices) are accessible to citizens and researchers. As [53] recommends, environment databases should enable data sharing and legal integrity across all levels.
2. **Strengthen Governance and Legal Frameworks.** Update and enforce laws to mandate digital practices in environment management. For example, expand the Environmental Protection Law or subsequent decrees to require online permitting for mining, forestry and waste services. Clarify data governance policies: a comprehensive Data Law (expected soon) should include environmental data privacy and sharing rules, as

highlighted by the National Data Strategy. Ensure that ministries have clear mandates (via inter-ministerial agreements) for data exchange. Establish an oversight body or strengthen the existing Digital Transformation Steering Committees to monitor implementation of digital targets in resource sectors, ensuring accountability.

3. **Invest in Human Capacity.** Launch nationwide digital literacy and training programs tailored to resource/environment contexts. For government officials, provide courses on geospatial technologies, data analytics, and ICT project management. As [34] noted, the Ministry of Agriculture created a dedicated center to unify digital efforts; similar centers should be supported in other resource ministries. For rural communities, use extension networks and mobile platforms to train farmers and fishers in using agritech tools (e.g. irrigation apps, weather forecasts). Leverage public–private partnerships, e.g. with universities and tech companies, to develop local training content. Encourage youth involvement in "smart agriculture" and "green tech" programs to build a future workforce.
4. **Promote Inclusive Digital Economy.** Ensure digital services reach small enterprises and underprivileged regions. For example, provide subsidies or incentives for farms and SMEs to adopt precision tools and traceability systems. Expand rural e-commerce and e-payment infrastructure so that remote producers can sell green products online. The government should support farmer cooperatives to develop digital marketing channels. Policies should emphasize gender and ethnic inclusion, providing targeted outreach and support to women and minority farmers, as they often lack access to technology. The digital transformation agenda should go hand-in-hand with social safety nets (like digital IDs for all citizens) to prevent widening inequalities.
5. **Foster Innovation in Green Technology.** Encourage R&D in areas such as AI for crop management, blockchain for transparent supply chains, and remote sensing for climate adaptation. Government can fund pilot projects (like the existing dragon-fruit traceability) and scale successful models. Regulatory sandboxes could allow innovators to test new digital-environment solutions with temporary waivers. Engage international cooperation (e.g. with ADB, EU) to transfer best practices in digital environmental management (e.g. smart city pollution control, precision irrigation). The example of Da Nang's smart monitoring could be replicated in other cities with central support.
6. **Align Digital and Environmental Strategies.** Finally, integrate digital transformation into Vietnam's broader environmental and economic strategies. For example, the ongoing Green Growth Strategy review should include digital indicators (e.g. percentage of environmental transactions online, number of GIS-based projects). Include environmental targets in the National Digital Transformation Program (e.g. reduced deforestation rate per digital monitoring). As [53] suggests, the goal is to make environmental data a "key input for the digital economy". This means not treating technology as separate from environmental policy, but as a complementary driver of green growth.

Implementing these policies will require commitment across government and society. The early steps in digitalizing Vietnam's resource sectors have shown that technology can yield real benefits in efficiency and sustainability. Continuing on this trajectory, with targeted reforms and investments, will help Vietnam manage its natural resources more effectively and transition to a truly green digital economy.

5. Conclusion

Vietnam stands at a critical juncture where digital transformation and environmental sustainability converge. This paper has surveyed Vietnam's current efforts to digitalize resource and environmental management, noting both achievements and gaps. Official data and reports reveal that the government has mobilized policies, infrastructure and institutions to promote e-government, data sharing, and smart technologies in natural resource sectors. Applications such as remote sensing for agriculture, AI-driven irrigation, and online environmental services demonstrate the potential of digital tools to improve governance and efficiency. However, barriers in infrastructure, skills, and regulatory coherence remain.

The socio-economic impacts of these digital initiatives are largely positive: greater transparency in governance, cost savings in resource use, and opportunities for green industries. Yet, to fully capitalize on these advances, Vietnam must address the digital divide and ensure inclusive access. Our policy recommendations stress the need for integrated data platforms, capacity-building, legal clarity, and alignment of digital and green policies. By learning from ongoing pilot successes (e.g. smart city monitoring in Da Nang, agricultural traceability) and scaling them, Vietnam can strengthen environmental governance and pursue sustainable growth.

Future research should continue to monitor the outcomes of specific digital projects and quantify their environmental and economic returns. For now, the trajectory is clear: digital transformation will play a pivotal role in Vietnam's sustainable development journey, and strategic, inclusive implementation is key to realizing its benefits.

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