Digital Transformation, Green Accounting and Environmental Taxation: Towards an Integrated Governance Framework for Sustainable Development in Emerging Economies – Evidence from Algeria

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Abstract:
This paper explores the role of digital transformation in reinforcing green accounting and environmental taxation as tools for sustainable development in emerging economies. Adopting a qualitative and conceptual approach, it proposes an integrated framework combining digital technologies—AI, big data, blockchain and IoT—with environmental accounting and digitalized taxation, applied to the Algerian context. The findings indicate that digitalization enhances the quality, transparency and traceability of environmental data, improves tax efficiency and compliance, and mitigates greenwashing risks. The study contributes by introducing an Integrated Digital Green Governance Model and offers policy recommendations to support sustainable and inclusive growth.

Keywords: *Digital transformation; Green accounting; Environmental taxation; Sustainable governance; Emerging economies*

Jel Classification Codes : *O33 ; M41 ; H23 ; Q56 ; O17.*

Résumé:

Cet article explore le rôle de la transformation numérique dans le renforcement de la comptabilité verte et de la fiscalité environnementale en tant qu'outils de développement durable dans les économies émergentes. Adoptant une approche qualitative et conceptuelle, il propose un cadre intégré combinant les technologies numériques (IA, mégadonnées, blockchain et IoT) avec la comptabilité environnementale et la fiscalité numérisée, appliqué au contexte algérien. Les résultats indiquent que la numérisation améliore la qualité, la transparence et la traçabilité des données environnementales, renforce l'efficacité et le respect de la fiscalité, et atténue les risques de greenwashing. L'étude contribue à l'introduction d'un modèle intégré de gouvernance verte numérique et propose des recommandations politiques pour soutenir une croissance durable et inclusive.

Mots clés: *Transformation numérique ; Comptabilité verte ; Fiscalité environnementale ; Gouvernance durable ; Économies émergentes*

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I. Introduction

The accelerating pace of technological change and the growing urgency of environmental degradati

on have placed economic systems under unprecedented pressure. Organizations and governments are increasingly required to reconcile economic performance with environmental responsibility, while simultaneously adapting to rapid digital transformation. Technologies such as artificial intelligence, big data analytics, blockchain and the Internet of Things are profoundly reshaping production processes, management practices and public governance structures (Pogrebna and Skilton, 2022). At the same time, climate change, resource depletion and societal expectations are compelling policymakers and firms to integrate environmental externalities into economic decision-making (Gray, 1995; Schaltegger and Burritt, 2018).

Within this evolving landscape, green accounting and environmental taxation have gained prominence as central instruments for steering sustainable development. Green accounting aims to measure, record and disclose the environmental impacts of economic activities, thereby extending traditional accounting systems beyond purely financial considerations (Bartelmus, 1992; Bennett et al., 2003). In parallel, environmental taxation, grounded in the polluter-pays principle, seeks to internalize environmental costs and incentivize cleaner production and consumption patterns (OECD, 2021). Together, these tools constitute key pillars of environmental governance and sustainable fiscal policy.

Nevertheless, the effectiveness of green accounting and environmental taxation remains uneven, particularly in emerging economies. Empirical and theoretical studies indicate that fragmented regulatory frameworks, limited data availability and weak monitoring mechanisms often undermine their implementation (Schaltegger and Burritt, 2018; El-Khaldi, 2022). Recent research suggests that digital transformation can play a catalytic role in addressing these constraints by enhancing data collection, improving transparency and enabling real-time monitoring of environmental performance (You et al., 2025; Lv and Wu, 2024). Digital technologies have the potential to transform environmental information into a strategic resource, strengthening both corporate accountability and public policy effectiveness.

Despite the growing body of literature on digitalization, sustainability and environmental governance, integrated analyses that explicitly connect digital transformation, green accounting and environmental taxation remain limited, particularly in the context of emerging economies. Existing studies tend to

address these dimensions separately, overlooking their systemic interdependencies and governance implications. This gap is especially pronounced in resource-dependent economies undergoing structural transformation, such as Algeria.

Against this background, the present study seeks to answer the following research question: **How can digital transformation enhance green accounting and strengthen environmental taxation to support sustainable development in emerging economies?** To address this question, the paper adopts a qualitative and conceptual approach and proposes an Integrated Digital Green Governance Model. The Algerian case is used to illustrate the institutional, regulatory and technological conditions shaping the digitalization of environmental accounting and taxation.

The paper contributes to the literature in three main ways. First, it develops an original conceptual framework linking digital technologies, green accounting and environmental taxation within a unified governance perspective. Second, it extends sustainability and accounting research by providing evidence from an emerging economy context. Third, it offers policy-relevant insights for governments seeking to modernize environmental governance through digital innovation.

