Digital Governance in Deforestation Prevention and Food Security Strengthening in Indonesia: A Cross-Country Comparative Study

Tata Kelola Digital dalam Mencegah Deforestasi dan Memperkuat Ketahanan Pangan di Indonesia: Studi Perbandingan Lintas Negara

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Abstract

Deforestation and inefficient land management threaten food security in Indonesia, necessitating a digital governance framework capable of strengthening inter-institutional coordination and data transparency. Responding to this urgency, this study adopted a systematic literature review of publications from 2014 to 2023 across six major databases, national policy documents, and international organization reports. From approximately 150 initial results, 45 publications were selected through the screening of titles, abstracts, and full texts. Text screening was then analyzed thematically based on the six dimensions of the OECD digital governance framework. Findings show that implementing digital governance can improve decision-making effectiveness, data transparency, and cross-agency coordination in land and food management. International practices in China (real-time centralized data systems), Brazil (satellite monitoring), and the European Union (satellite programs and data transparency) provide essential lessons. However, from a digital government perspective, in terms of maturity, Indonesia is still at an intermediate stage towards the interactive stage. This condition reflects the persistence of fundamental challenges in implementing digital governance, such as low data interoperability, inadequate information disclosure regulations, and limited institutional capacity to implement a digitally integrated government system. To prevent deforestation and strengthen sustainable food security, Indonesia needs to improve data disclosure regulations, develop interoperability platforms across institutions, and increase institutional capacity to implement digital governance principles.

Keywords

Digital Governance; Food Security; Land Management; Digital Transformation; Deforestation.

Abstrak

Deforestasi dan ketidakefisienan pengelolaan lahan mengancam ketahanan pangan di Indonesia, sehingga diperlukan kerangka tata kelola digital yang mampu memperkuat koordinasi antar lembaga dan transparansi data. Menjawab urgensi tersebut, penelitian ini mengadopsi studi literatur sistematis pada publikasi 2014–2023 di enam database utama, dokumen kebijakan nasional, serta laporan organisasi internasional. Dari sekitar 150 hasil awal, 45 publikasi terpilih melalui skrining judul, abstrak, dan full text screening, kemudian dianalisis secara tematik berdasarkan enam dimensi kerangka digital governance OECD. Temuan menunjukkan bahwa penerapan digital governance dapat meningkatkan efektivitas pengambilan keputusan, transparansi data, dan koordinasi lintas lembaga dalam pengelolaan lahan dan pangan. Praktik internasional di Tiongkok (sistem data terpusat real time), Brasil (monitoring satelit), dan Uni Eropa (program satelit dan keterbukaan data) memberikan pelajaran penting. Namun, bila dilihat dari sisi digital government maturity, Indonesia masih berada pada tingkat menengah menuju tahap interaktif. Kondisi ini mencerminkan masih adanya tantangan mendasar dalam penerapan digital governance, seperti rendahnya interoperabilitas data, belum memadainya regulasi keterbukaan informasi, serta keterbatasan kapasitas kelembagaan dalam menjalankan sistem pemerintahan yang terintegrasi secara digital. Untuk mencegah deforestasi dan memperkuat ketahanan pangan secara berkelanjutan, Indonesia perlu memperkuat regulasi keterbukaan data, mengembangkan platform interoperabilitas lintas lembaga, serta meningkatkan kapasitas institusi dalam menerapkan prinsip digital governance.

1. Introduction

In Indonesia, the need to utilize digital technology as part of reforming resource governance is increasingly pressing. Technological developments in the digital revolution have become a significant catalyst for governance changes across various sectors, including environmental management and governance (Huang et al., 2024). However, despite the enormous potential of technology, natural resource management in Indonesia still faces complex challenges. Land misuse, rapid deforestation, and a lack of accurate data-based management are key issues (Rasman et al., 2023). This situation is exacerbated by land tenure conflicts, weak local political roles, and the lack of integration of environmental policies with sustainable development goals, as seen in Riau Province (Tinov et al., 2022). In such a situation, the implementation of digital governance, as exemplified in many countries (Mantravadi & Srai, 2022), presents an opportunity to improve resource management while strengthening food security in Indonesia. In the context of improving governance, land management, and food resilience, the use of digital technology has become increasingly relevant. The implementation of e-government has a significant impact on sustainable development by enhancing good governance, strengthening corruption control, and enabling public administration to operate in a more effective, faster, easier, and more cost-efficient manner, particularly in developing countries (Sudirman, 2022).

