



Digital Transformation of Land Services in Indonesia: A Case Study of Bogor, Sleman, and Buleleng

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ARTICLE INFO	ABSTRACT
Keywords: Electronic Land Certificate, Digital Transformation, Media Conversion, Land Data Quality, Comparative Analysis Date logs: Received: Nov 3, 2025 Reviewed: Nov 7, 2025 Accepted: Nov 14, 2025 Published: Nov 15, 2025 How To Cite: Kusmiarto, Wahyono, E.B., Syaifullah, A., Wahyuni, Sitorus, O., Desmawan, H., Putra, B.T.A., Pratidina, N.P.A., Wulandari, I.Y. (2025). Digital Transformation of Land Services in Indonesia: A Case Study of Bogor, Sleman, and Buleleng. <i>Marcapada: Jurnal Kebijakan Pertanahan</i>, 5(1), 115–139. https://doi.org/10.31292/mj.v5i1.190	The digital transformation of land administration services in Indonesia through the Electronic Land Certificate Program represents a strategic government initiative aimed at improving efficiency, transparency, and legal certainty, as regulated under the Ministerial Regulation of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN) No. 3 of 2023. However, its implementation faces multifaceted complexities and challenges at the local level. This study aims to conduct a comparative analysis of the implementation of the electronic land certificate program across four prioritized land offices: Sleman, Bogor I, Bogor II, and Buleleng—by identifying common patterns and specific differences in encountered issues and applied strategies. A descriptive qualitative approach with a comparative case study method was employed. Data were gathered through in-depth interviews, direct observations, and document analysis at each location. The findings reveal shared challenges, including poor data quality, limited human resources, suboptimal information technology infrastructure, and constrained policy and budget dynamics. Nonetheless, differences arise across local contexts: Sleman highlights case backlogs; Bogor I focuses on media conversion issues; Bogor II emphasizes the relationship between data quality and implementation effectiveness; while Buleleng centers on post-disaster archival reconstruction strategies. This research contributes to a more profound understanding of regional implementation gaps and offers adaptive policy recommendations to accelerate sustainable digital transformation within Indonesia’s national land administration system.

A. Introduction

Digital transformation in land administration services in Indonesia constitutes an integral part of the national agenda to realize an efficient, transparent, and legally certain bureaucracy, as articulated in the Strategic Plan of the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN) 2020–2024 (Kementerian ATR/BPN, 2020). The Electronic Land Certificate Program, formally established through Ministerial Regulation of ATR/BPN No. 3 of 2023 on the Issuance of Electronic Documents in Land Registration Activities, marks a fundamental shift from analog to digital

documentation (Kementerian ATR/BPN, 2023). This initiative aims to reduce the risk of forgery, accelerate administrative processes, enhance accountability, and support national data integration through applications such as *Komputerisasi Kegiatan Pertanahan (KKP—Computerized Land Activities)* and *Sistem Validasi Tanah Kita (SITATA)* (Kanwil BPN Provinsi Sumatera Utara, 2025); (Kantor Pertanahan Kabupaten Wonogiri, 2025); (Diany et al., 2024). The phased implementation of this program began in May 2024 across 104 priority land offices, including Sleman, Bogor I, Bogor II, and Buleleng, as a response to the mandates of Law No. 11 of 2008 on Electronic Information and Transactions and Law No. 6 of 2023 on Job Creation (Pemerintah Republik Indonesia, 2023). However, the implementation of this strategic policy is not without complexities at the local level, where factors such as the quality of historical data, the readiness of human resources, and the availability of technological infrastructure have proven to be decisive for program success. Several studies have emphasized that these factors play a crucial role in determining the effectiveness of digital transformation in land administration, both from the perspective of institutional preparedness and system governance (Irfan et al., 2023; Bennett et al., 2023; Chehrehbargh et al., 2024).

Research on the digital transformation of land administration services has expanded rapidly alongside the adoption of information and communication technologies (ICT) in the public sector. Since the late 1990s, developed countries like Australia, New Zealand, and Singapore have used digital land administration systems. Examples of these systems are *Land Online* and *STARS e-Lodgment*. The study by Chehrehbargh et al. (2024) reviews various challenges and strategic directions for the modernization of land administration systems, including in Indonesia, emphasizing the importance of integrating spatial and textual data.

Although significant progress has been made in automating land administration processes, the conversion of legacy analog data into accurate digital formats remains a critical issue (Bennett et al., 2023). The digitization process requires not only adequate technological infrastructure but also systematic strategies for standardizing spatial and textual datasets so that they can be integrated across platforms and institutions. In the Indonesian context, collaborative mapping activities and juridical data validation have become vital components of these efforts, particularly to ensure consistency between parcel maps and recorded land-rights information (Aditya et al., 2021). Participatory and multi-agency collaboration approaches, including the involvement of local governments and communities, have proven effective in enhancing the accuracy, transparency, and efficiency of national cadastral data integration.

In Indonesia, Kusmiarto et al. (2021) conducted a comprehensive assessment of the country's readiness for digital transformation in land administration services, identifying major challenges related to data completeness, conformity, consistency, and accuracy, as well as the preparedness of ICT infrastructure and supporting legal frameworks. Suhattanto et al. (2021) and Huda & Wandebori (2021) further emphasized that the quality of spatial and textual data is a crucial prerequisite for the migration toward electronic systems, finding that low-quality data (classified as KW 4–6) leads to inefficiencies in validation processes and hampers system integration. Post-implementation studies,

such as that by Widiyantoro et al. (2022), revealed that policy dynamics, variations in human resource capacity, and disparities in local technological infrastructure significantly influence the effectiveness of electronic land certificate implementation. Moreover, recent international literature highlights the emerging paradigm of Intelligent Land Administration, which advocates the application of artificial intelligence along with the integration of 3D and Building Information Modelling (BIM) technologies to enhance interoperability, transparency, and efficiency in spatial planning and land governance (Hosseini et al., 2025; Rebong et al., 2025; Enemark et al., 2021).

Although the existing literature has provided valuable insights, several significant research gaps remain. First, most studies to date have been descriptive and single-location in nature; for instance, the focus of Elora (2024) on the normative issues of media conversion or Suhattanto et al. (2021) on data quality, thus failing to adequately capture the variations and implementation patterns across regions with differing characteristics (e.g., urban versus semi-rural settings or areas with a history of archival loss). Cross-regional comparative studies, which are crucial for identifying both universal challenges and context-specific nuances, remain scarce within Indonesia's body of literature (see also the policy discourse and progress on e-land registration in Diany et al., 2024).