II. Literature Review and Theoretical Background

II.1. Green accounting and ecosystem-based accounting

Green accounting represents a fundamental evolution of traditional accounting systems by explicitly integrating environmental impacts into economic measurement and decision-making processes. Unlike conventional financial accounting, which largely ignores ecological externalities, green accounting seeks to identify, quantify and communicate the environmental costs and benefits associated with economic activities (Gray, 1995; Bartelmus, 1992). Its primary objective is to improve transparency regarding the use of natural resources and the generation of pollution, thereby supporting more informed and responsible decision-making by firms, regulators and stakeholders.

Early contributions to green accounting focused on the development of environmental satellite accounts, which aimed to link physical environmental data—such as resource extraction and emissions—to national economic aggregates (Bartelmus and van Tongeren, 1991). These approaches laid the groundwork for integrated environmental-economic accounting systems, later formalized through initiatives promoted by international organizations, including the United Nations and the OECD. Uno and Bartelmus (1998) advanced this perspective by introducing the concept of integrated or ecosystem-based

accounting, emphasizing that natural capital should be treated as an active economic asset rather than an external constraint.

Subsequent research extended green accounting from the macroeconomic level to organizational contexts through the development of environmental management accounting (EMA). Studies by Bennett et al. (2003) and Schaltegger and Burritt (2018) demonstrate that incorporating environmental information into internal accounting systems enables firms to better control environmental costs, improve resource efficiency and align environmental performance with strategic objectives. In this sense, green accounting evolves from a compliance-oriented reporting tool into a strategic management instrument.

More recently, the growing emphasis on sustainability and responsible investment has accelerated the institutionalization of green accounting through international reporting standards. The introduction of IFRS Sustainability Disclosure Standards S1 and S2 in 2023 represents a significant milestone, as these standards require firms to disclose sustainability-related risks and climate impacts in a manner directly connected to financial performance (IFRS Foundation, 2023). These developments reinforce the convergence between financial and environmental reporting, promoting comparability, credibility and accountability at the global level.

From a theoretical standpoint, ecosystem-based accounting reflects a paradigm shift in which economic performance is assessed through the interdependencies between financial capital, human capital and natural capital. This integrated perspective aligns with broader sustainability frameworks and supports the transition towards cleaner production systems by embedding environmental considerations into core accounting practices (Gray, 2002; Schaltegger and Burritt, 2018). However, despite its conceptual maturity, the operationalization of green accounting remains constrained by data limitations, measurement challenges and institutional fragmentation—issues that digital transformation has the potential to address.

II.2. *Environmental taxation and sustainable development*

Environmental taxation constitutes a central policy instrument for aligning economic incentives with environmental objectives. Grounded in the polluter-pays principle, environmental taxes aim to internalize the social costs of pollution and resource depletion by incorporating them into market prices (Pearce, 1991; OECD, 2021). By increasing the cost of environmentally harmful activities, these taxes encourage producers and consumers to adopt cleaner technologies and more sustainable consumption patterns.

The literature identifies several categories of environmental fiscal instruments, including emission taxes, energy and carbon taxes, product taxes on

polluting goods, and market-based instruments such as tradable emission permits (Tietenberg, 2006; Ellerman et al., 2000). Empirical studies generally confirm that well-designed environmental taxes can lead to measurable reductions in emissions while generating public revenues that may be reinvested in green infrastructure or used to reduce distortionary taxes elsewhere in the economy.

Beyond their environmental impact, environmental taxes also play a critical role in supporting sustainable public finance. By broadening the tax base and linking fiscal policy to environmental performance, they contribute to long-term fiscal sustainability and policy coherence (OECD, 2021). However, their effectiveness depends heavily on administrative capacity, data accuracy and compliance mechanisms. In many emerging economies, weak monitoring systems and limited enforcement capabilities undermine the potential benefits of environmental taxation, leading to inefficiencies and equity concerns (El-Khaldi, 2022).

Recent studies emphasize that the success of environmental taxation increasingly relies on its integration with accounting and information systems. Without reliable environmental data, tax bases remain approximate, enforcement costs increase and the risk of tax evasion or greenwashing persists. This has led scholars to argue that environmental taxation should be understood not merely as a fiscal instrument, but as a component of a broader environmental governance framework that includes accounting standards, reporting requirements and digital monitoring tools (Dinis et al., 2023; Lv and Wu, 2024).

In this regard, environmental taxation and green accounting are deeply interdependent. While accounting systems provide the information necessary to measure environmental impacts, fiscal instruments translate this information into economic incentives. Strengthening this nexus is therefore essential for achieving cleaner production and sustainable development, particularly in contexts characterized by rapid structural change and environmental vulnerability.

II.3. Digital transformation and green governance

Digital transformation has emerged as a powerful enabler of sustainability-oriented governance by reshaping how environmental information is collected, processed and utilized. Technologies such as big data analytics, artificial intelligence, blockchain and the Internet of Things significantly enhance the capacity of organizations and public authorities to monitor environmental performance in real time and at lower cost (Pogrebna and Skilton, 2022; Kumar and Kumar, 2021).

