



Management and Utilisation of Digital Data in Vietnam's Natural Resources and Environment Sector: Current Status, Challenges and Solutions

Nguyen Van Bau^{1,2}

¹ University of Social Sciences and Humanities, Ho Chi Minh City, Vietnam

² Vietnam National University, Ho Chi Minh City, Vietnam

Corresponding author:

baunv@hcmussh.edu.vn



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ABSTRACT: Amid Vietnam's accelerated national digital transformation, digital data play an increasingly pivotal role in managing natural resources, protecting the environment, and promoting sustainable development. This study analyses the current state of digital data systems in Vietnam's Natural Resources and Environment (NRE) sector, identifying key challenges and proposing solutions for more effective data governance. Employing a qualitative approach combined with policy document analysis, the study reveals that the NRE data system remains fragmented, lacks interoperability, standardised technical frameworks, and underutilises its potential for societal benefits. Institutional, technical, and organisational barriers—including bureaucratic data-sharing processes, limited digital capacity among personnel, and inconsistent technological infrastructure—hinder the application of data in environmental monitoring, spatial planning, and evidence-based decision-making. Based on these findings, the study recommends developing a national NRE data strategy, reforming open data policies, enhancing digital workforce capacity, investing in integrated infrastructure, and promoting mechanisms for data utilisation to serve communities and businesses. These proposals aim to establish an efficient, transparent NRE data ecosystem that robustly supports Vietnam's sustainable development goals.

KEYWORDS: Digital data, Digital transformation, Open data policy.

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Introduction

Climate change has emerged as one of the most critical global challenges of the 21st century, threatening the sustainability of natural, economic, and social systems. In developing countries like Vietnam, where economies still heavily rely on natural resource exploitation, the impacts of extreme weather, ecological degradation, and environmental risks are becoming increasingly complex and difficult to manage. In this context, sustainable development is no longer optional but a strategic national priority, requiring interdisciplinary coordination among economic growth, social equity, and environmental protection.

The Natural Resources and Environment (NRE) sector plays a central role in achieving sustainable development goals through its functions of monitoring, planning, and managing critical resources, including land, water, air, forests, minerals, and coastal areas. However, for resource governance to be effective, proactive, and adaptive, enhancing forecasting, monitoring, and decision-making capabilities must rely on robust data, particularly digital data. In the era of digital transformation, data has evolved beyond a technical tool to become a new form of “strategic asset” for nations, playing an essential role in managing resource dynamics, analysing environmental trends, and formulating policies to adapt to climate change.

Recognising this importance, the Vietnamese government has identified digital transformation as a key driver for sustainable development. According to Decision No. 749/QĐ-TTg of 2020 on the National Digital Transformation Program (Government of Vietnam, 2020), the NRE sector is prioritised for early digitisation to enhance operational efficiency, public service delivery, and rapid response to environmental challenges. However, implementation in Vietnam reveals that the NRE digital data system remains fragmented, lacks synchronisation, and has yet to fully realise its potential to support decision-making and policy planning. Institutional barriers, technical infrastructure limitations, information-sharing mechanisms, and organisational capacity pose significant challenges to modernising the sector’s data systems.

Against this backdrop, this article aims to comprehensively analyse the current state of digital data management and utilisation in Vietnam’s NRE sector while evaluating the role of digital data in supporting decision-making and achieving sustainable development goals. It also identifies key challenges in the sector’s digital transformation process. It proposes practical solutions to enhance data governance efficiency, ultimately contributing to the development of an integrated, transparent, and sustainable NRE information ecosystem in the long term.

Research Aim

This study aims to comprehensively evaluate the management and utilisation of digital data in Vietnam's Natural Resources and Environment (NRE) sector, examining the current status, identifying institutional, technical, and organisational challenges, and proposing practical,

evidence-based solutions to strengthen data governance for sustainable development.

Research Questions

1. What is the current state of digital data systems in Vietnam's NRE sector in terms of interoperability, data accessibility, standardisation, and practical application?
2. What institutional, technical, and organisational barriers hinder the effective management, sharing, and utilisation of NRE digital data at national and local levels?
3. What policy, technological, and capacity-building solutions are needed to develop a more integrated, transparent, and sustainable digital data ecosystem in the NRE sector?

Research Results

Legal and Policy Framework for Digital Data Governance in the Natural Resources and Environment Sector

In recent years, Vietnam's legal and policy framework for digital data governance in the NRE sector has made significant strides, reflecting efforts to establish an institutional framework aligned with digital transformation and the Sustainable Development Goals. At the national level, Decision No. 749/QD-TTg (2020) on the National Digital Transformation Program (Government of Vietnam, 2020) clearly outlines the pivotal role of data in building a digital government, economy, and society. The NRE sector is prioritised for digitalisation, with the development and operation of large-scale databases, such as those for land, climate, environment, biodiversity, and remote sensing, emphasised as foundational for state management and climate change response.