Second, empirical analyses following the launch of the most recent regulatory framework—Ministerial Regulation of ATR/BPN No. 3 of 2023 on the Issuance of Electronic Documents in Land Registration—are still very limited, particularly regarding the nationwide implementation initiated in 2024. Preliminary discussions can be found in Ali et al. (2024) and Wijaya & Hidayati (2024), which address early legal and operational perspectives but have yet to provide in-depth empirical validation.

Third, there has not yet been a comprehensive study that integrates unique local factors such as the historical impacts of archival loss or the high volume of land applications in metropolitan regions into a comparative analysis of electronic land certificate implementation. These contextual dimensions are increasingly relevant to understanding how local institutional capacity and governance structures mediate policy outcomes. The integration of spatial-textual data and inter-agency coordination remains a pressing direction for future inquiry, as emphasized by Chehrehbargh et al. (2024), while the incorporation of 3D spatial planning and related standards is underscored in Guler (2023).

This study aims to address these research gaps through a comparative analysis based on field investigations conducted in four priority locations. The objective is to identify common challenges such as low data quality, limited human resources, and inadequate ICT infrastructure while also highlighting key contextual differences that shape implementation dynamics at the local level. Building upon these comparative insights, the study further seeks to formulate an adaptive and context-sensitive strategy framework to accelerate the digitalization of national land administration by integrating technical, institutional, and governance perspectives. This integrated approach is expected to support a more resilient, sustainable, and inclusive transformation of Indonesia's land-administration system.

B. Research Methods

This study employed a qualitative descriptive approach using a comparative case study method. A qualitative approach was selected to obtain an in-depth understanding of the implementation of electronic land certificate services, to explore local contexts, and to identify problems and holistic strategies from the perspectives of multiple stakeholders across the four study sites. The comparative case study method enabled the analysis and comparison of findings from each location, allowing for the identification of common patterns, significant differences, and contextual factors influencing the success or barriers to implementation. Similar methodological approaches have been widely used in land administration research to assess policy readiness and institutional transformation (see Chehrehbargh et al., 2024, and Bennett et al., 2023).

In this study, the four land offices were purposively selected to capture variation between metropolitan, high-pressure peri-urban, and semi-rural settings, as well as differing levels of archival integrity, ICT readiness, and service workload. The subjects of the study were the implementation processes of the electronic land certificate program at four priority land offices, namely, the Land Office of Sleman Regency, Land Office of Bogor I, Land Office of Bogor II, and Land Office of Buleleng Regency. Comprehensive fieldwork was conducted in each office between 2024 and 2025.

B.1. Rationale for Site Selection

The selection of Sleman, Bogor I, Bogor II, and Buleleng as the four study sites was based on their distinct geographical characteristics, administrative complexities, and varying levels of institutional and technological readiness, which collectively provide a comprehensive basis for comparative analysis. Sleman represents a highly urbanized and rapidly developing metropolitan area within Yogyakarta Province, characterized by dense population, high service demand, and relatively advanced ICT infrastructure. As a regional hub for education and technology, Sleman offers a suitable context for examining the performance of electronic land-certificate implementation in environments where digital literacy and administrative capacity are comparatively strong.

Bogor I and Bogor II were intentionally selected as two separate land offices within the same district to capture intra-regional variation. Bogor Regency experiences one of the highest land-service workloads in Indonesia due to its proximity to Jakarta and its growing peri-urban expansion. Despite being located in the same administrative region, the two offices serve different sub-regional clusters with varying cadastral histories, data quality, and service burdens. Bogor I faces a substantial backlog related to media conversion of historical archives, whereas Bogor II deals primarily with the implications of low-quality cadastral data and mismatches between spatial and textual datasets. The inclusion of both offices allows the study to compare how similar regulatory frameworks and demographic pressures manifest differently depending on institutional arrangements and resource allocation.

Buleleng, in contrast, was selected as a semi-rural site representing non-metropolitan conditions. Unique among the study locations, the Buleleng Land Office experienced a major archival disaster in 1999, when a large portion of its cadastral documents was destroyed by fire, resulting in

long-term data loss and forcing extensive reconstruction efforts. This historical condition directly explains why Buleleng's implementation emphasizes archival recovery, community-based data reconstruction, and quality revalidation. Additionally, relatively lower ICT readiness and digital-literacy levels in Buleleng offer important comparative insights into how semi-rural offices adapt digital transformation policies under significant structural constraints.

These four sites allow for a careful comparison of urban, peri-urban, and semi-rural settings, as well as different levels of legacy data integrity and institutional capacity. This purposive selection aligns with comparative land-administration research frameworks that emphasize contextual diversity as a prerequisite for identifying both shared systemic patterns and location-specific challenges (see Bennett et al., 2023; Chehrehbargh et al., 2024). By grounding the selection in clear institutional and geographic considerations, the study ensures that the comparative findings reflect real variations in Indonesia's digital land-governance landscape rather than sampling coincidence.

The data sources comprised both primary and secondary data. Primary data were obtained through in-depth interviews with key informants (heads of offices, section chiefs, validation officers, ICT staff, notaries/land deed officials (PPAT), and citizen applicants), direct observations of the media conversion and service delivery processes, and the review of internal documents (e.g., daily/monthly performance reports, KKP dashboards, standard operating procedures, and meeting minutes). Secondary data included relevant national regulations (Ministerial Regulation of ATR/BPN No. 3 of 2023 on the Issuance of Electronic Documents in Land Registration and Ministerial Decree of ATR/BPN No. 285/SK-OT.01/III/2024), official reports of the Ministry of ATR/BPN, and relevant scholarly literature from national and international journals (e.g., Kusmiarto et al., 2021; Diany et al., 2024; and Huda & Wandebori, 2021).

Data collection techniques included semi-structured interviews, non-participant observation, and document analysis. Interviews were conducted with both internal stakeholders (officials and staff of land offices) and external stakeholders (notaries/PPATs and citizen representatives) to elicit detailed information regarding implementation procedures, emerging issues, and problem-solving strategies. Observations focused on day-to-day activities within the land offices, particularly during the conversion of land books and survey records, verification of data in the KKP and SITATA applications, and public service delivery at the front desk, allowing the identification of operational constraints and workflow efficiency. The document study analyzed formal reports and quantitative records, such as percentages of validated data, backlogged files, and progress reports on digital conversion achievements.

Data analysis followed an inductive, iterative, and comparative logic, adopting the interactive model developed by Miles, Huberman, and Saldaña (2014). The analytical process consisted of four structured stages—data reduction, data display, pattern identification, and conclusion verification—each of which was guided by explicit inclusion–exclusion criteria to ensure analytical rigor.