Furthermore, the application of digital government allows the government to increase efficiency in public service, transparency, access to information, and public participation through the digitalization of bureaucracy, such as e-tax, e-permits, and e-services (Grigalashvili, 2023). However, to address the complex management challenge, a more holistic and necessary approach to digital governance is required, which includes the allocation of authority, decision-making roles, accountability, data security, and collaboration among actors in the digital ecosystem. Digital governance is not just about technology supporters; instead, it becomes a runway for strategic data-driven decision-making and focused on the sustainability of governance across sectors. In contrast, digital government is more focused on optimizing technical service government (Grigalashvili, 2023).

Experiencing various countries in implementing digital governance is an important reference for Indonesia in strengthening the sustainable management of natural power resources. China, for example, is building a digital ecosystem in forest management to prevent deforestation and optimize the use of land in a sustainable way (Gabrys, 2020). In Europe, the implementation of digital governance helps increase efficiency in food management through a transparent supply chain and strengthening data-based monitoring (Wolfert et al., 2023). Meanwhile, in England, policies such as "Digital Urban Forest" show how digital technology can be used to monitor the environmental health in urban areas via digital sensors, though it still faces constraints in data interoperability and inter-agency coordination (Department for Science, Innovation and Technology, 2025).

Various professional practices require a comprehensive digital governance framework that can be effectively implemented in each country's context. One of the many global references implemented is the Digital Government Policy Framework developed by the OECD, which offers six main dimensions in support of the implementation of digital governance, namely: Digital by Design, Data-Driven Public Sector, Government as a Platform, Open by Default, User-Driven, and Proactiveness (OECD, 2020). This provides a systematic framework for promoting

governance policy that is digital-based, adaptive, participatory, and real-time data-driven, including in the management of food and the environment.

However, the literature shows that a significant portion of existing research still focuses on aspects of digitalization services, public or digital government, such as the optimization of bureaucracy, e-government, and improvements in government administration, as well as on increasing food production capacity through the utilization of modern agricultural technology. Meanwhile, the study, which is a deep examination of the role of digital governance in a more strategic context, is still limited, especially in matters of policy integration across institutions, strengthening coordination between governance actors, preventing deforestation and its consequences, opening land for food production, and systemically strengthening food resilience by making decisions based on real-time data (Askar, 2024; Islami, 2021; Triananta & Purnomo, 2023). In fact, the complex management of proof, blem and food resilience in Asia requires a digital governance approach that is not only technology-oriented, but also regulates the relationship between institutions, ensuring accountability, and fostering cross-sector synergy in a sustainable manner. Moreover, food resilience strategies should be developed comprehensively from upstream to downstream, including strengthening household-level access to available food and enhancing human resource capacity in the field of food security to support innovation and sustainable food resilience development (Afriyanni et al., 2023). Therefore, this research offers a new contribution with a comprehensive study of the role of digital governance in strengthening land management policy and food resilience based on data in Indonesia, as well as drawing lessons from international practices to strengthen national governance.

Thus, analyzing the role of digital governance across sectors becomes crucial to address the gap and bridge it, which requires management to be more land-use effective and sustainable. Because of this, the research aims to explore the use of digital governance to strengthen policy management for land-food resilience in Indonesia, while also learning from international practices as a reference to improve governance for better food and a transparent, integrated, and sustainable environment.