Big data analytics allows the integration of heterogeneous data sources, including industrial sensors, energy systems, supply chains and satellite imagery, thereby overcoming traditional limitations associated with fragmented and

retrospective environmental reporting. Artificial intelligence further extends these capabilities by enabling predictive analysis, anomaly detection and scenario simulation, which support proactive environmental management and policy design (Lv and Wu, 2024; You et al., 2025).

Blockchain technology contributes to green governance by enhancing transparency, traceability and trust in environmental information. Through immutable and decentralized data records, blockchain-based systems reduce the risk of manipulation and facilitate verification by regulators, investors and other stakeholders (Jannah et al., 2023). These features are particularly relevant in addressing greenwashing and improving the credibility of sustainability reporting and environmental tax compliance.

The literature increasingly converges on the idea that digital transformation can bridge the gap between environmental objectives and economic instruments by integrating green accounting systems with digitalized environmental taxation. This integration supports the emergence of what may be termed digital green governance—a governance model in which digital technologies act as catalysts for aligning accounting practices, fiscal policies and sustainability goals (Ibrahim and Gangodawilage, 2024).

Despite these advances, scholars also highlight several challenges, including high implementation costs, data governance issues, cybersecurity risks and the need for specialized skills. These challenges are especially acute in emerging economies, where digital infrastructure and institutional capacities remain uneven. Nevertheless, the potential of digital transformation to enhance cleaner production and sustainable governance remains substantial, warranting further conceptual and empirical investigation.

III. Conceptual Framework: Integrated Digital Green Governance Model

III.1. Rationale for an integrated digital green governance framework

The increasing complexity of environmental challenges and the growing interdependence between economic systems and natural ecosystems require governance approaches that transcend traditional policy silos. Existing research on sustainability governance has largely examined green accounting, environmental taxation and digital transformation as separate domains, often overlooking their systemic interactions (Schaltegger et al., 2017; Bebbington et al., 2014). As a result, many sustainability initiatives remain fragmented, limiting their effectiveness in driving cleaner production and long-term value creation.

Recent contributions in environmental accounting and sustainability management emphasize the need for integrated governance frameworks that align information systems, fiscal instruments and regulatory mechanisms (Burritt and Christ, 2016; Adams et al., 2020). From this perspective, digital

transformation is not merely a technological upgrade but a structural enabler that reshapes how environmental information is produced, validated and translated into economic incentives. Digital technologies can reduce information asymmetries, enhance monitoring capabilities and support real-time decision-making, thereby strengthening the coherence of environmental governance systems (George et al., 2021; Vial, 2019).

Building on institutional theory and socio-technical systems perspectives, this study argues that effective green governance emerges from the interaction between technological infrastructure, accounting practices and fiscal policy instruments. Institutional theory highlights the role of formal rules, norms and enforcement mechanisms in shaping organizational behavior (Scott, 2014), while socio-technical approaches emphasize the co-evolution of technology and institutional arrangements (Geels, 2002). Integrating these perspectives allows for a more comprehensive understanding of how digital tools can transform green accounting and environmental taxation into mutually reinforcing components of sustainable governance.

Against this background, the paper proposes an **Integrated Digital Green Governance Model (IDGGM)**, which conceptualizes digital technologies as catalysts that connect green accounting systems with environmental taxation mechanisms to achieve cleaner production, enhanced transparency and sustainable development outcomes. This framework is particularly relevant for emerging economies, where institutional constraints and data limitations have historically hindered the effective implementation of environmental policies (Bebbington et al., 2020; George et al., 2021).



III.2. Components of the Integrated Digital Green Governance Model

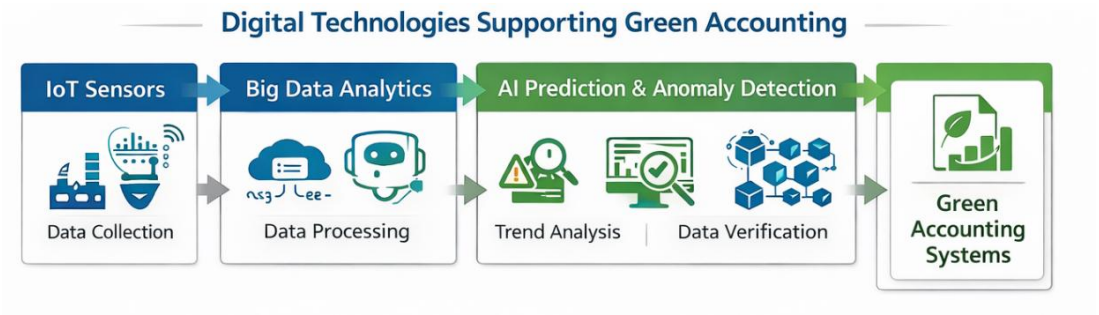
The proposed IDGGM consists of four interrelated pillars: digital technologies, green accounting systems, digital environmental taxation and governance outcomes

1) Digital technologies as enabling infrastructure

Digital technologies constitute the foundational layer of the model. Big data analytics enables the aggregation and processing of large volumes of heterogeneous environmental data, improving the accuracy and timeliness of environmental measurement (Kumar and Kumar, 2021; McAfee and Brynjolfsson, 2012). Artificial intelligence further enhances these capabilities by enabling predictive analytics, risk assessment and automated decision support, which are essential for proactive environmental management and policy design (George et al., 2021; Dwivedi et al., 2021).