First, data reduction involved selecting and condensing raw empirical material from interviews, observations, and internal documents to retain only information directly relevant to the research

objectives. Data excluded from analysis included (a) statements unrelated to electronic land-certificate implementation, (b) background narratives that did not contain operational details, and (c) duplicate information already captured in official documents. Key information retained included descriptions of workflow bottlenecks, ICT system failures, backlog statistics, archive conditions, human resource constraints, and policy implementation inconsistencies. Reduction was performed manually through coding summaries to cluster similar issues across cases (e.g., “validator shortage,” “KKP errors,” “media-conversion delay”).

Second, data summarizing was conducted by synthesizing reduced information into thematic categories. Summaries were prepared for each land office covering (1) data-quality problems; (2) human-resource readiness; (3) ICT infrastructure performance; (4) policy dynamics; and (5) media-conversion effectiveness. Summaries were then cross-checked with field notes and official records to ensure accuracy.

Third, data selection and focusing were implemented through an explicit inclusion–exclusion protocol. Data were included if they (i) described a challenge or strategy directly influencing electronic certificate implementation; (ii) appeared consistently across at least two sources (e.g., interview + observation, document + interview); or (iii) represented unique contextual conditions essential for comparative analysis (e.g., Buleleng’s post-disaster archive reconstruction). Data were excluded if they were anecdotal, unverifiable, or not relevant to the analytical dimensions defined in Table 1. This focusing process ensured that cross-case comparisons addressed substantive rather than incidental differences.

Table 1. Problem–Strategy Matrix Used for Cross-Case Comparative Analysis

Analytical Dimension	Types of Problems Identified	Corresponding Mitigation / Analytical Strategies	Purpose in Comparative Analysis
Data Quality	Incomplete BTEL/SUEL records; mismatched textual–spatial attributes; missing archives; KW 4–6 low-quality parcels	Data-cleaning protocols, cross-verification with physical archives, participatory reconstruction (for missing data), metadata standardization	Identifying variation in legacy-data integrity among offices
Human Resources	Insufficient validators; low ICT literacy; uneven workload; dependency on temporary staff	Competency mapping, targeted ICT training, workload redistribution, stakeholder interviews	Explaining performance differences linked to institutional capacity
ICT Infrastructure	Frequent KKP/SITATA errors; low uptime; insufficient hardware; poor bandwidth	Observation of system failures, infrastructure audits, documentation of downtime incidents	Assessing how technical constraints shape implementation outcomes
Policy/Governance	Changing internal directives; limited budget; unclear	Review of regulatory documents, triangulation with interviews, process-mapping	Understanding how policy alignment and governance structure affect implementation

	delegation lines; procedural ambiguities		
Service Workflow Performance	Backlogs, inconsistent processing speed, delays in PPAT submissions	Measurement of processing time, backlog tracking, time– motion observation	Comparing operational efficiency across the four offices

Source: Adapted from fieldwork protocol (2024–2025).

Fourth, pattern identification was undertaken through iterative cross-site comparisons. Three cross-case pattern types emerged: (a) convergent patterns—common challenges found in all four offices such as low data quality, validator shortages, unstable ICT systems, and budgetary constraints; (b) divergent patterns—site-specific issues including Buleleng’s archival-loss reconstruction, Bogor I’s degraded media-conversion materials, and Sleman’s validator bottleneck; and (c) explanatory patterns-relationships showing how particular constraints affected outcomes, for example: “lower data quality---> slower validation throughput,” “limited ICT capacity---> increased system downtime,” and “policy volatility---> reduced workflow consistency.” These patterns form the basis for the comparative analysis presented in Sections C.1–C.7.

Finally, conclusion drawing and verification were performed by triangulating cross-case patterns with regulatory documents, internal reports, and scholarly literature to ensure the credibility of interpretations. Emergent findings were validated through follow-up confirmations with selected key informants to verify accuracy and minimize interpretive bias.

Validity and reliability were ensured through data triangulation, achieved by comparing information across multiple informants and data types (interviews, observations, and documents) to confirm consistency and credibility of findings (Creswell & Poth, 2018). Method triangulation was implemented across all stages of the research, not only during data collection but also during data processing, analysis, and the formulation of conclusions. At each stage, findings from different sources were cross-verified to ensure accuracy, consistency, and analytical robustness.

C. Result and Discussion

C.1. Implementation Context and Regulatory Framework

The digital transformation of Indonesia’s land administration system is anchored in the national reform agenda set forth by the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN). The issuance of Ministerial Regulation No. 3 of 2023 on the Issuance of Electronic Documents in Land Registration formally redefined cadastral documentation procedures from analog to digital form. This regulation represents the operationalization of earlier reform commitments contained in the ATR/BPN Strategic Plan 2020–2024, which emphasizes efficiency, transparency, and legal certainty. As part of this strategy, the Ministry launched pilot implementations in 104 priority land offices, including Sleman, Bogor I, Bogor II, and Buleleng. The gradual rollout since early 2024 marked the first coordinated attempt to digitize registry and spatial datasets simultaneously, creating an integrated land-information ecosystem that supports interoperability with broader e-government systems (Bennett et al., 2023; Chehrehbargh et al., 2024).

Field implementation across the four offices demonstrates both uniform policy intent and local diversity in execution. Sleman initiated operations on 31 May 2024 with a dual-phase service approach encompassing pre-electronic land book (BTEL) and pre-survey map (SUEL) processing. Bogor I began on 22 July 2024, emphasizing media conversion, while Bogor II—serving a denser metropolitan clientele—focused on improving data-quality assurance. Buleleng, by contrast, commenced earlier in February 2024 with four prioritized electronic services reflecting Bali’s regional development priorities. Table 2 illustrates this staggered timeline of activation. The phased adoption strategy parallels international practice observed in Australia’s Land Online and Singapore’s STARS e-Lodgment platforms, which similarly relied on sequential rollouts to test institutional readiness before scaling nationally (Enemark & Williamson, 2004).

Despite alignment under a single ministerial framework, contextual variation remains substantial. Urban offices such as Sleman and Bogor II manage significantly higher volumes of service requests—averaging more than 400 applications per week—leading to administrative congestion and extended processing times. In contrast, semi-rural Buleleng faces a different structural challenge: historical data fragmentation caused by the 1999 archive fire, which necessitated reconstructing cadastral documents from physical remnants and community records. These contrasts underscore that a “one-size-fits-all” regulatory application cannot capture the diversity of institutional capacity and data maturity among Indonesian land offices. Such differentiation echoes the governance-adaptation arguments of Williamson, I., Enemark, S., Wallace, J., & Rajabifard (2010), who emphasized that cadastral modernization succeeds only when legal frameworks accommodate local socio-technical realities.