2. Methods

This research uses a qualitative approach through a Systematic Literature review. A cross-country comparative analysis was conducted to examine digital governance practices in preventing deforestation and strengthening food security. The SLR method was chosen because it provides a structured, transparent scientific synthesis and enables researchers to identify digital governance patterns, policies, and strategies across diverse global contexts (Chigbu et al., 2023). A literature search was conducted in five international academic databases— Scopus , JSTOR, ProQuest , Emerald Insight , and Google Scholar—using the keywords "digital governance", "smart agriculture", "GIS land monitoring", and "e-governance" (Khanra et al., 2021). The initial search yielded over 198,000 publications: 106,703 for digital governance, 52,882 for smart agriculture, 18,740 for GIS land monitoring, and 24,502 for e-governance.

The number is then filtered using an advanced search. The search was limited to 2014–2023, retrieving only peer-reviewed articles and publications in English or Indonesian. This narrowing step resulted in 5,230 articles entering the identification stage. Next, the title and abstract were analyzed, screening was conducted to exclude purely technical publications such as agronomy, mechanical engineering, or computer studies unrelated to governance. This stage left 312 articles. As part of an eligibility evaluation, an assessment was conducted on the suitability of the substance, the governance focus, the use of digital technology in the land-food

sector, and its relevance to the research analysis framework. This feasibility stage resulted in 45 articles that met the criteria. Of these, 12 core articles were selected. Studies that make the most empirically and theoretically relevant contributions to the research objectives serve as the basis for the discussion's thematic analysis.

To ensure a transparent and systematic literature selection process, this study includes a PRISMA diagram depicting the search, screening, and study selection processes used in the review. The diagram shows the number of publications found in the initial stage, the literature eliminated based on inclusion and exclusion criteria, and the final number of studies analyzed as the basis for the discussion.
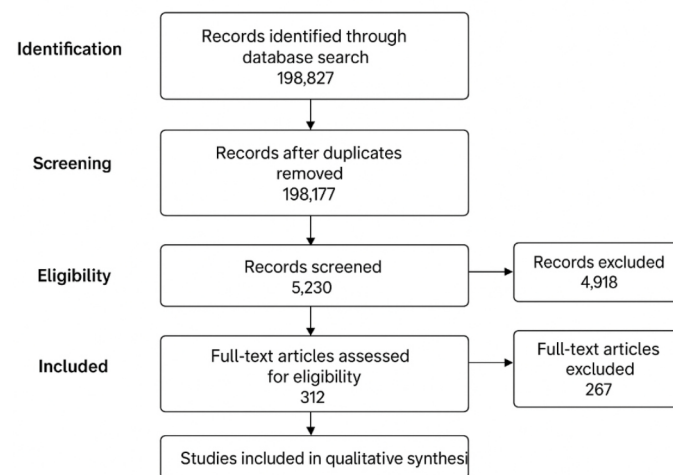
Figure 1. PRISMA Diagram

Source: Hamilton et al., 2026

Furthermore, the core literature forming the foundation of this research analysis is systematically reviewed by considering the country or object of study, research focus, and main contributions of each study. This approach helps clarify the conceptual foundation of the study and demonstrates the direct link between the literature selection and the key themes discussed, including digital governance, technology-based land monitoring, and food security.

Data analysis was carried out using two main techniques, namely content analysis and thematic Analysis. Content analysis is used to identify key concepts such as digital governance frameworks, digital land management strategies, and food security policies. Meanwhile, thematic analysis is used to group findings from the core literature into three broad themes: (1) digital governance policies in the land and food sectors; (2) the application of digital technologies such as AI, IoT, satellite imagery, blockchain, and big data; and (3) a comparison of digital governance implementation in China, Brazil, the European Union, and the United Kingdom based on the OECD framework. The use of 12 core studies aligned with the discussion ensures that the research methods, results, and discussion are consistent and mutually reinforcing.

3.   Results and Discussion

This chapter discusses the synthesis of the reviewed literature, with a focus on the application of digital governance to support food security and land management policies. To fully understand the framework of digital-based public policy transformation, it is essential to distinguish among three main terms: digitization, digitalization, and digital transformation. These three stages reflect the evolution of the use of digital technology, from information conversion and increasing process efficiency to structural changes in governance and organizational culture (Khan, 2016). This digital transformation, in turn, gives rise to the need for digital

governance, namely one that relies not only on technology as a tool but also revolutionizes the way governments design policies, manage data, and engage stakeholders collaboratively and transparently.