The Internet of Things (IoT) plays a critical role in real-time data collection by linking physical processes—such as energy consumption, emissions and waste generation—to digital platforms (Porter and Heppelmann, 2015). Blockchain technology complements these tools by providing secure, transparent and immutable records of environmental and fiscal data, thereby reducing information manipulation and enhancing trust among stakeholders (Saberi et al., 2019; Jannah et al., 2023).

Together, these technologies create a digital infrastructure that supports reliable environmental information flows across organizations and regulatory bodies.



2) Green accounting systems

Green accounting systems translate environmental data into structured information that can be integrated into organizational and national accounting frameworks. Building on environmental management accounting and ecosystem-based accounting approaches, these systems allow firms and governments to recognize environmental costs, assess resource efficiency and evaluate environmental performance alongside financial outcomes (Burritt et al., 2002; Schaltegger and Burritt, 2018).

Digitalization enhances green accounting by automating data collection, reducing measurement errors and enabling dynamic reporting aligned with international standards such as IFRS S1 and S2, the Global Reporting Initiative (GRI) and the Task Force on Climate-related Financial Disclosures (TCFD). This

integration strengthens the credibility and comparability of sustainability disclosures, responding to increasing demands from investors and regulators for decision-useful environmental information (Adams et al., 2020; IFRS Foundation, 2023).

Within the IDGGM, green accounting acts as an intermediary mechanism that converts raw environmental data into actionable knowledge, forming the informational basis for environmental taxation and strategic decision-making.

3) Digital environmental taxation mechanisms

Environmental taxation mechanisms represent the economic translation of green accounting information into fiscal incentives and disincentives. When supported by digital technologies, environmental taxes can be calculated more accurately, enforced more efficiently and aligned more closely with actual environmental performance (OECD, 2021; Dinis et al., 2023).

Digital environmental taxation involves automated tax assessment based on real-time emissions data, smart allocation of tax incentives for green investments and enhanced compliance monitoring through blockchain-based systems. Such mechanisms reduce administrative burdens, limit opportunities for evasion and increase policy credibility (Lv and Wu, 2024; Saberi et al., 2019).

In emerging economies, where administrative capacity is often constrained, digitalization can significantly improve the effectiveness of environmental taxation by lowering enforcement costs and strengthening institutional trust. Within the proposed framework, environmental taxation serves as a feedback mechanism that reinforces cleaner production behaviors and supports sustainable public finance.

4) Governance outcomes and cleaner production

The interaction between digital technologies, green accounting and environmental taxation generates a set of governance outcomes that are central to sustainable development. These outcomes include enhanced transparency and accountability, reduced greenwashing, improved environmental performance and stronger alignment between fiscal policy and sustainability objectives (Bebbington et al., 2014; Schaltegger et al., 2017).

By embedding environmental information into both accounting and taxation systems, the IDGGM promotes cleaner production practices through continuous monitoring and incentive alignment. Firms are encouraged to reduce emissions and resource consumption, while governments benefit from more effective policy instruments and increased fiscal legitimacy. This integrated approach supports long-term value creation and contributes to the achievement of the Sustainable

Development Goals, particularly those related to responsible consumption and production, climate action and institutional effectiveness (UN, 2023).

III.3. Research propositions

Based on the conceptual framework, the following research propositions are formulated to guide the empirical and policy analysis:

- **P1**: Digital technologies significantly enhance the accuracy, reliability and timeliness of environmental information used in green accounting systems.
- **P2**: The digitalization of green accounting strengthens the effectiveness of environmental taxation by improving tax base accuracy and compliance mechanisms.
- **P3**: Blockchain-based environmental reporting reduces greenwashing risks and increases stakeholder trust in sustainability disclosures and environmental tax systems.
- **P4**: In emerging economies, integrated digital green governance contributes positively to cleaner production and sustainable development outcomes.

IV. Research Methodology

IV.1. Research design

This study adopts a qualitative and conceptual research design, supplemented by a case-based analysis of Algeria to contextualize the proposed Integrated Digital Green Governance Model (IDGGM). Given the exploratory nature of the research question—how digital transformation can enhance green accounting and environmental taxation in emerging economies—a conceptual framework approach is appropriate for integrating insights from multiple domains, including sustainability governance, accounting, digital technology and fiscal policy (Eisenhardt, 1989; Yin, 2018).

