Localizing AI-Driven Environmental Policy: Indonesia's Challenge in Adopting Global Governance Trends

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Abstract. Artificial intelligence (AI) is increasingly integrated into environmental governance to support emissions monitoring, disaster risk reduction, and data-driven decision-making. However, adapting globally developed digital technologies and policy frameworks to Indonesia's institutional and sociopolitical contexts remains a significant challenge. This study examines the localization of AI-driven environmental policy in Indonesia through a qualitative analysis of three national environmental information systems: SIMONTANA, SIPUHH, and SRN-PPI. Drawing on Global Governance Localization and Sociotechnical Transition Theory, the study explores how institutional arrangements, technological capacities, and sociopolitical dynamics shape the adaptation of digital environmental governance. The findings highlight several interconnected challenges, including fragmented institutional coordination, uneven digital infrastructure and technical capacity, tensions between centralized policy frameworks and local governance needs, and concerns about transparency and public trust. The study also proposes *Digital Catalytic Leadership* as a potential mechanism to bridge technological innovation, institutional coordination, and local participation. It argues that effective policy localization requires not only technological adaptation but also stronger subnational institutional capacity, transparent and interoperable data governance, and more inclusive public engagement mechanisms. These findings underscore the importance of aligning digital innovation with local institutional realities to support more accountable, legitimate, and sustainable environmental governance in Indonesia.

Keywords: Artificial Intelligence; Environmental Governance; Policy Localization; Sociotechnical Transitions; Digital Catalytic Leadership

1 Introduction

The rapid development of digital technologies, particularly artificial intelligence (AI), has created new opportunities for addressing complex environmental challenges. Digital technologies are increasingly incorporated into environmental governance to improve data collection, monitoring, policy coordination, and decision-making. International organizations,

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including the United Nations Environment Programme (UNEP) and the World Bank, have encouraged integrating digital innovation into environmental management as part of broader efforts to strengthen institutional effectiveness and sustainability [1, 2]. Within this context, AI offers potential applications in emissions monitoring, environmental risk assessment, early warning systems, and climate change mitigation [3]. However, these technologies' effectiveness depends not only on their technical capabilities but also on the institutional and social conditions in which they are introduced.

A central challenge is adapting globally developed technologies and governance frameworks to different national and local contexts. Digital environmental policies are often promoted through international standards and technological models that assume relatively stable institutional arrangements, adequate infrastructure, and sufficient administrative capacity. These conditions are not necessarily present in developing countries, where fragmented authority, uneven technological resources, and diverse sociocultural expectations may characterize governance systems. Consequently, adopting digital technologies cannot be understood as simply transferring technical solutions from one setting to another. It also requires policy localization, through which global approaches are interpreted, negotiated, and adapted to local institutional arrangements, political priorities, and community needs [4].

Indonesia provides a relevant context for examining these challenges. As a country with extensive forest ecosystems, considerable biodiversity, and significant exposure to climate-related risks, Indonesia faces persistent pressures associated with deforestation, environmental degradation, pollution, and hydrometeorological disasters. Although government reports indicate progress in reducing deforestation, forest protection and sustainable resource management remain important policy concerns. Environmental pressures also extend beyond forest areas. Pollution in major river systems, deteriorating air quality in urban areas, and recurring floods, landslides, and droughts demonstrate the interconnected nature of the country’s environmental challenges. These conditions require coordinated responses across government institutions, economic sectors, and administrative levels [5].

In response, the Indonesian government has developed several digital information systems to strengthen environmental monitoring and administration. The National Forest Monitoring System (SIMONTANA) supports collecting and analyzing forest-related spatial information. At the same time, the Forest Product Administration Information System (SIPUHH) facilitates the documentation and monitoring of forest product administration. The National Registry System for Climate Change Control (SRN-PPI) provides a framework for recording and reporting climate change mitigation and adaptation activities. Together, these initiatives illustrate Indonesia’s efforts to integrate digital information into environmental governance. They also provide useful cases for examining how national technological systems interact with existing institutional arrangements and implementation capacities.

Alongside these systems, advances in remote sensing, satellite-based monitoring, and machine learning have expanded the ability to identify environmental risks and support preventive action. These technologies are particularly relevant to forest and peatland fire monitoring, where timely information can improve hotspot identification and inform government responses [6]. Nevertheless, the availability of digital technologies does not automatically translate into effective environmental policy. Their practical contribution depends on data quality, institutional coordination, technical expertise, and the capacity of responsible authorities to interpret information and translate it into appropriate decisions. It is therefore

important to distinguish the broader digitalization of environmental administration from the specific application of AI-based analytical capabilities.

Despite ongoing digitalization efforts, Indonesia still faces challenges in integrating technological innovation into environmental governance. Differences in institutional mandates, limited interoperability among information systems, uneven digital infrastructure, and disparities in technical capacity can constrain implementation across administrative levels. Moreover, the relationship between centralized policy frameworks and decentralized governance arrangements creates additional difficulties when national technological initiatives must respond to diverse local environmental conditions. These challenges suggest that digital environmental policy effectiveness cannot be assessed solely by the availability or sophistication of technological systems. Greater attention is needed to the institutional relationships and governance processes through which these systems are implemented.