In the context of food security and land management, digital governance is crucial because these sectors face significant complexity, including cross-agency coordination, the need for spatial and real-time data, and transparency in land monitoring and food distribution. With an effective digital governance system, the government can integrate data from various sectors, conduct satellite-based deforestation monitoring, and design evidence-based policies (Khan, 2016). Therefore, this chapter's discussion focuses on the six dimensions of digital governance outlined in the OECD Digital Government Policy Framework (OECD, 2020) and compares them with practices in developed countries such as China, Brazil, the European Union, and the United Kingdom. This analysis aims to identify challenges and opportunities that can be adapted to the Indonesian context.

3.1. Implementation of Digital Governance in Food Security and Land Management

Digital governance is a strategic concept for strengthening governance through the integration of technology, policy, and cross-sector collaboration to make public services more transparent, responsive, and data-driven (Grigalashvili, 2023). In its implementation, digital governance not only emphasizes the use of technology as an operational tool but also encompasses improvements to decision-making processes, role allocation, accountability, and more active citizen participation (OECD, 2020). With this foundation, the government's ability to utilize digital technology develops gradually in line with its readiness and capacity, a phenomenon referred to in the literature as digital government maturity (Tingkes et al., 2024). This concept describes the stages of government maturity in providing digital services, from the initial stage, which is only informative, to the transformational stage, where the government can integrate data and services, involve the public in policy formulation, and make proactively evidence-based decisions. (OECD, 2020; Tingkes et al., 2024). By understanding this level of maturity, the government can design a more measured and sustainable digital technology development strategy, notably to support efforts to manage natural resources and food security in Indonesia.

In addition to the concept and maturity stages, a study Tingkes et al., (2024) shows that the implementation of digital governance in Indonesia still faces fundamental challenges, particularly in strengthening data integration and cross-agency coordination. Based on their analysis, the national SPBE (Electronic-Based Government System) maturity score has reached only 2.40 at the central level and 2.37 at the provincial level, placing Indonesia generally at the "Managed " stage, moving towards "Interaction". This condition reflects that although basic procedures and infrastructure for digital services are in place, implementation in the field is often hampered by technical and institutional issues. In other words, this low level of maturity is a significant factor slowing sectoral digitalization efforts, particularly in the food and resource management sectors, making it difficult for government strategic programs and policies in these sectors to run optimally.

Policies such as food programs, the estate, and the use of the Agriculture War Room (AWR) system have demonstrated the government's commitment to digitizing the food sector in Indonesia (Rachmawati, 2021). However, various evaluations indicate that technical constraints, including data interoperability and a lack of agency integration, still hamper this implementation (Islami, 2021). Implementing digital policies also requires strong and systematic data governance, a case study of the implementation of the One Data policy in Sleman Regency shows that, despite the existence of a regulatory framework and organizational structure,

significant challenges remain in data integration, consistency across agencies, and the quality of human resources responsible for data management. Limited digital infrastructure and weak coordination are significant obstacles to fully integrating the public service information system (Triananta & Purnomo, 2023).

Indonesia faces significant challenges in land management and food security, particularly related to deforestation and the imbalance between agricultural land expansion and ecosystem protection. The Food Estate program, developed in various regions, including Merauke, has been criticized for increasing carbon emissions due to massive deforestation (Askar, 2024). The implementation of digital governance is a crucial solution to ensure that agricultural expansion and land management are carried out more sustainably. By leveraging technologies such as satellite-based monitoring systems, AI, and big data, the government can optimize ecosystem restoration strategies while ensuring the effectiveness of food policies (Higgins & Bryant, 2020).

In line with this, the development of the digital economy also plays an important role in strengthening digital governance in the agricultural and land management sectors. Internet penetration in Indonesia has reached 79.50%, which can increase the adoption of digital-based agricultural technologies. Furthermore, financial inclusion, which has increased to 75.02%, enables farmers to access broader digital financial services, including digital credit, thereby supporting sustainable agricultural production (Huda et al., 2024). Implementation integrated digital governance can strengthen food security by ensuring that food production, distribution, and consumption can run more effectively and efficiently (Rina Herawati et al., 2023).