The research follows a **multi-level analytical approach**:

1. **Macro-level**: Analysis of regulatory, institutional and policy frameworks in Algeria relevant to green accounting and environmental taxation.
2. **Meso-level**: Examination of organizational adoption of digital technologies, green accounting systems, and environmental reporting practices.
3. **Micro-level**: Evaluation of technological tools (IoT, AI, blockchain, big data) and their operational impact on the accuracy, timeliness and reliability of environmental and fiscal information.

This design allows the study to capture the complex interactions between digital infrastructure, accounting practices and fiscal instruments while situating them within the broader governance context of an emerging economy.

IV.2. Data sources

The study relies on multiple sources of **secondary data** to construct a comprehensive analysis:

1) **Regulatory and policy documents**:
   - Algerian environmental legislation, fiscal codes and strategic development plans (e.g., Law n°03-10, Ministry of Digital Transition reports).
   - International standards and guidelines, including IFRS S1/S2, GRI, TCFD, and OECD environmental taxation recommendations.
2) **Academic literature**:
   - Peer-reviewed articles in environmental accounting, sustainability governance, and digital transformation (e.g., Gray, 1995; Schaltegger & Burritt, 2018; Pogrebna & Skilton, 2022; George et al., 2021).
3) **Industry and institutional reports**:
   - Reports from Algerian agencies such as ANVREI and ANGEM.
   - Case studies on digitalization initiatives in industrial sectors including energy, chemicals and mining.
4) **Technological and market analyses**:
   - Documentation on IoT deployment, AI adoption, blockchain applications and big data analytics in environmental monitoring.

The triangulation of these sources ensures data validity and provides a robust basis for developing propositions and policy recommendations.

IV.3. Analytical approach

The study employs a **structured qualitative content analysis** to synthesize findings from the diverse data sources:

1) ***Coding and thematic analysis***: Documents and literature were systematically coded according to key themes derived from the IDGGM framework, including:
   - Digital technologies and infrastructure,
   - Green accounting mechanisms,
   - Environmental taxation processes,
   - Governance outcomes and cleaner production indicators.
2) ***Cross-case comparison***: Data from Algerian pilot projects and international benchmarks were compared to identify gaps, opportunities and best practices in the implementation of digitalized green governance.
3) ***Conceptual integration***: Insights from coding and cross-case analysis were integrated into the IDGGM framework, refining its components,

relationships, and research propositions. This process also allowed for the identification of contextual factors specific to emerging economies that influence the feasibility and effectiveness of integrated digital green governance.

The methodology is designed to support generalizable conceptual insights while remaining grounded in the practical realities of the Algerian context. It provides a systematic basis for evaluating how digital transformation can strengthen the synergy between green accounting and environmental taxation, thereby contributing to cleaner production and sustainable development.

IV.4. Justification of the methodological approach

Qualitative, case-based and conceptual research designs are widely accepted in sustainability governance and environmental accounting studies, particularly when investigating emerging technologies and institutional innovations (Burritt & Christ, 2016; Schaltegger et al., 2017). Given the limited empirical evidence in the Algerian context and the need to integrate multi-disciplinary perspectives, this approach allows for:

- **Theory-building**: Developing a new framework (IDGGM) grounded in empirical and conceptual evidence.
- **Contextualization**: Capturing the unique institutional, technological and regulatory characteristics of emerging economies.
- **Policy relevance**: Generating actionable recommendations for digital green governance and cleaner production.

V. Case Analysis: Algeria

V.1. Regulatory and institutional environment

Algeria has made initial efforts to integrate environmental considerations into its legislative and institutional framework, although implementation remains fragmented. The primary environmental legislation, Law n°03-10 (2003), establishes principles for resource conservation, pollution prevention, and sustainable development, but it provides limited operational guidance for environmental accounting and taxation (Belkacem, 2022). The law mandates environmental responsibility for firms and public administrations but lacks standardized reporting requirements and enforcement mechanisms.

Environmental fiscal instruments exist in a partial and sector-specific manner, including tax exemptions for renewable energy investments and levies on certain industrial emissions. However, these measures are largely confined to major sectors such as energy, mining, and chemicals, and are not systematically integrated with accounting systems (Ait Ali et al., 2023). Weak enforcement, limited administrative capacity, and inconsistent data collection hinder the

effectiveness of environmental taxation and prevent the full internalization of ecological costs (OECD, 2021; El-Khaldi, 2022).

Institutional initiatives such as ANVREI (National Agency for the Valorization of Research and Innovation) and ANGEM (National Agency for Microcredit and Entrepreneurship) support green projects and the adoption of clean technologies. While these initiatives demonstrate a policy intent towards sustainable development, their impact remains limited due to insufficient integration within a cohesive national strategy for digital green governance (Belkacem, 2022; Lv & Wu, 2024).