From an administrative-governance perspective, the Ministerial Decree No. 285/SK-OT.01/III/2024 formalized each office’s role as a “digital transformation node” responsible for internal re-engineering of workflows, stakeholder coordination, and monitoring of implementation indicators. Field evidence shows that local leadership styles and internal management significantly affect compliance levels with central directives. For instance, Sleman’s Head of Office instituted a weekly coordination meeting involving validation, IT, and service units to monitor progress—an adaptive governance practice rarely seen in Bogor I or II. These local initiatives illustrate how decentralization interacts with national policy design: while the regulatory architecture is centralized, operational interpretation remains context-dependent. Similar dynamics were reported by Roche (2014), who observed that spatial-data-infrastructure policies require meso-level institutional mediation to be effective.

International comparison further clarifies Indonesia’s trajectory within the global e-cadastre movement. The transition from paper-based registries to digital titles has been a defining feature of twenty-first-century land administration reforms. In New Zealand, for example, the Landonline project achieved full digital conveyancing within eight years, yet its success was predicated on comprehensive data cleansing and legislative synchronization. Indonesia’s current framework, though ambitious, still operates under partial data integration and evolving regulatory harmonization across related

ministries (Finance, Home Affairs, and Environment-Forestry). Consequently, while the country aligns conceptually with the Fit-for-Purpose Land Administration model (Enemark et al., 2016), the empirical findings from the four study sites reveal that regulatory implementation must progress in tandem with technical standardization and institutional learning. The analysis presented here establishes the foundational context for the subsequent sections, which explore how these regulatory ambitions translate into actual performance outcomes in data quality, human-resource readiness, technological infrastructure, and adaptive policy behavior.

Table 2. Timeline of E-Certificate Implementation per Land Office (May 2024 – March 2025)

Land Office	Launch Date	Initial Service Focus	Notable Feature
Sleman	31 May 2024	Dual-phase BTEL & SUEL	Two-tier validation workflow
Bogor I	22 Jul 2024	Media conversion	Integration with scanning vendor
Bogor II	Jul 2024	Data quality improvement	Validator training pilot
Buleleng	Feb 2024	Four priority services	Archive reconstruction protocol

(Source: Field Survey 2025)

The comparative evidence from the four pilot land offices (Table 2) demonstrates that Indonesia's digital cadastral reform has advanced beyond policy formalization into an active institutional learning phase. While the overarching framework of Ministerial Regulation No. 3/2023 provides legal uniformity, its translation into operational practice reveals a heterogeneous pattern of readiness and adaptation. This heterogeneity is a critical diagnostic indicator: in digital-governance transitions, the "implementation gap" often arises not from legislative weakness but from asymmetry in organizational capability and local infrastructure (Heeks, 2022). The varying launch dates and service configurations in Sleman, Bogor, and Buleleng illustrate an emergent multi-speed digitalization, where each office must balance compliance with contextual flexibility. Such a differentiated rollout, though administratively complex, has the advantage of functioning as a learning system, enabling feedback-driven adjustments before nationwide expansion.

Moreover, the interplay between national mandates and local interpretation underscores the hybrid nature of Indonesia's e-cadastral governance. The ATR/BPN central office designs standardized procedures, but their enactment depends heavily on the agency of regional managers, local IT teams, and data-validation officers. Evidence from Sleman's weekly coordination and Buleleng's reconstruction committee reflects a pattern that Bennett et al. (2023) describe as "situated innovation"—an adaptive process where local bureaucracies reinterpret central digital reforms according to institutional constraints. This finding resonates with Cordella & Paletti (2019), who emphasize that effective digital transformation in the public sector emerges not from top-down imposition but from negotiated co-production between central and peripheral actors. Thus, what appears as uneven progress across offices may actually signify an ongoing co-evolution of policy and practice within Indonesia's administrative structure.

From a comparative land-administration perspective, Indonesia's case also reflects a broader pattern among developing economies striving to modernize their cadastral systems. The staged pilot

implementation mirrors the strategies adopted in Thailand’s eLand initiative and Vietnam’s VLIS program, both of which relied on selected regional prototypes to calibrate national standards before full deployment (Vu et al., 2025). However, Indonesia’s institutional complexity, comprising over 500 district-level offices with diverse data legacies, amplifies the scale of coordination required. The four study sites collectively demonstrate the tension between policy standardization and local institutional diversity. Sleman’s metropolitan density, Bogor’s archival backlog, and Buleleng’s post-disaster reconstruction each represent distinctive operational ecologies that challenge uniform implementation. Recognizing and managing these contextual differences is essential for ensuring that the transformation does not merely digitize inefficiencies but rather restructures workflows toward sustainable and verifiable cadastral governance.

C.2. Data Quality and Cadastral-Information Integrity

The empirical findings across the four pilot offices indicate that data quality remains the single most decisive variable in determining the effectiveness of the electronic land-certificate rollout. Despite the presence of sophisticated digital platforms such as the Komputerisasi Kegiatan Pertanahan (KKP) and Sistem Validasi Tanah Kita (SITATA), legacy issues embedded in historical cadastral data continue to constrain performance. In Sleman, only about 40 percent of pre-digital land books (Pra BTEL) and survey documents (Pra SUEL) had reached validated status by September 2024, producing a queue of unprocessed applications. In Bogor I, low-quality archival materials and damaged survey sheets caused recurrent mismatches between scanned attributes and spatial geometry. Bogor II showed a concentration of problematic parcels in categories KW 4–6, roughly 3.3 percent of the total dataset, while Buleleng confronted the exceptional task of reconstructing data lost in the 1999 archive fire. These heterogeneous deficiencies confirm that digitalization cannot substitute for prior data curation, a conclusion consistent with Chehrehbargh et al. (2024) and Bennett et al. (2023), who stress that cadastral modernization begins with data governance rather than software deployment.