On the other hand, deforestation in Indonesia continues to change. The Ministry of Environment and Forestry (KLHK) recorded a total of 133,833.4 hectares deforested between 2022 and 2023, with secondary forests accounting for 124,598.9 hectares and primary forests for 9,234.5 hectares. Meanwhile, plantation forests experienced a regeneration of -12,729.9 hectares (Ministry of Environment and Forestry Republic of Indonesia, 2024). The main causes of deforestation remain land conversion, mining, infrastructure, and illegal logging. However, since the moratorium on clearing primary forests and peatlands in 2011, deforestation rates have tended to decline (Manihuruk et al., 2024). Peak deforestation occurred in 1996-2000 with 3.51 million hectares, but since 2004, the deforestation trend has remained stable at below 1 million hectares. A spike occurred again in 2014-2015 (1.09 million hectares) before declining until 2022-2023 (0.03 - 0.12 million hectares). The most considerable deforestation still occurs in Kalimantan, with East Kalimantan and North Kalimantan reaching 13,758.8 hectares, followed by Central Kalimantan (11,564.4 hectares), West Kalimantan (7,845.7 hectares), and South Kalimantan (134.9 hectares). Sumatra and Papua also recorded high levels of deforestation due to the expansion of plantations and mining (Badan Pusat Statistik, 2024).

This shows the importance of implementing digital governance to monitor land changes and reduce deforestation rates through satellite mapping and big data analysis (Si Mohammed et al., 2024). By digitizing oversight, the government can increase transparency and accountability in managing concession permits and ensure that the industry does not excessively damage ecosystems. A more integrated and accurate data management system, with uniform standards across all relevant agencies, is needed to create more effective, evidence-based policies in addressing deforestation (Feng et al., 2024). Therefore, digital governance based on data sharing between institutions such as the Ministry of Environment and Forestry, Bappenas, and the Ministry of Agriculture is key to creating a more accurate and comprehensive information system (Wu et al., 2021).

Furthermore, food security is an issue inseparable from land management policies. If the Food Estate program is not monitored correctly, it will not only increase deforestation but also reduce food production efficiency (Yeny et al., 2022). Rather than strengthening food security, improper land management can lead to soil degradation, biodiversity loss, and the depletion of essential water resources for agriculture. Therefore, implementing innovative agricultural technologies such as soil moisture sensors, satellite monitoring of land changes, and AI for weather prediction and food distribution is essential to ensure that agricultural land expansion is carried out sustainably and efficiently (Dawkins, 2025).

If this program continues without technology-based oversight, there is a significant risk that cleared land will not yield optimal yields, while deforestation continues to increase. Consequently, food security goals will be missed, and the environmental crisis could worsen (Askar, 2024). Therefore, a digital governance and data-sharing approach must be implemented comprehensively to ensure that food security programs like the Food Estate truly support community well-being without damaging existing ecosystems.

3.2. Implementation Digital Governance in Land and Food Governance: A Global Study on Digital Governance

In today's digital era, the use of technology in land management and food security has become a priority for many countries (Mazwane et al., 2022). Implementing digital governance in this sector not only increases efficiency and productivity but also contributes to environmental sustainability by reducing deforestation, optimizing resource use, and increasing policy transparency. Digital governance offers innovative solutions to address global challenges related to food security and land degradation through technologies such as big data, artificial intelligence, and the Internet of Things. Things (IoT), GIS-based mapping systems, and blockchain (Oliveira et al., 2020).

Digitization in land and food governance enables various parties, from governments and farmers to the food industry, to collaborate more effectively in natural resource management (Mazwane et al., 2022). The implementation of data-driven systems enables real-time land monitoring, reducing the risk of land overexploitation and increasing the efficiency of food distribution (Gabrys, 2020). With satellite mapping technology, changes in land use can be detected more quickly, allowing mitigation policies to be implemented immediately to avoid uncontrolled environmental degradation (Ehrlich-Sommer et al., 2024). Furthermore, the data generated by this monitoring can serve as a basis for developing evidence-based policies, enabling more accurate and responsive decision-making in response to changing environmental and social conditions (Giest, 2025).