V.2. Digitalization of environmental data

The adoption of digital technologies in Algeria is nascent but promising, particularly in high-impact industrial sectors. IoT-enabled sensors are being piloted to monitor energy consumption, water usage, emissions, and waste generation in real time. Big data platforms allow aggregation of heterogeneous environmental data across sites and regions, supporting operational decision-making and compliance monitoring (Pogrebna & Skilton, 2022; Lv & Wu, 2024).

Blockchain applications remain limited, primarily in pilot programs within energy and mining sectors. These technologies provide immutability, traceability, and enhanced transparency, which are critical for verifying environmental claims and ensuring credibility in fiscal reporting (Jannah et al., 2023; Saberi et al., 2019). The combination of IoT, AI, and blockchain lays the foundation for an integrated digital green infrastructure, though coverage is still uneven across regions and industries.

Key challenges identified include:

- Limited internet connectivity and digital infrastructure in remote industrial zones.
- High costs of technology deployment and maintenance, which constrain scalability.
- Insufficient skilled personnel combining expertise in digital tools, accounting, and environmental standards (Ait Ali et al., 2023; Ibrahim & Gangodawilage, 2024).

V.3. Integration of accounting and taxation

Digitalization enables a convergence of green accounting and environmental taxation, creating opportunities for more effective environmental governance. Real-time environmental data collected via IoT sensors can feed directly into accounting systems, allowing firms and regulators to quantify environmental costs and assess tax liabilities accurately (Bennett et al., 2003; Lv & Wu, 2024). Automated systems facilitate allocation of tax incentives,

calculation of penalties, and verification of compliance, reducing administrative burden and enhancing policy credibility (Dinis et al., 2023; Pogrebna & Skilton, 2022).

International standards such as IFRS S1/S2, GRI, and TCFD offer guidance for linking environmental accounting with fiscal mechanisms. Adoption of these standards in Algeria remains limited but provides a benchmark for future harmonization and integration within the IDGGM framework (IFRS Foundation, 2023; Schaltegger & Burritt, 2018).

V.4. Challenges and opportunities

1) Challenges

1. **Institutional fragmentation**: Lack of coherent alignment between environmental regulations, fiscal instruments, and digital reporting standards.
2. **Infrastructure gaps**: Unequal access to digital tools across regions and industries.
3. **Skills deficit**: Shortage of professionals with combined expertise in accounting, taxation, environmental science, and digital technologies.
4. **Limited awareness and incentives**: SMEs often perceive digital green initiatives as costly rather than strategically beneficial (Belkacem, 2022; Ait Ali et al., 2023).

2) Opportunities

1. **Policy-driven digitalization**: Government-led digital platforms can centralize environmental reporting and integrate tax systems.
2. **Technology adoption in high-impact sectors**: Energy, mining, and chemical industries can serve as pilots for broader implementation.
3. **International standards alignment**: Harmonization with IFRS, GRI, and TCFD standards enhances credibility and facilitates foreign investment.
4. **Integrated governance benefits**: Convergence of digital technologies, green accounting, and environmental taxation can strengthen cleaner production, reduce emissions, and enhance fiscal transparency (Bebbington et al., 2014; George et al., 2021).

In summary, the Algerian case illustrates both the potential and the constraints of implementing the IDGGM framework in an emerging economy context. While technological pilots and institutional initiatives provide a foundation, systemic digitalization and harmonized policy design are essential to unlock the full benefits of integrated digital green governance.



IV. Discussion

IV.1. Digital transformation as an enabler of green governance

The analysis of the Algerian context demonstrates that digital technologies play a critical role in enabling the integration of green accounting and environmental taxation. Real-time data collection through IoT sensors, predictive analytics via AI, and immutable recording using blockchain facilitate the accurate measurement, verification, and reporting of environmental performance. These findings are consistent with international studies indicating that digitalization enhances data reliability, transparency, and decision-making in sustainability governance (George et al., 2021; Pogrebna & Skilton, 2022; Saberi et al., 2019).

In Algeria, although digital infrastructure is unevenly distributed, pilot projects show that even partial adoption of these technologies can improve environmental monitoring, automate fiscal calculations, and strengthen compliance. This highlights the potential of digitalization to bridge institutional gaps and resource constraints typically faced by emerging economies (Bebbington et al., 2020; Lv & Wu, 2024).

IV.2. Integrating green accounting and environmental taxation

The convergence of green accounting and environmental taxation, facilitated by digital technologies, emerges as a key mechanism for cleaner production. Digital integration allows environmental costs and emissions data to be directly linked with fiscal instruments, ensuring that tax incentives, penalties, and subsidies are proportionate to actual environmental performance. This integration supports the polluter-pays principle and improves policy efficiency, as

observed in more advanced economies adopting digitalized carbon taxation and green fiscal reporting (OECD, 2021; Dinis et al., 2023).