The Global Governance Localization perspective provides a useful foundation for understanding this process. Rather than treating internationally promoted policy models as universally applicable, this perspective emphasizes how global ideas and practices are adapted through interactions with domestic institutions, political interests, and local social conditions [4]. From this standpoint, localization involves more than technical adjustment. It is also a political and institutional process in which the meaning, legitimacy, and practical application of technological innovations are shaped by the actors implementing them. This perspective is particularly relevant to Indonesia, where variations in administrative capacity and local governance priorities may influence how digital environmental initiatives are interpreted and used.

Sociotechnical Transition Theory offers a complementary explanation by emphasizing the relationship between technological innovation, established institutional arrangements, and broader social and environmental pressures [7]. Technological change is understood as part of a wider transformation involving interactions among emerging innovations, existing governance regimes, and changing societal conditions. Applied to environmental governance, this perspective suggests that digital systems cannot produce sustained institutional change without the organizations, regulatory practices, and social relationships in which they operate. Adopting them may require adjustments to established administrative procedures, coordination practices, and expectations about how environmental information is used. Combining this perspective with Global Governance Localization makes it possible to examine both the adaptation of global policy approaches and the institutional dynamics that shape technological change in Indonesia.

Another consideration is the role of leadership in linking technological innovation with institutional adaptation. Digital transformation requires more than technical supervision or the introduction of new information systems. It also involves coordinating actors with different responsibilities, addressing institutional barriers, and encouraging collaboration across organizational boundaries. Building on the concept of catalytic collaboration, which emphasizes cross-sectoral relationships and collective problem-solving in supporting innovation [8], this study introduces *Digital Catalytic Leadership* as a potential mechanism for facilitating the localization of digital environmental governance. The concept highlights leadership's capacity to connect technological opportunities with institutional coordination, local knowledge, and collaborative decision-making.

Within this framework, digital catalytic leadership is not limited to promoting technological adoption. It also involves creating conditions in which government agencies, local authorities, researchers, private actors, and communities can participate meaningfully in governance processes. Such coordination matters because environmental problems often cross administrative boundaries and involve competing interests. Inclusive engagement may help institutions identify locally relevant priorities, address implementation constraints, and strengthen the legitimacy of digital initiatives. Accordingly, the relationship between technological innovation and effective governance needs to be understood through both institutional collaboration and public participation [9].

Questions of transparency and public trust further complicate implementing AI-driven environmental policy. When algorithmic processes are difficult to understand or scrutinize, concerns may arise regarding accountability, fairness, and the distribution of decision-making authority. These concerns become particularly significant when environmental policies affect communities whose livelihoods depend directly on natural resources. Without adequate opportunities for explanation, participation, and institutional oversight, technological interventions may reinforce existing inequalities or weaken public confidence in government decisions [10]. Strengthening the legitimacy of digital environmental governance therefore requires attention not only to technical performance but also to the social and political relationships through which technologies are introduced and governed.

Although existing studies of digital environmental governance have highlighted the potential benefits of technological innovation, they have paid less attention to how globally promoted digital approaches are adapted to Indonesia's institutional and sociopolitical context. In particular, the relationship between policy localization, sociotechnical change, and leadership in facilitating institutional adaptation has not been sufficiently examined within an integrated analytical framework. Addressing this gap requires an approach that considers technological systems alongside the governance arrangements, organizational relationships, and local conditions that shape their implementation.

Against this background, this study examines how AI-driven environmental policy can be localized within Indonesia's political, institutional, and sociocultural contexts. It focuses on three national environmental information systems, SIMONTANA, SIPUHH, and SRN-PPI, as cases through which to explore the opportunities and constraints associated with digital environmental governance. By integrating Global Governance Localization and Sociotechnical Transition Theory, the study analyzes how institutional fragmentation, technological capacity, governance legitimacy, and collaborative leadership shape the adaptation of digital environmental initiatives. Its main conceptual contribution is to propose *Digital Catalytic Leadership* as a potential bridge between technological innovation and locally responsive governance. Through this approach, the study contributes to discussions on how digital environmental transformation can become more institutionally coordinated, socially legitimate, and responsive to Indonesia's diverse environmental governance needs.

2 Methods

This study employed a qualitative multiple-case study design to examine the localization of digital environmental governance within Indonesia's institutional and sociopolitical context. A qualitative approach explored how technological innovation interacts with policy frameworks, institutional arrangements, and governance practices. This approach is particularly relevant for

understanding complex policy processes in which organizational structures, political dynamics, and context-specific conditions shape technological adoption [11, 12, 14]. Rather than assessing the technical performance of artificial intelligence (AI) systems, the study focused on the institutional and sociotechnical factors influencing the implementation of digital environmental initiatives.

The analysis focused on three national environmental information systems: the National Forest Monitoring System (SIMONTANA), the Forest Product Administration Information System (SIPUHH), and the National Registry System for Climate Change Control (SRN-PPI). These cases were selected because they represent distinct yet interconnected areas of environmental governance, including forest monitoring, forest product administration, and climate change reporting. Their comparative examination offered an opportunity to identify common governance challenges and context-specific differences in implementing digital environmental initiatives. The analysis considered each system's policy objectives, institutional responsibilities, regulatory context, and administrative functions, particularly in relation to the broader challenges of adapting emerging digital technologies to Indonesia's governance landscape.