This chapter will discuss how several countries have successfully implemented digital governance in their food and land policies. This comparative study covers China, Brazil, and the European Union, each of which has a unique approach to adopting digital technology to improve the effectiveness of policies and natural resource management. By examining best practices from these countries, Indonesia can learn relevant lessons to develop a more adaptive and sustainable digital governance system in the agricultural and land governance sectors. Furthermore, the implementation of sound digital governance can help Indonesia address various challenges, such as limited productive land, a growing population that continues to drive food demand, and the threat of climate change that directly impacts national agricultural production. Therefore, the adoption of digital technology is not only a tool to increase efficiency but also a long-term strategy to achieve more inclusive and sustainable food security at the global level.

3.3. Digital Governance in Land and Food Governance in China

China has successfully implemented digital governance in land management and food security using high-tech technologies such as artificial intelligence, IoT, big data, and satellite mapping. The application of these technologies has increased agricultural efficiency and optimized sustainable land use.

As part of the strategy of digital governance, the Chinese government adopted the "Outline" policy of Digital Village Development Strategy, and "Digital Agriculture and Rural Development Plan (2019–2025)" (Guo & Lyu, 2024). This policy aims to modernize agriculture through sensor monitoring, real-time data analysis, and the automation of food production and distribution. This technology makes the agricultural sector more adaptive to climate change and increasing food demand.

Big data and satellite mapping are being utilized to identify land-use changes in real time, enabling governments to respond more quickly to the impacts of climate change on the agricultural sector. These systems also aid in more optimal planning and management of natural resources (Gkikas et al., 2023). Furthermore, blockchain is being applied in the food supply chain to increase transparency and security (Wang & Li, 2023). This technology ensures accurate traceability of data on the origins of food products, their production processes, and their distribution, increasing consumer trust and improving food logistics efficiency.

China's success in implementing digital governance in the agricultural sector demonstrates that technology can be a solution to global challenges. This approach can improve food security while creating a more efficient and sustainable agricultural system. This model can serve as a reference for other countries developing digital-based agricultural sectors.

In addition to international studies, digital governance practices in local contexts also provide important lessons. One example can be seen in the acceleration of digital governance during the COVID-19 pandemic. The Pekanbaru City Government's experience demonstrates that a crisis can be a crucial opportunity to promote the comprehensive use of information technology. Through the launch of various digital tracking applications and systems, the government accelerated policy responses, increased data transparency, and forged close collaboration with the media, universities, and civil society (Rizki et al., 2023). Lessons from this experience demonstrate that targeted digitalization can also be applied in the forestry and food security sectors, including monitoring deforestation, food distribution, and public participation in reporting and oversight of environmental policies.

3.4. Digital Governance in Land and Food Management in Brazil

Brazil is a country that has embraced digital technology in land management and food security. With its vast Amazon rainforest and its crucial role as a major global agricultural exporter, Brazil faces significant challenges in balancing agribusiness growth with environmental conservation. To address this, the Brazilian government has implemented various digital-based policies to improve deforestation monitoring (Benzeev et al., 2022).

One of the central policies implemented is the Detecção system of Desmatamento em Tempo Real (DETER), developed by the National Institute for Space Research (INPE). This system enables real-time monitoring of deforestation using satellite data and artificial intelligence to detect changes in forest cover driven by agricultural expansion and illegal encroachment. This system allows the government to take faster action in forest protection efforts, resulting in a 25% reduction in illegal deforestation in the past five years (Assunção et al., 2023).