Additionally, the National Data Strategy to 2030 aims to establish an open, shared, and interdisciplinary data ecosystem to facilitate information sharing across government levels, ministries, and localities. At the sectoral level, Decree No. 73/2017/ND-CP (Government of Vietnam, 2017) serves as a central legal document regulating the collection, management, and use of NRE data, covering 13 key sectoral data groups. The Environmental Protection Law (National Assembly, 2020) further strengthens the legal basis for developing and operating a national environmental information system, mandating integration and interoperability at all levels, from central to local. Circular 03/2022/TT-BTNMT (Ministry of Natural Resources and Environment, 2022) also plays a critical role in guiding the management and storage of electronic NRE documents, promoting data connectivity with national platforms such as the National Archives. Moreover, the NRE sector's development strategy to 2030, with a vision to 2050, clearly sets the goal of establishing a unified digital database capable of broad sharing and multi-sectoral applications.

However, the current policy framework reveals certain limitations, including a lack of specific

regulations on open data, the absence of unified technical standards for sectoral data, and fragmented information management structures. These shortcomings underscore the need for institutional reforms to ensure the strategic role of digital data in resource management, environmental protection, and sustainable development.

Current State of Digital Data Management in the NRE Sector

The implementation of digital data management in Vietnam's NRE sector has shown notable progress but remains uneven, with significant technical and organisational challenges. Data generation has gradually shifted from manual methods to modern technologies, such as automated monitoring systems, remote sensing, and digital topographic surveys, reflecting efforts to enhance data timeliness and accuracy. However, data classification and standardisation remain limited. The data are often stored in varied formats and do not follow uniform metadata standards, such as the ISO 19115 standard, and are not fully integrated with metadata, which complicates retrieval, sharing, and reuse.

The data storage model remains fragmented, primarily managed independently by sectoral units or localities. Investment in IT infrastructure, such as servers, storage software, and backup systems, is inconsistent, particularly in provinces and remote areas, leading to risks of data loss, limited long-term accessibility, and reduced overall management efficiency.

On a positive note, the Ministry of Natural Resources and Environment has deployed key data platforms like GeoPortal, VnMAPS, and EnviSoft (Northern Centre for Environmental Monitoring, 2023). These tools have begun to enhance real-time data connectivity, access, and support for decision-making. However, their application remains limited, with many systems operating in isolation and not yet integrated with national shared data platforms. The adoption of advanced technologies, such as AI, machine learning, or blockchain, is still in the experimental phase, with no established mechanisms for broader implementation.

Overall, the absence of a comprehensive data governance framework, coupled with inadequate organisational and human resource capacities, poses significant barriers to modernising NRE data systems and limits their role in sustainable development governance.

Utilisation of Digital Data for Sustainable Development

As sustainable development becomes a national strategic priority and a focus of numerous policies, the role of NRE digital data is increasingly recognised as a critical foundation for evidence-based decision-making. Effective data utilisation not only enhances state management efficiency but also fosters innovation, transparency, and climate change adaptation, one of Vietnam's most pressing challenges.

In practice, the NRE sector has made strides in leveraging digital data to support sustainable

development goals, particularly through integrating data into planning, resource monitoring, and environmental risk management. Several localities have implemented spatial data, remote sensing, and digital terrain modelling to assess risks. These include erosion, salinisation, and land degradation, supporting climate change adaptation and sustainable socioeconomic development plans. For instance, provinces in the Mekong Delta, such as Ben Tre, Tra Vinh, and Soc Trang, have actively utilised remote sensing data to map risks and integrate them into land use, dike system, and infrastructure planning for response to sea-level rise.

In major urban centres like Hanoi and Ho Chi Minh City, automated air quality monitoring systems provide real-time data integrated into digital platforms. They are PAMAir and EnviSoft. These tools enable air quality tracking, environmental alerts, and timely adaptation measures for both citizens and policymakers. These applications mark a shift in data's role from purely administrative functions to supporting proactive forecasting and decision-making, aligning with smart environmental governance and sustainable urban development.

However, data utilisation faces significant challenges related to organisational capacity, institutions, and technology. At the local level, data analysis and visualisation capabilities are limited due to a lack of trained personnel in IT, GIS, remote sensing data processing, or environmental modelling. Often, data are collected and stored in raw form without being processed into actionable insights for policy analysis, leading to a scenario where "data exists but cannot be used". This skill gap creates a significant divide between the potential of data systems and their practical realisation.