Data were collected through document analysis and a review of relevant academic literature. Documentary sources included publicly available government policies, regulatory documents, technical guidelines, institutional reports, and official information on the three environmental information systems. The study examined relevant publications from Indonesian government institutions, particularly those responsible for environmental management, forestry, climate policy, and technological development, to understand the regulatory and institutional contexts of implementation. The study reviewed academic literature to establish its theoretical foundations and contextualize the relationship between digital innovation, policy localization, and environmental governance. These sources were analyzed to identify institutional arrangements, implementation constraints, and recurring challenges associated with digital environmental transformation.

The analysis drew on two complementary theoretical perspectives: Global Governance Localization and Sociotechnical Transition Theory. Global Governance Localization provided a framework for examining how internationally promoted policy approaches and technological models are interpreted and adapted within national and subnational institutional settings [4]. Sociotechnical Transition Theory helped explain how emerging technological innovations interact with established governance structures, institutional practices, and broader sociopolitical conditions [7]. Integrating these perspectives enabled the study to examine digital environmental governance as both a process of policy adaptation and a broader institutional transformation.

The collected materials were examined through qualitative thematic analysis. The analytical process involved identifying relevant information within each case, organizing the material into recurring themes, and comparing the findings across the three systems. The analysis focused on institutional coordination, technological and administrative capacity, transparency and public trust, and the potential role of collaborative leadership in facilitating institutional adaptation. These themes were interpreted through the two theoretical frameworks to explain how institutional and sociotechnical conditions influence the localization of digital environmental initiatives. Particular attention focused on identifying patterns across cases while recognizing differences in their respective governance functions.

To strengthen analytical credibility, we compared information from different documentary sources wherever possible. This cross-source comparison helped identify converging accounts, inconsistencies, and gaps in the available evidence, reducing reliance on any single institutional perspective. The use of multiple documentary sources followed the qualitative research principle of triangulation [13]. The study developed interpretations by relating the documentary findings to established theoretical arguments, while distinguishing documented institutional characteristics from broader conceptual explanations.

This study has several limitations. Its reliance on documentary sources and academic literature limits direct insight into the experiences of policymakers, system administrators, and affected communities. Furthermore, publicly available documentation may not fully capture internal decision-making processes, technical configurations, or the extent to which AI-based analytical capabilities are integrated into each system. Consequently, the findings should be understood as a qualitative interpretation of institutional and sociotechnical conditions rather than a technical assessment of AI performance or a direct evaluation of policy outcomes. Nevertheless, the comparative approach provides a useful analytical basis for understanding the opportunities and constraints associated with localizing digital environmental governance in Indonesia.

3 Results and Discussion

Localizing AI-driven environmental policy in Indonesia involves more than adopting digital technologies or transferring internationally promoted governance models. It represents a broader process of institutional adaptation in which technological innovation interacts with existing regulatory arrangements, administrative capacities, and sociopolitical conditions. Drawing on Global Governance Localization [4] and Sociotechnical Transition Theory [7, 15], this study examines how institutional settings shape digital environmental initiatives. These perspectives provide a basis for understanding policy localization as an evolving process of negotiation and adaptation rather than a straightforward transition from conventional administration to technology-driven governance.

From the perspective of Global Governance Localization, internationally promoted policy approaches do not necessarily produce uniform outcomes when adopted within different institutional contexts. Domestic priorities, administrative structures, and the capacity of national and local actors to interpret and adapt policy objectives shape implementation [4]. Sociotechnical Transition Theory complements this perspective by emphasizing that technological innovations interact with established institutional practices and broader societal conditions. Incorporating new technologies into governance processes therefore depends on their compatibility with existing administrative arrangements and the extent to which institutions can accommodate organizational and procedural change [7, 15].

Indonesia's environmental information systems provide a useful context for examining these dynamics. The National Registry System for Climate Change Control (SRN-PPI), the National Forest Monitoring System (SIMONTANA), and the Forest Product Administration Information System (SIPUHH) represent efforts to strengthen environmental governance through digital information management. Although these systems serve different administrative purposes, they share a broader objective of improving the availability,

organization, and use of environmental information in public administration. Their development also reflects Indonesia's efforts to align domestic environmental governance with international commitments, particularly those concerning climate change mitigation, forest management, and environmental reporting.

Each system performs a distinct function within this governance landscape. SRN-PPI supports the registration and reporting of climate change mitigation and adaptation activities, helping organize information relevant to national climate policy. SIMONTANA provides forest-related monitoring information, including spatial data that can inform assessments of changes in forest cover. SIPUHH facilitates the electronic administration and documentation of forest products, supporting regulatory oversight and traceability within the forestry sector. These functions demonstrate the growing importance of digital information systems in environmental administration. However, their existence does not necessarily establish that all three platforms employ AI-based analytical processes. Their relevance to this study lies primarily in the institutional conditions that may enable or constrain the broader integration of advanced digital technologies into environmental governance.

The comparative analysis of documentary materials highlights several interconnected governance challenges. First, implementing digital environmental initiatives requires coordination among institutions with different mandates, responsibilities, and administrative capacities. National information systems may establish common reporting procedures and technological frameworks. Still, effective operation also depends on institutions' ability to collect, manage, interpret, and exchange relevant information. Differences in organizational priorities and administrative procedures can complicate these processes, especially when environmental issues span sectoral and territorial boundaries.