Brazil has also developed a digital land registration system, Cadastro. Ambiental Rural Areas (CAR), which aims to increase transparency of land ownership and reduce illegal encroachment. This system enables tracking of land status based on geospatial coordinates, aiding data-driven decision-making for conservation policies and optimization of the agricultural sector (Horn, 2024). Precision agriculture technology (Precision Agriculture) is increasingly being used in Brazil to improve food production efficiency. By leveraging big data and artificial intelligence, farmers can analyze weather patterns, optimize fertilizer and water use, and reduce agricultural waste. The implementation of this system can increase agricultural efficiency by up to 20% while reducing negative environmental impacts (Raj & De Carvalho, 2023).

On the other hand, Brazil has implemented blockchain technology in its agricultural supply chain to improve transparency and food safety. This technology ensures the legitimacy of products, their origins, and their production processes, enabling exports such as soybeans, beef, and coffee to meet international sustainability standards. The blockchain system has increased global trust in Brazilian agricultural products and has led to efficiencies in food trade and distribution (Salah et al., 2019).

Brazil's success in implementing digital governance in the agricultural and land management sectors demonstrates that technology can help maintain a balance between economic growth and environmental conservation. Through this approach, Brazil can improve national food security while also ensuring the sustainability of its ecosystems for future generations (Mendes & Viola, 2023).

3.5. Digital Governance in Land and Food Governance in the European Union

The European Union has implemented digital governance in land and food management to increase productivity and maintain environmental sustainability. Through policies such as the Common Agricultural Policy (CAP) and the Farm to Fork Strategy, the EU encourages the use of digital technology in agriculture to create a more efficient and environmentally friendly food system (Mezzacapo, 2024).

One of the technologies used is Precision Agriculture, which leverages big data to optimize the use of fertilizers, water, and pesticides, thereby increasing crop yields and reducing agricultural waste. In addition, the EU utilizes the Copernicus satellite system. Earth Observation: A program to monitor land-use changes in real time enables early detection of land degradation and the impacts of climate change (Bellini et al., 2023). Through these policies and technologies, the European Union seeks to create a healthier, more sustainable, and more resilient food system in response to global environmental change.

3.6. Six Dimensions of Digital Governance in Land Policy and Deforestation Management

Digital governance plays a crucial role in land policy and deforestation management efforts, particularly by leveraging digital technologies to enhance monitoring effectiveness, improve policy transparency, and enable data-driven decision-making. The OECD has formulated six key dimensions of digital governance that can be applied to land policy and deforestation mitigation. These six dimensions can be used as analytical materials to assess contributions to more effective and sustainable land policy governance and deforestation management.

3.6.1. Digital by Design

The digital approach to land policy design emphasizes integrating technology from the earliest stages of policy planning. Countries that implement this principle build digital systems from the outset to ensure efficient land management. For example, the use of geographic information systems and satellite-based mapping allows governments to identify areas prone to deforestation, establish conservation zones, and develop forest rehabilitation strategies digitally (Oliveira et al., 2020).

3.6.2. Data-Driven Public Sector

This dimension refers to the use of data as the primary basis for policy decision-making. In land management and deforestation, technologies such as big data and AI can be used to analyze land use change trends, predict the impacts of agricultural expansion, and develop data-driven environmental protection strategies (Gkikas et al., 2023). Countries like Brazil have used the DETER system for real-time deforestation monitoring, enabling swift action to curb illegal activities (Assunção et al., 2023).

3.6.3. Government as a Platform

This principle emphasizes collaboration between the government, the private sector, and communities in resource management. Digital governance in land policy can be realized through cloud-based platforms that enable data sharing between institutions, companies, and environmental organizations (Guo & Lyu, 2024). For example, the European Union is implementing this approach through satellite-based land-monitoring systems such as Copernicus, which enable collaboration in research and evidence-based policymaking (Bellini et al., 2023). However, the effective implementation of digital governance remains constrained by unequal internet infrastructure, as internet access has not been evenly distributed across regions. This digital divide limits the ability of all communities to fully benefit from digital innovations and participate in digital governance processes, particularly in developing countries (Dewi et al., 2023).

3.6.4. Open by Default

By default, transparency in public policy is encouraged by making land management data and information publicly accessible (Mendes & Viola, 2023). With open data policies, various parties can monitor land-use changes, identify areas experiencing deforestation, and propose participatory solutions. Blockchain technology has also been implemented in several countries to ensure transparency in the supply chain of forest-based products, thereby reducing the illegal timber trade (Wang & Li, 2023).