Moreover, data sharing and access mechanisms lack transparency and consistency within and across various sectors, including transportation, construction, agriculture, and energy. Data are frequently treated as an "internal asset," leading to data silos that hinder interdisciplinary integration and analysis—essential for comprehensive, long-term sustainable development policies. The absence of effective technical and institutional frameworks for data sharing further limits the ability to make decisions based on an integrated information ecosystem.

From a societal perspective, the private sector's role in leveraging NRE data is increasingly acknowledged, particularly in high-tech fields, smart agriculture, real estate, renewable energy, and risk insurance. However, unclear regulations on data access, usage costs, and personal data protection hinder the commercialisation and reuse of data for innovation and green growth. The lack of open, internationally compatible technology platforms also poses challenges for domestic businesses integrating NRE data into digitalised production and operations.

Critically, NRE digital data have not been fully integrated into policy planning and sustainable development impact assessments. Strategic Environmental Assessments (SEA), Environmental Impact Assessments (EIA), and regional or sectoral development plans often fail

to utilise real-time data or integrate socioeconomic indicators. As a result, the resulting policies often lack predictive accuracy and limited verifiability. Modern governance principles, such as evidence-based management, adaptive decision-making, and early risk warnings, require a synchronised, high-quality, and interdisciplinary data system.

In summary, the utilisation of digital data in Vietnam's NRE sector is at a critical transition phase: from passive data models to proactive data governance, from fragmented to interdisciplinary integration, and from purely technical applications to strategic decision-making support. Overcoming existing barriers requires refining the legal framework for open data, investing in synchronised technological infrastructure, establishing transparent data-sharing mechanisms, and, crucially, enhancing human resource capacity in digital data management. Only when NRE data are treated as a strategic asset, managed, accessed, and utilised systematically, can their full potential be realised in advancing sustainable development and comprehensive digital transformation in Vietnam.

Discussion

The management and utilisation of digital data in Vietnam's NRE sector, while showing certain progress, continue to face multifaceted barriers encompassing institutional, technical, organisational, and human resource dimensions. These challenges not only hinder the effective implementation of digital transformation policies but also limit the potential of data to contribute to sustainable development. The following discussion outlines three key groups of issues derived from the research findings.

First, Organisational and Institutional Challenges in Data Governance

A central issue is the lack of uniformity and coordination in digital data management across NRE sector entities. Databases are often developed in a fragmented manner, with each agency (general departments, specialised bureaus, or local authorities) maintaining separate systems, leading to duplication, lack of connectivity, and ineffective integration. Inconsistencies in data formats, metadata standards, and information organisation further prevent datasets from being interoperable, reducing their value for interdisciplinary analysis.

The absence of a flexible, transparent, and efficient data-sharing mechanism remains a significant barrier. Current data-sharing processes are predominantly bureaucratic and manual, ill-suited to the demands of rapid and open access in the digital era. While legal frameworks such as the Environmental Protection Law (National Assembly, 2020) and Decree No. 73/2017/ND-CP (Government of Vietnam, 2017) provide basic guidelines, they lack specific regulations on open data, access rights, and data-sharing obligations among stakeholders. This weakens the ability to coordinate actions on environmental issues, which are inherently interdisciplinary and cross-regional in nature.

Additionally, the organisational structure and workforce for digital data governance are inadequate. Most data management units are embedded within IT or administrative departments that lack specialised expertise in data governance. This hinders the development of comprehensive data architectures, the implementation of data lifecycle models, or the adoption of international standards for storage, security, and integration.

Second, technical and Technological Barriers in Data utilisation

Technological infrastructure is a critical foundation for operationalising and maximising the value of digital data. However, Vietnam's NRE sector infrastructure lacks synchronisation, modernity, and scalability. Data are commonly stored in disparate systems, unable to be integrated or shared through national, interoperable platforms. The absence of automated backup solutions, data redundancy systems, access control mechanisms, or robust cybersecurity measures increases the risks of data loss, leakage, or misuse.

Although the NRE sector has begun adopting digital technologies such as automated monitoring systems, GIS software, and open data portals, their application remains limited to data collection and display. Advanced technologies, such as artificial intelligence (AI), machine learning, big data, and environmental modelling, are still in early experimental stages, largely due to constraints in technological and human resources.

The technical workforce is a particular concern. Most personnel lack formal training in digital technologies, data governance, or cybersecurity. As a result, they rely heavily on external vendors and have limited operational autonomy. The capacity gap between central and local levels further complicates matters, especially as the demand for real-time and multi-source data integration becomes increasingly critical.