Second, the effectiveness of digital environmental governance depends on the relationship between technological infrastructure and institutional capacity. Environmental information systems require reliable data, adequate technical resources, and personnel who can manage digital procedures. These requirements may be harder to meet consistently across regions with different administrative and infrastructural conditions. Consequently, introducing nationally standardized systems does not automatically ensure uniform implementation. The potential benefits of digital environmental governance depend on how technological arrangements are adapted to the capacities and operational needs of the institutions responsible for their use.

Third, the relationship among different information systems raises important questions about data coordination and interoperability. Although SRN-PPI, SIMONTANA, and SIPUHH address related aspects of environmental governance, they operate within distinct policy and administrative domains. This functional differentiation can support specialized information management, but it also creates a need for effective coordination when environmental decisions require information from multiple sectors. The analysis therefore identifies interoperability as an important governance consideration rather than assuming that the systems are technically disconnected. Assessing their actual level of integration would require more detailed technical and institutional evidence than the documentary sources examined in this study provide.

Beyond administrative and technical considerations, expanding digital environmental governance also raises questions about transparency, accountability, and public participation. As environmental decisions increasingly rely on digital information, the legitimacy of these processes depends partly on whether relevant actors can understand how information is

collected, interpreted, and used. These concerns matter most when environmental policies affect communities whose livelihoods and social practices are closely connected to natural resources. Advanced analytical technologies may create additional governance challenges if decision-making procedures are insufficiently transparent or opportunities for public engagement remain limited. However, the documentary evidence considered here does not establish that the three systems independently generate algorithmic risk scores or systematically exclude particular communities. These issues are therefore examined as broader governance risks that should inform the development and oversight of digital environmental initiatives.

Taken together, the three cases illustrate a central tension in Indonesia's digital environmental transformation: technological development creates opportunities for more coordinated and information-based governance. At the same time, its institutional value depends on public organizations' capacity to integrate digital systems into established policy processes. The localization of digital environmental governance should therefore be understood as a process that involves technological adaptation, institutional coordination, administrative capacity, and governance legitimacy. This interpretation provides the foundation for the following discussion of institutional fragmentation, infrastructural constraints, public trust, and the potential contribution of Digital Catalytic Leadership to more adaptive and locally responsive environmental governance.

3.1 Institutional Fragmentation and Governance Misalignment

Institutional fragmentation poses a significant challenge to localizing digital environmental governance in Indonesia. Although national information systems such as SRN-PPI, SIMONTANA, and SIPUHH have been developed to support environmental monitoring, reporting, and administration, they operate within a governance structure characterized by differentiated institutional mandates and administrative responsibilities. These arrangements create coordination challenges when agencies must exchange environmental information or incorporate it into broader policy decisions. The analysis suggests that the effectiveness of digital environmental initiatives depends not only on the availability of technological infrastructure but also on public institutions' capacity to coordinate responsibilities and establish consistent procedures for managing environmental information [10].

These challenges become particularly relevant in Indonesia’s decentralized governance system, where national policy priorities must be translated into subnational planning and implementation processes. Regional governments operate within distinct administrative, financial, and institutional conditions that may affect their capacity to adopt nationally developed digital systems. Aligning national environmental information initiatives with regional spatial planning (*Rencana Tata Ruang Wilayah*, RTRW) and environmental protection and management planning (*Rencana Perlindungan dan Pengelolaan Lingkungan Hidup*, RPPLH) therefore requires coordination between central policy frameworks and local governance priorities. Without such alignment, digital systems risk functioning primarily as administrative reporting instruments rather than supporting integrated environmental planning and decision-making.

Institutional fragmentation also reflects persistent sectoral boundaries within public administration. Government agencies and technical units often operate under specialized mandates, procedures, and information requirements. While this specialization supports

managing sector-specific responsibilities, it may complicate efforts to establish coordinated governance arrangements across institutional boundaries. From a sociotechnical perspective, these challenges illustrate how established organizational practices can constrain the integration of emerging technologies into existing administrative systems [16]. Consequently, technological innovation alone cannot resolve coordination problems when the institutional relationships required to support information exchange and collaborative decision-making remain insufficiently developed.

Differences in institutional capacity further complicate the relationship between national digital initiatives and subnational implementation. Operating environmental information systems requires administrative resources, technical expertise, reliable infrastructure, and sustained organizational support. However, these resources may vary across regional governments, creating unequal conditions for implementing nationally standardized technological arrangements. Where institutional capacity is limited, digital systems may be used primarily to fulfill formal reporting requirements rather than to inform continuous environmental monitoring and policy evaluation. This possibility highlights the importance of understanding digital transformation as an institutional process that requires adjustments in administrative practices, resource allocation, and organizational capabilities [17].

These challenges also raise questions about how responsibilities are distributed between central and regional authorities. National institutions may set technological standards and reporting obligations, while regional governments are expected to implement them within existing administrative structures. When technical assistance, financial resources, and institutional coordination are not adequately aligned with implementation responsibilities, digital initiatives may increase administrative demands without generating corresponding improvements in governance effectiveness. The broader literature on digital transformation emphasizes that technological investments must be matched by institutional capacity and organizational readiness to produce meaningful improvements in public sector performance [18]. This perspective reinforces the need to consider institutional preparedness alongside technological development.