3.6.5. User-Driven

A user-centric approach to digital governance emphasizes understanding the needs of various stakeholders in land management. By developing responsive digital services, the government makes information more easily accessible to farmers, environmental activists, and the wider community. One example is a forest-monitoring application that allows the public to report illegal deforestation directly via digital devices (Wang & Li, 2023). This approach is critical considering the complexity of stakeholder roles in forest resource management, which involve key actors such as forest village community institutions, local governments, and forest management agencies. Previous research has shown that the success of environmental conservation is primarily determined by the quality of interactions between key stakeholders (players) and direct user community groups (subjects), which, when well coordinated, can encourage sustainable and inclusive environmental governance (Hidayat et al., 2020).

3.6.6. Proactiveness

The final dimension of digital governance focuses on the government's ability to anticipate environmental issues before they become larger crises. By leveraging artificial intelligence and predictive models, governments can develop deforestation mitigation scenarios and implement more adaptive policies. The use of drone technology and IoT-based sensors has helped several countries detect forest fires early and prevent uncontrolled deforestation (Gkikas et al., 2023) In Indonesia, the opportunity to develop digital systems based on open collaboration is growing, bolstered by the successful synergy between the government and NGOs, such as WWF Indonesia's Switch Asia–Local Harvest Program. This program demonstrates that collaboratively managed environmental issues and policies can address the challenges of ecological and food degradation with a more participatory and sustainable approach (Apriyani, 2024).

Applying the six dimensions of digital governance to land policies and deforestation management can improve regulatory effectiveness, strengthen transparency, and enable faster responses to environmental challenges. By optimally leveraging digital technology, countries can reduce deforestation rates and ensure sustainable land use without compromising existing ecosystems.

4. Conclusion

This study confirms that strengthening digital governance is crucial to improving food and land governance policy in Indonesia. Integrated data management, coordination across effective institutions, and the use of technology to ensure information can help increase decision-making speed, transparency, and policy accuracy. Study results show that digital governance practices in several countries offer important lessons for Indonesia. For example, China is strengthening its centralized data system to monitor land and disaster resilience in real time; Brazil is utilizing satellite monitoring systems to curb deforestation; and the European Union is pushing for cross-border data transparency to strengthen accountability in policy. The third practice shows that collaboration across institutions, support for digital infrastructure, and open data management have become key mainstays in the governance of food and land, with effective digital-based governance.

However, from the perspective of digital government maturity, Indonesia is still at a medium level, moving toward the next stage of interactive maturity. The challenge mainly involves suboptimal inter-institutional data integration, low human resource capacity in data management, and weaknesses in coordination and digital infrastructure. Conditions. This aims to implement digital governance in the food and land sector. It is not yet fully mature and impactful. Therefore, comprehensively repairing data governance, enhancing technical and institutional capacity, and developing a culture of information sharing becomes a priority so that Indonesia can accelerate the improvement of digital government maturity and realize the management of food and land in a more transparent, integrated, and sustainable way.

This research, however, has several limitations, the study focuses on conceptual literature and policy analysis without direct testing at the implementation level. Limited access to primary data, a lack of empirical studies, and limited regional-level analysis also restricts the breadth of mapping actual challenges on the ground. Furthermore, Indonesia's digital infrastructure readiness, human resource capacity, and data management regulations still require strengthening to ensure optimal implementation of digital governance.

Moving forward, the research agenda should focus on empirical testing to evaluate the effectiveness of digital governance in food policy and land management at both the central and regional levels. Further studies are also needed to develop

institutional collaboration models, strengthen data integration across sectors, and prepare regulatory frameworks for data protection and digital security. Furthermore, strengthening human resource capacity and developing equitable digital infrastructure across all regions are crucial factors in ensuring the readiness of the digital governance system. By maintaining these aspects, Indonesia is expected to build an adaptive, transparent, and sustainable food and land governance system, capable of better responding to the dynamics of global food security.

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