Third, limitations in Data Access and Utilisation for Sustainable Development

NRE data holds immense potential to support policy planning, implementation monitoring, and tracking progress toward sustainable development. However, its current utilisation remains limited. High-value datasets, such as topographic maps, climate data, forest information, and water resources, are often restricted to internal government use. In many cases, complex access conditions create barriers for researchers, businesses, and communities. Mechanisms for data licensing, usage fees, or reuse restrictions are not aligned with international open data standards, such as the FAIR principles (European Commission, 2018; European Commission, 2019).

Moreover, digital data are not effectively integrated into management and decision-making tools. Environmental assessments, development planning, and climate adaptation strategies often rely on outdated, non-interactive, or partially digitised data. This compromises the quality of policy inputs, leading to low governance efficiency and limited responsiveness to escalating environmental risks.

There is also a perceptual gap between policymakers and implementers regarding the strategic value of data. When data are viewed as an “internal asset” rather than a “national asset,” incentives for sharing, integration, and utilisation remain limited. Sustainable development, however, demands an open, interdisciplinary, and continuously interactive data ecosystem, which the current NRE data system does not fully support.

In conclusion, the challenges in NRE data governance, technology, and access are fundamental but addressable with a cohesive strategy spanning institutions, technology, and organisational capacity. Overcoming these bottlenecks is a prerequisite for advancing the NRE sector’s digital transformation and enhancing national sustainable development governance amid climate change, rapid urbanisation, and increasing environmental pressures.

Conclusion and Recommendations

This study has comprehensively analysed the role, current state, and potential of digital data in Vietnam’s NRE sector, particularly in the context of the country’s accelerated digital transformation and sustainable development goals. Through document analysis, legal reviews, and expert interviews, the findings confirm that digital data are indispensable for evidence-based decision-making, supporting policy planning, governance, and monitoring related to natural resource management, environmental protection, and climate change response.

The NRE digital data system currently encompasses critical domains, including land, environment, hydrometeorology, coastal areas, and remote sensing. However, its management, exploitation, and utilisation face significant limitations, including fragmented and non-interoperable systems, an incomplete legal framework for open data, access rights, and sharing responsibilities, inconsistent technical standardisation, weak analytical and technological application capacities, and a shortage of specialised data personnel. Consequently, despite its high value, data are underutilised in state governance, research, innovation, and community monitoring.

A notable finding is that NRE data exploitation remains largely confined to internal government use, with researchers, businesses, and citizens facing access barriers. Data-sharing mechanisms are overly bureaucratic, lacking platforms for open, integrated, and real-time interaction, which contradicts international open data principles, such as FAIR. This limits the reuse of data and its value in achieving multi-sectoral, interdisciplinary sustainable development goals.

To fully harness the role of NRE digital data for sustainable development, the following recommendations are proposed:

Refine the Legal and Policy Framework: Develop a national NRE data strategy to provide unified guidance on data creation, storage, sharing, and utilisation. This framework should clearly

define stakeholders' rights and obligations, technical standards for data formats and metadata, tiered access based on data sensitivity, and information security protocols throughout the data lifecycle. Integration with other national data platforms is crucial to create an interoperable ecosystem that supports digital governance and sustainable socioeconomic development.

Establish Specialised Data Governance Units: Create dedicated units within the NRE sector to oversee strategic data management, design sectoral data architectures, enforce format standards, ensure data quality, and coordinate interdisciplinary sharing. These units should move beyond technical operations to play a strategic role in data governance.

Enhance Human Resource Capacity: Prioritise comprehensive, flexible training programs that combine theory and practice to build expertise in big data, AI, cybersecurity, and information system management. A skilled workforce is crucial to the successful implementation of NRE data strategies.

Invest in Technological Infrastructure: Develop integrated data platforms, cloud storage, and international-standard backup and security systems to enhance data exploitation and utilisation. Adopting advanced technologies, such as AI, big data, and blockchain, for resource management, environmental forecasting, and climate monitoring is essential. Integrating NRE data with national databases will facilitate interdisciplinary analysis, optimise decision-making, and enhance public accountability.

Promote Non-Governmental Participation: Encourage the private sector, research institutions, and community involvement in the NRE data ecosystem by expanding access rights, creating transparent data catalogues, simplifying licensing processes, and providing user-friendly data platforms. Integrating data into education, scientific research, planning, policy development, and innovation will amplify its practical value and societal benefits.

The findings affirm that digital data in the NRE sector is a strategic resource, not only supporting state governance but also serving as a foundation for a green, smart, and sustainable economy. Realising this potential requires a comprehensive approach integrating institutions, technology, organisation, and human resources, underpinned by clear direction and long-term investment.

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