Table 3. Land-Parcel Data Quality by Category (KW)

Office	KW 1–3 (High Quality)	KW 4 (Medium)	KW 5 (Low)	KW 6 (Very Low / Missing)	Notes on Data Issues
Sleman	≈ 60 %	25 %	10 %	5 %	Incomplete BTEL/SUEL records; format inconsistency
Bogor I	52 %	28 %	15 %	5 %	Unreadable archives; geometry–text mismatch
Bogor II	64 %	20 %	12 %	4 %	Duplicate NIB; overlapping polygons
Buleleng	48 %	22 %	20 %	10 %	Post-fire data reconstruction from scratch

(Source: Field Survey 2025)

These empirical observations (Table 3) confirm the broader theoretical consensus that data readiness is the foundation for cadastral modernization. Chehrehbargh et al. (2024) identify “legacy

heterogeneity” as the principal bottleneck for digital transformation in Southeast Asia, where analog cadastral sources vary in accuracy, projection, and legal reliability. Similarly, Devillers et al. (2007) demonstrated that overlapping parcels and misaligned coordinate systems produce cascading errors once migrated into integrated GIS environments. The Indonesian findings mirror these patterns: the KKP and SITATA applications often awarded 100 percent validation scores to datasets that were syntactically correct yet substantively inconsistent. This “false validation effect” introduces governance risk to digital completeness without factual accuracy, illustrating what Devillers, Jeansoulin, et al. (2007) term “form-without-function” in land-information infrastructures.

Comparative inspection among the four offices also highlights that data quality problems are not purely technical but historically institutional. Sleman’s inconsistent spatial polygons trace back to early fiscal cadastres from the 1970s that used local datum references; Bogor’s textual anomalies stem from decentralized manual registries maintained by sub-district units before integration into the national database. In Buleleng, the absence of original survey sheets forced reliance on reconstructed boundaries through participatory mapping, raising epistemic questions regarding legal certainty and evidence. Such conditions illustrate the enduring “path dependency” of cadastral modernization, where historical administrative routines shape present digital capabilities, a dynamic similarly observed by Bennett et al. (2023) in their longitudinal study of Indonesian digital-land initiatives. Hence, improving data quality requires not merely technical remediation but institutional memory management and documentation recovery.

From an analytical standpoint, these discrepancies stem from three structural roots: (1) the analog-to-digital migration of non-standardized datasets; (2) the inconsistent application of quality-assurance protocols; and (3) the limited technical literacy among data-entry personnel. Similar causal chains have been reported in New Zealand’s Landonline migration and Kenya’s ArdhiSasa initiative, where duplicated or incomplete spatial features undermined the reliability of digital land records (Toitu Te Whenua Land Information New Zealand, n.d.). In the Indonesian context, the SITATA system’s algorithmic validation sometimes produced misleadingly perfect scores of 100 percent formal compliance without substantive accuracy. This phenomenon exemplifies what Setiawan (2022) calls “formative validity bias,” wherein automated verification mechanisms check syntax but not semantic correctness. Consequently, manual cross-checking between digital and physical archives remains indispensable to guarantee legal authenticity.

The cross-site comparison reveals that data quality is not merely a technical attribute but a socio-institutional construct. Offices that fostered intersectional coordination (e.g., Sleman’s data-validation committee) achieved faster progress in cleaning inconsistencies than those relying solely on central directives. This finding aligns with Williamson (2007) and Ngo (2016), who argue that spatial-data infrastructures evolve through institutional negotiation rather than mere technological procurement. In Bogor II, where validators lacked continuous communication with surveyors, duplicate NIB numbers proliferated. Conversely, Buleleng’s locally initiated “data-reconstruction task force,” though born out of crisis, demonstrates how collective institutional memory and community participation can restore

archival integrity, an approach reminiscent of participatory reconstruction in Nepal’s post-earthquake cadastral recovery (Government of Nepal: National Planning Commission, 2015).

From a governance perspective, the persistence of low-quality cadastral data poses a systemic risk to the trustworthiness of electronic certificates. Insecure or inconsistent underlying records may lead to conflicting rights, administrative disputes, or judicial challenges. Enemark et al. (2021) and Hosseini et al. (2025) highlight that the credibility of an intelligent land-administration system depends on end-to-end data lineage—tracking each modification from source survey to final certificate. The Indonesian field results echo this principle: offices with better metadata documentation (e.g., Sleman’s daily logbooks) reported fewer disputes. Strengthening these audit trails and adopting blockchain-based notarization could provide additional transparency and prevent retroactive tampering.

In sum, the comparative evidence indicates that Indonesia’s cadastral digitalization will succeed only if data-quality enhancement precedes full system automation. The lesson emerging from Sleman, Bogor, and Buleleng parallels that of other jurisdictions: digital transformation amplifies existing data weaknesses rather than masking them. Therefore, future policy design should institutionalize periodic data audits, allocate targeted funding for archival restoration, and link staff performance indicators to data-integrity metrics. These measures would align the program with global Fit-for-Purpose Land Administration standards (Enemark et al., 2016) and ensure that Indonesia’s electronic-certificate ecosystem evolves into a truly reliable, legally robust, and interoperable digital cadastre.

C.3. Human Resources and Institutional Capacity

The comparative findings reveal that human resource capacity is a critical determinant of digital land-service performance across all four pilot offices. While Indonesia’s ATR/BPN has formally adopted national competency standards, the field implementation of electronic land certification demonstrates substantial disparities in staff readiness, workload balance, and technical literacy. Sleman reported shortages of trained personnel to manage both the Pra-BTEL and Pra-SUEL phases, resulting in prolonged queues during the verification stage. In Bogor I relied on temporary staff recruited externally, often without formal ICT training or allocated budgets. Bogor II struggled to align validator capacity with daily application volumes, especially in Pejabat Pembuat Akta Tanah (PPAT) channels, causing recurrent processing delays. In Buleleng, insufficient validation officers and uneven comprehension of specific services, such as right-transfer updates, constrained efficiency. This asymmetry reflects what Heeks (2006) terms the capacity divide, a structural mismatch between technological ambition and human capability within digital-government projects.

Table 4. Land-Parcel Data Quality by Category (KW)

Office	Staffing Capacity	Training & Digital Literacy	Workload Distribution	Institutional Notes
Sleman	Adequate core staff but insufficient validators	Moderate; limited advanced ICT training	High during Phase II (mid-2024)	Frequent role overlap, reliance on ad hoc teams

Bogor I	Temporary recruits without budget allocation	Low; basic administrative skills only	Uneven; backlog in document scanning	Lack of formal ICT mentorship
Bogor II	Validation team below target ratio	Moderate; self-learning through trial	Overload in PPAT channel	Weak communication across divisions
Buleleng	Limited validation staff	Low–moderate; post-fire data recovery training ongoing	Manageable after restructuring	Strong leadership coordination, community-based taskforce

(Source: Field Survey 2025)

The results (Table 4) indicate that technical capacity-building has not kept pace with policy and infrastructural reform. Digital platforms such as KKP and SITATA require not only system familiarity but also conceptual understanding of digital workflows and data semantics. However, current training schemes often emphasize procedural compliance rather than analytical competence. Moynihan (2025) observes that such proceduralism produces a surface-level digitalization, in which officials learn to operate software but not to interpret its outputs. Field interviews revealed that several validation officers perceived data anomalies as “system errors” rather than potential governance issues. This limited digital reflexivity constrains institutional learning and perpetuates dependency on central IT units. Comparable findings have been reported in public-administration reforms across Southeast Asia, where digital transformation advanced faster than staff upskilling initiatives (Moynihan, 2025).