International comparisons indicate that countries like Germany, Sweden, and Singapore have successfully implemented digital green governance platforms that combine accounting, taxation, and monitoring systems. In these cases, digitalization reduces administrative burdens, increases transparency, and enhances stakeholder trust, providing valuable lessons for Algeria (Burritt & Christ, 2016; Adams et al., 2020).

IV.3. Institutional and capacity-related challenges

Despite the potential benefits, the Algerian case underscores several persistent challenges:

1) **Institutional fragmentation**: Regulatory and fiscal frameworks remain uncoordinated, limiting the scalability of digital green governance.

2) **Infrastructure gaps**: Unequal access to high-speed internet and digital platforms impedes uniform implementation across regions.

3) **Skills shortages**: A lack of professionals combining accounting, environmental expertise, and digital literacy constrains effective deployment.

4) **Awareness and incentives**: SMEs often underappreciate the strategic value of digitalization, perceiving it as a cost rather than an opportunity for operational efficiency and compliance.

These challenges echo findings in other emerging economies, where digital green governance often depends on coordinated policy efforts, capacity-building, and incentives to overcome institutional inertia (Bebbington et al., 2014; Ibrahim & Gangodawilage, 2024).

IV.4. Implications for policy and practice

The findings suggest several **practical and policy implications**:

1) **National digital strategy**: Establishing a central digital platform for environmental reporting and fiscal management would enhance transparency, reduce duplication, and facilitate compliance monitoring.
2) **Capacity-building initiatives**: Training programs and certifications integrating environmental accounting, taxation, and digital technologies are critical to develop skilled human capital.
3) **International standardization**: Alignment with IFRS S1/S2, GRI, and TCFD frameworks would improve comparability and attract international investment.
4) **Incentive-based adoption**: Automated environmental tax incentives and performance-linked subsidies can accelerate technology adoption and cleaner production practices.

By addressing these factors, Algeria could leverage the synergy between digitalization, green accounting, and environmental taxation to achieve measurable sustainability outcomes, enhance fiscal efficiency, and strengthen regulatory credibility (George et al., 2021; Lv & Wu, 2024).

IV.5. Contribution to theory and literature

This study advances the literature in three key ways:

1) **Conceptual integration**: By linking digital technologies, green accounting, and environmental taxation, it proposes an Integrated Digital Green Governance Model (IDGGM) that captures systemic interactions in sustainability governance.

2) **Contextual evidence**: The Algerian case highlights the challenges and opportunities of digital green governance in an emerging economy, contributing to the limited empirical literature in non-OECD contexts.

3) **Policy-oriented insight**: The framework provides actionable recommendations for governments and firms seeking to implement digitalized sustainability practices, supporting cleaner production and the achievement of Sustainable Development Goals (UN, 2023; Schaltegger et al., 2017).

IIV. Conclusion and Future Research

IIV.1. Conclusion

This study examined the intersection of digital transformation, green accounting, and environmental taxation, proposing the Integrated Digital Green Governance Model (IDGGM) as a framework to support cleaner production and sustainable development. The Algerian case illustrates both the potential and the constraints of implementing such a framework in an emerging economy context.

Key findings include:

1) **Digital technologies as enablers**: IoT, AI, big data, and blockchain enhance the accuracy, timeliness, and transparency of environmental data, creating a reliable basis for accounting and fiscal decision-making (George et al., 2021; Pogrebna & Skilton, 2022).
2) **Integration of green accounting and environmental taxation**: Linking environmental performance to fiscal incentives strengthens the polluter-pays principle, improves compliance, and encourages cleaner production practices (OECD, 2021; Dinis et al., 2023).
3) **Institutional and capacity challenges**: Fragmented regulations, limited infrastructure, skills shortages, and low awareness among SMEs pose

significant barriers to full-scale implementation (Belkacem, 2022; Ait Ali et al., 2023).

4) **Opportunities for strategic digitalization**: Centralized reporting platforms, capacity-building initiatives, alignment with international standards, and incentive-driven adoption can unlock the benefits of integrated digital green governance (Lv & Wu, 2024; Burritt & Christ, 2016).

Overall, the study demonstrates that digitalization is not merely a technological upgrade but a strategic lever that can enhance the effectiveness, efficiency, and credibility of environmental governance, enabling emerging economies to pursue sustainable development while fostering cleaner production and fiscal accountability.

IIV.2. Policy and managerial implications

The findings provide actionable guidance for policymakers and practitioners:

- National strategy: Developing a comprehensive digital platform for environmental reporting and taxation can centralize data, streamline compliance, and reduce administrative burdens.
- Capacity-building: Training programs, certifications, and educational initiatives are essential to develop expertise at the intersection of digital technology, accounting, and environmental management.
- International alignment: Harmonization with IFRS S1/S2, GRI, and TCFD standards enhances comparability, transparency, and attractiveness to foreign investors.
- Incentive design: Automated, performance-linked fiscal incentives encourage firms, particularly SMEs, to adopt cleaner technologies and sustainable practices.