Addressing institutional fragmentation therefore requires a more integrated approach to digital environmental governance. Regulatory coordination across relevant ministries and government agencies is essential to clarify institutional responsibilities and reduce overlapping administrative procedures. Equally important is developing interoperable data governance arrangements that facilitate information exchange while respecting the distinct functions of existing environmental systems. At the subnational level, stronger technical assistance, administrative capacity development, and alignment with regional planning processes can help ensure that national digital initiatives respond to local governance needs. From a policy localization perspective, these measures are necessary to bridge the gap between nationally designed technological frameworks and the institutional realities of decentralized environmental governance in Indonesia.

3.2 Infrastructural Constraints and Capacity Gaps

Infrastructural limitations and disparities in institutional capacity pose another major challenge to localizing digital environmental governance in Indonesia. The effectiveness of environmental information systems depends on reliable digital infrastructure, consistent data collection procedures, and adequate technical expertise within implementing institutions.

These requirements are particularly important in a geographically diverse country such as Indonesia, where differences in connectivity, administrative resources, and technological readiness may affect the implementation of nationally developed digital initiatives. For systems such as SIMONTANA and SRN-PPI, limitations in these supporting conditions can constrain the timely collection, processing, and reporting of environmental information. The broader literature on digital transformation similarly emphasizes that technological innovation requires complementary investments in infrastructure, organizational capabilities, and human resources [19].

Beyond physical infrastructure, public institutions' capacity to operate and interpret digital systems is essential to their effectiveness. Environmental information platforms require personnel who can manage administrative procedures, assess data quality, and translate digital information into relevant policy considerations. However, differences in technical expertise and organizational resources across government institutions may create uneven implementation conditions. These challenges become particularly significant when national reporting requirements depend on information generated or managed at the subnational level. Without sufficient technical guidance and institutional support, digital procedures may increase administrative demands without necessarily improving the quality or practical use of environmental information [20].

The relationship between technological capability and data quality also deserves particular attention. Digital environmental systems depend on accurate, consistent, and appropriately updated information to support monitoring and policy evaluation. Incomplete records, inconsistent reporting practices, or limited capacity to verify environmental data can reduce the reliability of the information available to decision-makers. These limitations are especially relevant to the prospective integration of AI-based analytical tools, whose performance depends on the quality and suitability of the underlying data. Consequently, introducing more advanced technological functions should be accompanied by improvements in data management, verification procedures, and institutional accountability. Otherwise, digitalization risks becoming primarily an administrative exercise rather than a meaningful improvement in environmental governance [21].

Sociotechnical Transition Theory helps explain these challenges by emphasizing that technological innovation develops through interactions with established institutional arrangements and broader social conditions [7]. From this perspective, digital environmental transformation cannot be achieved by introducing new platforms or analytical capabilities alone. Its sustainability depends on whether implementing institutions possess the resources, organizational practices, and technical competencies required to incorporate technological innovations into routine governance processes. Where these supporting conditions remain uneven, digital systems' potential contribution to environmental monitoring and decision-making may be limited, regardless of their technological sophistication.

Geographical disparities further complicate efforts to establish consistent digital governance practices across Indonesia. Differences in connectivity and access to digital services can create additional challenges for institutions operating in remote or environmentally sensitive areas. These conditions matter for environmental monitoring because effective information management may depend on communication between national systems and local administrative units. However, the available documentary evidence does not establish a uniform level of connectivity or technical readiness across all regions. Infrastructure disparities should therefore be understood as an important contextual consideration that

requires location-specific assessment rather than as evidence of identical implementation problems throughout the country [22].

Addressing these constraints requires sustained investment in both technological infrastructure and institutional capacity. Improving digital connectivity matters, but infrastructure development should be paired with practical training, technical assistance, and organizational support for personnel responsible for environmental information management. Equally important is establishing consistent data standards, accessible operational guidance, and mechanisms for sharing technical knowledge across administrative levels. These measures can strengthen national and subnational institutions' ability to use environmental information systems effectively while reducing disparities in implementation capacity.

Ultimately, the localization of digital environmental governance depends on aligning technological development with the institutional conditions needed to sustain it. From a sociotechnical perspective, investments in infrastructure and human resources are not merely supporting measures but integral components of technological transformation. Strengthening these foundations can improve the reliability and practical relevance of environmental information while creating more favorable conditions for the responsible integration of AI-based analytical capabilities into Indonesia’s environmental governance framework.

3.3 Algorithmic Legitimacy and Public Trust

The legitimacy of digital environmental governance depends not only on technological effectiveness and institutional capacity but also on public trust, transparency, and accountability. As environmental information systems become increasingly integrated into policy processes, questions arise concerning how digital information is generated, interpreted, and used to support decisions affecting communities and natural resources. These concerns are especially relevant to the prospective application of artificial intelligence (AI), which may add complexity to administrative decision-making. From a governance perspective, technological acceptance within public institutions does not necessarily ensure broader social legitimacy, especially when affected communities have limited opportunities to understand or influence the decisions supported by digital technologies [10].