Another persistent challenge involves institutional fragmentation between administrative and technical divisions. In Bogor II, weak coordination between cadastral surveyors and validators caused duplication of parcel IDs (NIBs) and delays in updating the *Komputerisasi Kegiatan Pertanahan* (KKP) database. Similar coordination failures were observed in other e-government projects in developing countries, where siloed bureaucratic structures reduced reform efficacy (Moynihan, 2025). Conversely, Buleleng’s recovery-oriented leadership adopted an adaptive, cross-functional approach by integrating administrative, IT, and field units into a single “task force.” This organizational integration mirrors the concept of adaptive bureaucracy proposed by Sharp (2021), in which flexible team structures enhance institutional responsiveness during digital transitions.

The broader implication is that human and institutional readiness jointly determine system resilience. Offices with stronger leadership and internal communication, such as Buleleng, were better able to navigate technical failures and policy changes. This finding is consistent with Bennett et al. (2023), who emphasize that digital transformation in land administration requires not only technology adoption but also organizational learning mechanisms and role redefinition. Indonesia’s experience underscores the necessity of institutional intelligence, the ability to sense, learn, and adjust organizational behavior through feedback loops. Without it, digital systems risk becoming brittle bureaucracies that automate inefficiency rather than eliminate it.

In summary, human resource and institutional capacity issues remain central to Indonesia’s digital cadastral reform. While the pilot offices exhibit commendable commitment and innovation, sustainable transformation will depend on long-term investments in professional development,

knowledge transfer, and interdepartmental governance. Establishing continuous-learning programs and integrating competency metrics into performance appraisals would align with global standards on human-centric e-government reform (European Commission, 2023) and ensure that Indonesia’s electronic land-certification initiative evolves from procedural compliance toward institutional maturity.

C.4. ICT Infrastructure and Technical Constraints

The empirical findings reveal that limitations in ICT infrastructure remain a structural bottleneck in the implementation of electronic land certificates across the four pilot offices. While the Komputerisasi Kegiatan Pertanahan (KKP) and Sistem Validasi Tanah Kita (SITATA) platforms represent substantial technological progress, their effectiveness is undermined by inconsistent network reliability, inadequate hardware, and insufficient local maintenance capacity. In Sleman, intermittent network slowdowns and limited workstation availability constrained verification efficiency. In Bogor I frequently experienced “403 Access Denied” errors on KKP-Web due to server overload and unstable synchronization with national databases. Bogor II reported frequent SITATA validation interruptions that forced repeated log-ins, while Buleleng—although equipped with new computers—struggled with bandwidth fluctuations and lack of IT maintenance budgets. Such recurrent disruptions illustrate the fragile digital backbone typical of early-stage e-government infrastructures in developing contexts (Yimbo, 2011).

Table 5. ICT Infrastructure Constraints Across Pilot Land Offices

Office	System Availability	Common Errors / Failures	Network & Hardware Condition	Institutional Support
Sleman	Moderate (70–80 % uptime)	Slow login; KKP time-outs	Limited workstations; aging routers	Occasional support from central IT
Bogor I	Low–moderate (60–70 %)	“403 Access Denied” KKP errors	High user load; server latency	No dedicated budget for maintenance
Bogor II	Moderate (75 %)	SITATA crashes during validation	Network fluctuations during peak hours	Minimal coordination with Pusdatin
Buleleng	Moderate (78 %)	Slow HT Online synchronization	New PCs but unreliable bandwidth	Limited local IT technicians

(Source: Field Survey 2025)

From a technical perspective, the findings (Table 5) highlight the gap between national-level system design and local-level infrastructure capacity. The centralized architecture of KKP and SITATA depends heavily on stable broadband and high-throughput servers, yet many district offices operate on low-bandwidth connections or shared networks. Similar patterns have been documented in the Philippines’ LAMS (Land Administration Management System), where performance degradation occurred when central databases lacked edge-server support (The Land Management Bureau of the Department of Environment and Natural Resources, 2022). In Indonesia’s case, the absence of local caching or fail-safe mechanisms leads to downtime that halts entire workflows. This structural fragility

underscores the argument by Bennett et al. (2023) that “digital transformation without infrastructural resilience merely shifts risk from paper to pixels.”

The operational inefficiencies associated with unstable ICT environments also have behavioral consequences. Interviews revealed that repeated system crashes and login failures eroded staff confidence and fostered passive resistance to digital procedures. This aligns with Heeks (2022), who describes the design–reality gap in which end-users revert to manual workarounds when digital tools become unreliable. In Bogor I, several officers admitted to keeping parallel paper ledgers “for backup,” inadvertently undermining the single-source-of-truth principle that electronic certification aims to establish. Such behavioral adaptation is not mere inertia but a rational response to infrastructural unreliability—highlighting the socio-technical interplay within digital transformation.

Comparatively, Buleleng’s adaptive response demonstrates that infrastructural constraints can stimulate local innovation. Facing unstable internet connections, the office configured a local offline validation buffer to temporarily store transactions before synchronization. Though rudimentary, this workaround reduced downtime and improved data throughput, echoing the resilience-by-design principle discussed by Maia et al. (2025). The contrast between Buleleng’s pragmatism and Bogor’s dependency on central IT support highlights the importance of local autonomy in maintaining operational continuity. Decentralized technical governance, when combined with standard security protocols, can enhance system reliability even in bandwidth-constrained environments.

Beyond hardware and connectivity, cybersecurity and data-protection readiness remain emergent concerns. While none of the pilot offices reported direct security breaches, limited awareness of data-governance protocols poses latent risks. Hosseini et al. (2025) emphasize that secure digital land administration requires encryption standards and audit trails embedded across system layers. The absence of automated backup systems or redundant data centers could compromise business continuity in the event of system failure or cyberattack. Institutional coordination between ATR/BPN and the Ministry of Communication and Information is therefore critical to align technical safeguards with national cybersecurity frameworks (OECD, 2023).

In summary, Indonesia’s experience demonstrates that ICT infrastructure forms both the backbone and the bottleneck of cadastral digital transformation. Sustainable improvement requires investment not only in hardware procurement but also in scalable cloud architecture, local caching, and user-centric interface design. Routine stress-testing, transparent incident reporting, and integration of performance indicators into the national Pusdatin monitoring dashboard would bring the system closer to international benchmarks for resilient land-information infrastructures (Moghadas et al., 2022). By addressing these technical and organizational constraints, Indonesia can ensure that the promise of e-certification is matched by the reliability of its digital backbone.