IIV.3. Limitations

This study has several limitations that should be considered:

1) **Contextual focus**: While the Algerian case provides valuable insights for emerging economies, generalization to other countries with different institutional and technological conditions should be done cautiously.

2) **Conceptual framework**: The IDGGM remains largely theoretical; empirical testing across diverse sectors and countries is needed to validate its applicability and impact.

3) **Data availability**: Secondary data sources were used due to limited access to primary firm-level environmental and fiscal data in Algeria, which may constrain the granularity of analysis.

IIV.4. Future research directions

Based on the study's findings and limitations, several avenues for future research are proposed:

1. **Empirical validation**: Conduct longitudinal studies and cross-country comparisons to empirically test the IDGGM framework and assess its impact on environmental performance and fiscal outcomes.
2. **Sectoral analysis**: Examine the adoption of digital green governance across different industrial sectors to identify context-specific success factors and barriers.
3. **Technology assessment**: Investigate the effectiveness of emerging digital tools (AI, blockchain, IoT) in improving environmental accounting accuracy and tax compliance in practice.
4. **Policy experimentation**: Evaluate the outcomes of different incentive schemes and digitalization strategies in emerging economies to inform evidence-based policy design.
5. **Stakeholder engagement**: Explore the role of firms, government agencies, investors, and civil society in co-creating effective digital green governance ecosystems.

IIV.5. Concluding remarks

The convergence of digitalization, green accounting, and environmental taxation offers a transformative pathway for emerging economies to achieve cleaner production, improve fiscal transparency, and advance sustainable development. The IDGGM framework provides a conceptual foundation for integrating technological, institutional, and policy elements into a coherent governance model. By addressing infrastructure gaps, building human capital, and aligning with international standards, countries like Algeria can leverage digital green governance as a strategic instrument to promote sustainability, reduce environmental impact, and create long-term socio-economic value.

IV. References:

- Ait Ali, M., Benaissa, M., & Rahmani, L. (2023). *Digitalisation et développement durable en Algérie : perspectives pour la fiscalité verte*. *Revue Algérienne de Gestion et Finance*, 11(2), 45–62.
- Amayed, A. (2025). *Digitalisation, fiscalité verte et capacités énergétiques : une analyse de la qualité environnementale en Afrique du Nord*. *MPRA Paper*, 124127.

- Bartelmus, P., Stahmer, C., & van Tongeren, J. (1991). *Integrated Environmental and Economic Accounting: Framework for a SNA Satellite System*. *Review of Income and Wealth*, 37(2), 111–148.
- Belkacem, S. (2022). *Fiscalité environnementale et développement durable en Algérie*. *Cahiers de l'Économie Algérienne*, 18(1), 77–95.
- Belkacem, S. (2022). *Fiscalité environnementale et développement durable en Algérie*. *Cahiers de l'Économie Algérienne*, 18(1), 77–95.
- Dinis, A., Machado, C., & Ferreira, J. (2023). *Digitalization and green taxation: Challenges for fiscal policy in sustainable economies*. *Journal of Cleaner Production*, 406, 137092.
- El-Khaldi, R. (2022). *Fiscalité environnementale et gouvernance écologique dans les économies en développement*. *Revue Maghrébine d'Économie et de Gestion*, 20(2), 45-60.
- Gray, R. (1995). *Social and Environmental Accounting: The Path to Sustainability? Critical Perspectives on Accounting*, 6(6), 457–487.
- IFRS Foundation (2023). *IFRS S1 and IFRS S2: Sustainability Disclosure Standards*. London: IFRS Foundation.
- Ibrahim, M., & Gangodawilage, S. (2024). *Digital transformation and environmental accounting practices in emerging economies*. *Sustainability Accounting, Management and Policy Journal*, 15(2), 225–243.
- Jannah, M., Hidayat, M., & Rohman, A. (2023). *Environmental Accounting System Model in the Era of Artificial Intelligence and Blockchain Technology: A Bibliometric Analysis*. *Environmental and Energy Accounting Journal*, 11(3), 155–172.
- Kumar, S., & Kumar, N. (2021). *Blockchain Technology and Environmental Accounting: Emerging Perspectives*. *International Journal of Energy Economics and Policy*, 11(4), 321–328.
- Lv, J., & Wu, X. (2024). *The Green Effect of Digital Transformation: The Impact of Digital Transformation in Fiscal and Taxation on Regional Green Development*. *Environmental Economics and Policy Studies*, 26(1), 85-109.
- Ministère de la Transition Digitale et de la Modernisation de l'Administration (2024). *Stratégie nationale de transformation numérique 2024–2030*. Alger : Gouvernement Algérien.
- You, S., Zhang, Y., & Liu, H. (2025). *Digitalization and the Quality of Environmental Accounting Information: Evidence from China's Manufacturing Sector*. *Journal of Environmental Management*, 360, 120594.