A central concern involves the transparency of data-driven and algorithmic decision-making. AI-based analytical systems may rely on computational processes that users and affected stakeholders find difficult to interpret. When the assumptions, data sources, or decision-making criteria underlying these processes are insufficiently transparent, questions may arise regarding the reliability, fairness, and accountability of their outputs. Algorithmic systems should therefore not be regarded as entirely neutral instruments, as their design and operation reflect choices concerning data selection, analytical priorities, and institutional objectives. Without appropriate governance safeguards, these choices may reproduce existing inequalities or introduce new forms of exclusion into public decision-making [23].

These concerns align with Eubanks’ analysis of automated decision-making in public services, which shows how technological systems can reinforce social inequalities when implemented within unequal institutional and social environments [24]. Although this argument does not establish that similar outcomes have occurred in Indonesia’s environmental information systems, it offers an important analytical lens for assessing the potential social implications of AI-driven environmental governance. In particular, using digital information to inform decisions on forest management, environmental protection, or resource access raises questions

about whose knowledge is represented, how affected interests are considered, and whether adequate mechanisms exist to challenge potentially inaccurate or unfair decisions.

The relationship between digital governance and local communities is especially significant in environmental policy because regulatory decisions may affect livelihoods, customary practices, and access to natural resources. Indigenous peoples, smallholder farmers, and other resource-dependent communities may hold forms of ecological knowledge that standardized digital datasets do not fully capture. Their meaningful participation can therefore contribute to more context-sensitive interpretations of environmental information and strengthen the legitimacy of policy implementation. From a policy localization perspective, incorporating local knowledge and community perspectives is not merely a procedural requirement but a key condition for adapting technological approaches to diverse sociocultural settings.

Public trust also depends on institutional mechanisms that let stakeholders understand and question decisions informed by digital technologies. Transparent data governance, accessible explanations of administrative procedures, and opportunities for public consultation can help reduce the distance between technological systems and the communities affected by their use. Where AI-based analytical capabilities are introduced, additional safeguards may be necessary to assess potential bias, clarify institutional responsibility, and provide appropriate channels for reviewing contested outputs. These measures are especially important when digital assessments inform decisions with significant environmental, economic, or social consequences.

Strengthening algorithmic legitimacy in Indonesia's environmental governance therefore requires an approach that integrates technological accountability with meaningful public participation. Relevant measures include establishing transparent data-management standards, developing independent review procedures for algorithmic assessments, and ensuring affected communities have accessible opportunities to raise concerns or contest decisions. Participatory mechanisms should also recognize the relevance of local ecological knowledge and the diversity of institutional and sociocultural conditions across Indonesia. Such arrangements can support more accountable and context-sensitive digital governance while reducing the risk that technological innovation reinforces existing disparities in political influence and access to decision-making.

Ultimately, the legitimacy of AI-driven environmental governance cannot be determined solely by the sophistication of technological systems or their administrative efficiency. It also depends on whether institutions can demonstrate fairness, transparency, responsiveness, and accountability in using digital information. The documentary analysis does not establish that SIMONTANA, SIPUHH, or SRN-PPI independently employ automated risk scoring or algorithmic enforcement mechanisms. Nevertheless, their role within Indonesia's evolving digital environmental governance landscape highlights the importance of anticipating these concerns as more advanced analytical technologies are introduced. Building public trust should therefore be understood as an integral component of policy localization and sustainable sociotechnical transformation, rather than a secondary consideration after technological adoption.

3.4 Catalytic Leadership and Local Innovation

The institutional, infrastructural, and legitimacy-related challenges identified in the preceding sections highlight leadership's importance in facilitating the localization of digital

environmental governance. Although technological innovation can improve the availability and management of environmental information, its contribution to policy implementation depends on institutions' ability to coordinate responsibilities, mobilize resources, and respond to local governance conditions. In this context, leadership plays an important role in connecting national technological initiatives with the administrative capacities, environmental priorities, and sociocultural characteristics of subnational communities. Existing discussions of digital governance emphasize the relevance of leadership, organizational adaptation, and collaborative arrangements in supporting institutional transformation [25–27].

This study proposes *Digital Catalytic Leadership* as a conceptual mechanism for addressing these interconnected challenges. The concept refers to leadership that facilitates integrating digital innovation into governance processes by encouraging cross-sectoral collaboration, institutional learning, and context-sensitive adaptation. Rather than focusing exclusively on technological adoption or administrative control, digital catalytic leadership emphasizes the capacity to connect actors, resources, and knowledge across institutional boundaries. This understanding builds on Juhro et al.'s discussion of catalytic collaboration, which highlights the importance of collaborative relationships and transformational leadership competencies in supporting sustainable innovation [8]. Applied to environmental governance, this perspective suggests that leadership can help bridge the gap between nationally developed technological frameworks and the institutional conditions shaping their implementation at the local level.

One potential contribution of digital catalytic leadership lies in facilitating the translation of technological information into locally relevant knowledge. Environmental information generated through digital platforms, including forest monitoring and climate reporting systems, may provide useful inputs for policy planning and environmental management. However, the practical value of such information depends on whether it can be interpreted and communicated in ways that respond to local environmental conditions and administrative needs. Collaborative leadership can support this process by encouraging interaction among government agencies, technical specialists, local authorities, and community representatives. Through these relationships, digital information can be considered alongside contextual knowledge and local policy priorities, creating opportunities for more responsive environmental decision-making.