C.5. Policy Dynamics and Budgetary Support

Empirical results from the four pilot land offices demonstrate that policy fluidity and funding asymmetry are decisive institutional variables shaping the pace of Indonesia’s electronic land-certificate implementation (Table 6). Sleman faced shifting policy directives—particularly changes in

service flow and validation sequencing—without corresponding budget adjustments, resulting in temporary file congestion during mid-2024. In Bogor I experienced difficulties in procuring new hardware and remunerating its temporary digitization team because no dedicated funding line existed for local ICT reinforcement. Buleleng, despite early enthusiasm, struggled to sustain community outreach programs due to limited operational funds. These conditions illustrate the broader phenomenon of policy–budget misalignment, a recurrent obstacle in digital transformation projects within decentralized bureaucracies (Nawaludin, 2023).

Table 6. Policy and Budgetary Dynamics Across Pilot Land Offices

Office	Policy Stability	Budget Availability	Governance Adaptability	Key Impacts
Sleman	Moderate; frequent procedural revisions	Partial funding for IT support	Responsive leadership, yet limited fiscal flexibility	Backlog of 263 cases (Mar 2025) during transition
Bogor I	Low; unclear delegation lines	No separate digitization budget	Reliance on improvisation	Delayed media-conversion progress
Bogor II	Moderate; policy guidance consistent but rigid	Limited operating funds for validators	Low discretion at local level	Validation delays due to resource shortages
Buleleng	High; consistent local coordination	Insufficient outreach & maintenance funds	Strong adaptive coordination	Public skepticism toward e-certificates

(Source: Field Survey 2025)

The evidence underscores that policy continuity is as vital as technological innovation. Frequent revisions of procedural guidelines—often issued through internal memoranda—created interpretive ambiguity at local levels. Officers reported spending considerable time reconciling conflicting instructions between ATR/BPN’s central and regional units. This institutional churn aligns with Chehrehbargh et al. (2024), who highlight policy volatility as a primary barrier to cadastral modernization in Indonesia. The resulting administrative uncertainty not only hampers decision-making but also discourages long-term investment in capacity building and infrastructure. Stable regulatory sequencing is therefore crucial for sustaining reform momentum.

Budgetary fragmentation further constrains execution. The absence of a dedicated national financing framework for e-certification forces local offices to reallocate funds from conventional land services, diluting operational focus. Comparative studies on e-government financing show that underfunded transformation projects often generate “islands of digitalization,” localized successes unsupported by systemic sustainability (Umasugi, 2025). In Sleman and Bogor I, capital expenditure was sufficient for hardware procurement but inadequate for system maintenance or continuous training. This imbalance mirrors fiscal decentralization challenges noted across Southeast Asia, where vertical budget rigidity undermines horizontal innovation capacity (ASEAN +3 Macroeconomic Research Office, 2024).

The contrast between Buleleng and Bogor II demonstrates how governance adaptability mediates financial scarcity. Buleleng’s management adopted a participatory budgeting approach—

redirecting minor allocations from community-mapping programs to network maintenance, yielding better service continuity. This flexibility exemplifies adaptive fiscal governance (Klumpp, 2025), wherein local managers reprioritize limited resources to preserve reform coherence. Bogor II, conversely, maintained rigid adherence to standard expenditure codes, preventing swift reallocation even when funds remained underutilized. Thus, institutional autonomy becomes not a deviation but a prerequisite for sustainable reform.

From a policy-integration perspective, the Indonesian case illustrates the importance of synchronizing digital-governance reforms with broader fiscal-policy frameworks. Bennett et al. (2023) emphasize that the success of land-administration modernization depends on embedding digital transformation within stable policy trajectories supported by predictable funding. The current ad hoc budgeting cycle discourages multiyear planning, complicating the establishment of procurement standards and performance benchmarks. Introducing medium-term expenditure frameworks (MTEFs) and performance-based budgeting for digital services could bridge this institutional gap, aligning financial planning with reform objectives (OECD, 2023).

In conclusion, policy stability and budgetary sufficiency emerge as dual pillars of sustainable cadastral digitalization. The pilot offices demonstrate commendable commitment under fiscal constraints, yet enduring progress will require institutional reforms that link regulatory clarity, fiscal predictability, and performance accountability. Establishing an E-Certification Reform Fund, integrating cost-recovery models, and aligning local and national key performance indicators could transform current piecemeal efforts into a coherent financing ecosystem. Such measures would elevate Indonesia's program to meet international standards for accountable and sustainable land-administration reform (Jahani et al., 2024).

C.6. Effectiveness of Media Conversion Implementation

Media conversion—the process of digitizing physical cadastral records into authenticated electronic form—constitutes the core operational pillar of Indonesia's electronic land-certificate initiative. As the primary mechanism through which analog land books (BT), measurement records (SU), and juridical documents are transformed into the digital registry environment, the effectiveness of media conversion directly determines the reliability and legal credibility of the resulting electronic certificates. Across the four pilot land offices studied, significant variation emerged in scanning progress, validation consistency, and processing throughput, illustrating that media conversion is highly sensitive to archival conditions, staff capacity, and infrastructural readiness. These empirical patterns are consistent with international experiences, which emphasize that digitization effectiveness is path-dependent, determined by both the historical condition of archives and the institutional capacities managing the conversion process (Bennett et al., 2023; Chehrehbargh et al., 2024).

The findings indicate that Sleman achieved moderate conversion effectiveness, constrained primarily by validator shortages and high service volumes. While approximately 68% of BTEL/SUEL archives were successfully scanned by March 2025, only 54% reached validated status, resulting in a cumulative backlog that peaked during the second implementation phase. Bogor I, by contrast,

demonstrated notably lower effectiveness despite higher scanning rates. The degradation of physical documents—blurred ink, torn pages, and incomplete sheets—combined with inconsistencies between textual descriptions and parcel geometries created recurrent obstacles during digitization, requiring repeated rescanning and manual verification. This pattern parallels earlier cautions in cadastral literature that digital transformation does not automatically improve data quality; instead, it amplifies legacy inconsistencies, especially when the analog substrate is weak (Devillers et al., 2007).