Integrating local ecological knowledge is particularly relevant to environmental governance in regions where communities maintain longstanding relationships with surrounding ecosystems. Knowledge of seasonal patterns, land use, forest conditions, and environmental changes may complement information from formal monitoring systems. Digital catalytic leadership provides a conceptual basis for facilitating dialogue between these different sources of knowledge without assuming that technological information should automatically take precedence over local experience. Such an approach can strengthen the contextual relevance of environmental policies while creating opportunities for meaningful participation in their formulation and implementation.

Beyond knowledge integration, digital catalytic leadership may contribute to institutional learning and adaptive governance. Environmental challenges frequently involve changing ecological conditions, overlapping administrative responsibilities, and uncertainty concerning policy outcomes. Addressing these complexities requires institutions to review procedures, share experiences, and adjust implementation strategies as needed. Leadership that encourages experimentation, interorganizational communication, and collaborative problem-solving can help create an institutional environment in which digital innovation is accompanied by

continuous learning. Within this perspective, technological transformation becomes a process of organizational adaptation rather than a one-time investment in information systems.

Nevertheless, the potential contribution of digital catalytic leadership depends on the broader institutional conditions within which it operates. Local experimentation and collaborative initiatives may encounter limitations when regulatory arrangements are inflexible, administrative responsibilities remain fragmented, or financial and technical resources are insufficient. National policy frameworks therefore need to provide sufficient flexibility for context-specific adaptation while maintaining appropriate standards of accountability and coordination. Mechanisms for documenting institutional experiences, exchanging knowledge across regions, and supporting collaboration among government agencies can also help strengthen the continuity and broader relevance of locally developed governance practices.

From the perspective of Global Governance Localization, digital catalytic leadership can be understood as a potential bridging mechanism between internationally promoted technological approaches and locally embedded governance arrangements. Its significance lies in facilitating the interpretation and adaptation of digital innovation through institutional coordination, collaborative learning, and engagement with relevant stakeholders. This interpretation also complements Sociotechnical Transition Theory by emphasizing leadership's role in supporting adjustments between emerging technologies and established administrative practices. Although this documentary analysis does not empirically establish the effectiveness of digital catalytic leadership in specific localities, it offers a conceptual explanation of how leadership may contribute to more adaptive, inclusive, and institutionally sustainable digital environmental governance in Indonesia.

3.5 Theoretical Synthesis and Policy Implications

The preceding analysis demonstrates that the localization of AI-driven environmental policy in Indonesia cannot be understood solely as a process of technological modernization. Rather, it involves digital innovation interacting with existing institutional arrangements, administrative capacities, and sociopolitical conditions. A comparative examination of SRN-PPI, SIMONTANA, and SIPUHH highlights four interconnected governance challenges: institutional fragmentation, disparities in infrastructure and technical capacity, concerns about transparency and public trust, and the need for leadership that supports institutional adaptation. These challenges suggest that the effectiveness of digital environmental governance depends not simply on introducing advanced technologies but on the institutional and social conditions that enable their meaningful integration into policy processes.

The findings can be interpreted through the complementary perspectives of Global Governance Localization and Sociotechnical Transition Theory. Global Governance Localization emphasizes that internationally promoted governance approaches acquire different meanings and implementation characteristics when adapted to domestic institutional contexts [4]. From this perspective, Indonesia’s adoption of digital environmental initiatives involves more than incorporating technological models associated with global environmental governance. It also requires adjustments to national regulatory arrangements, decentralized administrative structures, and locally specific environmental priorities. Sociotechnical Transition Theory further explains why technological innovation may encounter difficulties when existing institutional practices, organizational capabilities, and broader governance conditions do not adequately support change [7, 15]. Together, these perspectives suggest that

policy localization is a negotiated and potentially uneven process in which technological development and institutional transformation must advance in a mutually supportive manner.

This theoretical synthesis also provides a basis for understanding the potential contribution of Digital Catalytic Leadership. As discussed in the preceding section, this concept emphasizes leadership that connects technological innovation with cross-sectoral coordination, institutional learning, and meaningful stakeholder engagement. Its relevance lies in addressing the institutional and sociopolitical relationships that influence whether digital environmental initiatives can be adapted to local governance conditions. Digital Catalytic Leadership therefore offers a conceptual bridge between adapting global policy approaches and the institutional changes required to sustain technological innovation. However, its effectiveness remains a proposition for further empirical investigation rather than an outcome established by the present documentary analysis.

This interpretation yields several policy implications. First, strengthening digital environmental governance requires closer coordination among national institutions and between central and regional governments. Clearer institutional responsibilities, compatible data standards, and effective information-sharing arrangements can help reduce administrative fragmentation and improve the use of environmental information across policy sectors. These measures should also align national digital initiatives with subnational planning and environmental management priorities. Rather than treating interoperability solely as a technical issue, policymakers should recognize it as an institutional requirement involving regulatory coordination, administrative procedures, and sustained cooperation among implementing agencies.

Second, infrastructure development must be accompanied by investments in institutional capacity. Improving digital connectivity and technical resources is important, particularly where geographical and administrative conditions constrain the operation of environmental information systems. Nevertheless, technological investment alone is insufficient without personnel who can manage data, interpret digital information, and incorporate relevant findings into policy processes. Practical training, technical assistance, consistent operational guidance, and opportunities for interregional knowledge exchange can strengthen implementing institutions' capacity. These measures are also important to ensure reliable data and appropriate organizational readiness to support the prospective integration of AI-based analytical capabilities.

Third, governance arrangements for digital environmental initiatives should incorporate transparency, accountability, and public participation. Clear procedures for data management, accessible explanations of how information informs administrative decisions, and meaningful opportunities for stakeholder engagement can strengthen public confidence. Where AI-based analytical tools are introduced, additional safeguards should address potential bias, the explainability of analytical outputs, and the availability of appropriate review or contestation mechanisms. Pay particular attention to communities whose livelihoods and environmental knowledge may be affected by decisions on forests, land use, and natural resource management. Incorporating their perspectives can improve the contextual relevance of digital governance while supporting more inclusive policy implementation.

Fourth, national policy frameworks should provide sufficient flexibility for local adaptation and institutional learning. Indonesia’s diverse environmental and administrative conditions make it difficult to assume that standardized technological arrangements will operate

identically across regions. Supporting context-sensitive experimentation, collaborative problem-solving, and systematic documentation of implementation experiences can help institutions identify approaches suited to their operational needs. Such flexibility should be accompanied by clear accountability standards and mechanisms for sharing relevant knowledge across administrative boundaries. Within this approach, Digital Catalytic Leadership may provide a useful orientation for connecting local initiatives with broader institutional coordination and policy development.

Taken together, these implications point toward a more integrated approach to digital environmental transformation in Indonesia. Technological development, institutional coordination, capacity building, and public legitimacy should be treated as mutually reinforcing dimensions of governance rather than separate policy concerns. This study's principal contribution is to conceptualize the localization of AI-driven environmental policy as an institutional and sociotechnical process in which technological possibilities must align with administrative realities and societal expectations. For Indonesia and other countries navigating similar governance transitions, the analysis suggests that sustainable digital innovation depends not on directly replicating global technological models but on carefully adapting them to local institutional capacities, environmental priorities, and principles of accountable, inclusive governance.

4 Conclusion

This study examined the localization of AI-driven environmental policy in Indonesia by exploring the institutional and sociotechnical conditions surrounding three national environmental information systems: SIMONTANA, SIPUHH, and SRN-PPI. Drawing on Global Governance Localization and Sociotechnical Transition Theory, the analysis demonstrates that digital environmental transformation cannot be understood solely as the adoption of advanced technologies. Rather, it involves a complex process of institutional adaptation in which technological development interacts with administrative structures, governance capacities, and sociopolitical conditions. The findings highlight four interconnected challenges: institutional fragmentation and coordination difficulties, disparities in digital infrastructure and technical capacity, concerns regarding transparency and public trust, and the need for collaborative leadership to support locally responsive institutional change.

The study contributes to the understanding of digital policy localization by emphasizing the interdependence between technological innovation and institutional transformation. Global Governance Localization helps explain how internationally promoted governance approaches are interpreted and adapted within domestic institutional settings. At the same time, Sociotechnical Transition Theory highlights the organizational and social conditions that shape technological change. Integrating these perspectives, the study proposes Digital Catalytic Leadership as a potential mechanism for connecting digital innovation with cross-sectoral coordination, institutional learning, and meaningful stakeholder participation. This conceptual contribution suggests that localizing digital environmental governance requires not only technological readiness but also leadership that facilitates collaboration and adapts policy approaches to diverse local contexts.

The policy implications highlight the need to strengthen coordination across government institutions, improve digital infrastructure and administrative capacity, and establish

transparent, accountable arrangements for environmental information management. National digital initiatives should also provide sufficient flexibility to accommodate regional differences while maintaining consistent standards for data governance and institutional responsibility. Meaningful engagement with local communities, including the recognition of relevant ecological knowledge, can further support the legitimacy and contextual relevance of environmental policies. These considerations are particularly important as AI-based analytical capabilities become more widely considered for environmental monitoring and decision-making.

This study is limited by its reliance on documentary sources and academic literature, which restricts direct assessment of implementation practices, stakeholder experiences, and the technical capabilities of the systems examined. Accordingly, interpret its conclusions as an institutional and conceptual analysis rather than an empirical evaluation of AI performance or policy effectiveness. Future research could examine these issues through comparative subnational case studies, interviews with policymakers and affected communities, and longitudinal assessments of digital environmental initiatives. Further empirical investigation is also needed to assess whether and under what conditions Digital Catalytic Leadership contributes to institutional coordination, public trust, and more effective environmental governance.

Ultimately, Indonesia's experience illustrates that the potential of AI-driven environmental governance depends on more than technological sophistication. Its long-term contribution will depend on public institutions' ability to align digital innovation with local capacities, transparent decision-making, and inclusive governance arrangements. By treating policy localization as an institutional and sociotechnical process, Indonesia can create stronger foundations for environmental governance that is not only technologically responsive but also accountable, context-sensitive, and socially legitimate.

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