In Bogor II, the conversion process benefited from relatively better-preserved archives and stronger inter-divisional coordination. Approximately 63% validation completion—higher than Sleman and Bogor I—was achieved through systematic quality-assurance cycles and structured communication between surveyors, validators, and IT personnel. However, even in this comparatively stronger context, the prevalence of duplicate NIB, overlapping polygons, and inconsistencies between spatial and textual sources required continuous corrective iterations. Such issues highlight the inherent complexity of digital cadastral integration and reinforce what Roche & Rajabifard (2021) describe as the requirement for semantic alignment between multi-source datasets for successful modernization of land-information infrastructures.

The most distinctive case is Buleleng, where effectiveness must be interpreted through the lens of extreme archival disruption. Following the 1999 fire that destroyed a substantial portion of the office's cadastral archives, media conversion required reconstructing documents from community testimonies, field re-surveys, and participatory mapping. Although progress metrics appear lower (42% validation), these figures obscure the methodological depth and reliability of the reconstructed datasets. Buleleng’s approach reflects international post-disaster cadastral reconstruction frameworks, such as those used in Nepal after the 2015 earthquake (Dhakal et al., 2019), demonstrating that slower numerical output can correspond to higher substantive rigor in contexts requiring reconstruction instead of simple digitization.

A comparative synthesis of media-conversion performance across the four offices is presented in Table 7, highlighting divergence in archival conditions, scanning rates, and validation completeness. These variations demonstrate that conversion effectiveness is not solely dependent on technology but is shaped by institutional coordination, historical archive conditions, and the robustness of quality-assessment procedures. More critically, the findings underscore a structural risk: without rigorous and context-sensitive media conversion, the transition to electronic certificates risks transferring analog deficiencies directly into the digital system, thereby undermining legal certainty and increasing the likelihood of administrative disputes (Enemark et al., 2021).

Table 7. Comparative Effectiveness of Media Conversion Implementation

Office	Archive Condition (Pre-Conversion)	Media Conversion Progress (as of Mar 2025)	Common Conversion Issues	Effectiveness Assessment
Sleman	Generally intact archives;	68% scanned; 54% validated	Blurred scans; inconsistent	Moderate – bottlenecks due to validator capacity

	BTEL/SUEL incomplete		pagination; validator shortage	
Bogor I	Many damaged/aging physical archives; high backlog	72% scanned; 48% validated	Geometry–text mismatches; unreadable archives; vendor delays	Low–Moderate: legacy archive condition is main barrier
Bogor II	Better archive condition; high-volume service area	70% scanned; 63% validated	Duplicate NIB; overlapping parcels; spatial–text inconsistencies	Moderate–High: strong QA workflow aids progress
Buleleng	Severe archive loss due to 1999 fire	58% reconstructed; 42% validated	Participatory reconstruction; missing BT/SU; manual verification	Context-dependent: methodologically rigorous reconstruction

Source: Field Survey 2024–2025

Overall, the comparative results demonstrate that effective media conversion requires more than adequate technology; it demands institutional coordination, clear operational protocols, reliable archives, and a quality-assurance framework aligned with international standards. The heterogeneous conditions observed across Sleman, Bogor I, Bogor II, and Buleleng reveal that digital transformation amplifies existing disparities in archival integrity and institutional readiness. These insights emphasize the importance of tailoring policy and resource allocation to the specific baseline conditions of each land office, rather than applying uniform performance targets. Strengthening audit trails, introducing periodic data-quality reviews, and enabling context-differentiated workflows will be essential to ensure that Indonesia’s electronic land-certificate ecosystem evolves toward a legally reliable and technically resilient cadastral infrastructure.

C.7. Adaptive Strategies and Policy Implications

The comparative analysis across Sleman, Bogor I, Bogor II, and Buleleng reveals that adaptive strategies are essential for overcoming the diverse institutional, infrastructural, and archival challenges encountered during the implementation of the electronic land-certificate system. Although national regulations provide a unified legal and procedural framework, each land office demonstrated varied levels of operational flexibility in adjusting workflows, reallocating resources, and modifying internal coordination mechanisms. These adaptive behaviors align with the broader literature on digital public-sector transformation, which emphasizes that successful reform requires “situated innovation,” the capacity of local institutions to interpret and adjust centralized digital policies in response to their unique socio-technical environments (Bennett et al., 2023; Cordella & Paletti, 2019).

Across the four case sites, three categories of adaptive mechanisms were identifiable: (1) technical adaptations, such as configuring offline buffers or alternative validation sequences; (2) institutional adaptations, including cross-unit task forces, redefined validator roles, and enhanced workflow monitoring; and (3) community-engagement adaptations, notably in Buleleng, where participatory methods compensated for archival losses. These strategies were not merely reactive but

reflected a form of organizational learning in which staff and leaders incrementally refined practices based on real-time performance challenges. This pattern reflects global findings in e-cadastre modernization—particularly in Vietnam’s VLIS reform and Thailand’s e-Land initiative, where incremental internal adjustments proved more effective than rigid adherence to national directives (Vu et al., 2025).

A crucial finding is that adaptive strategies were most effective in offices where leadership encouraged collaborative problem-solving and transparent communication. Sleman’s weekly coordination meetings, Bogor II’s structured validator–surveyor interface, and Buleleng’s reconstruction committee illustrate how internal governance can accelerate responsiveness to emerging operational constraints. Conversely, Bogor I—where adaptive mechanisms were limited or informal—showed slower progress and higher procedural bottlenecks. These differences underscore the importance of leadership style, internal communication pathways, and organizational culture as determinants of reform effectiveness—elements emphasized in the institutional-theory work of Sharp (2021) and the public-sector digital readiness framework of Moynihan (2025).

In terms of policy implications, the findings indicate that Indonesia’s national transition toward a fully digital land-administration system requires a more flexible and regionally differentiated governance model. Uniform Key Performance Indicators (KPIs) and centrally standardized workflows may unintentionally disadvantage offices facing structural constraints, such as degraded archives or limited human-resource capacity. Instead, a multi-speed implementation framework that aligns targets with local baseline conditions could improve both fairness and feasibility. Furthermore, embedding adaptive governance mechanisms—such as rapid-feedback loops, continuous technical mentoring, and local discretion over operational adjustments—would enhance institutional resilience and reduce implementation gaps. These recommendations are in line with international Fit-for-Purpose Land Administration (FFPLA) principles, which advocate contextualization and phased development as prerequisites for sustainable modernization (Enemark et al., 2021).

The synthesis of findings is summarized in Table 8, which consolidates the adaptive strategies identified at each pilot office and outlines corresponding policy implications for national-scale reform. These insights suggest that Indonesia’s electronic land-certificate program will benefit from a governance approach that balances standardization with contextual flexibility, strengthens institutional learning capacities, and ensures alignment between policy ambition, technical infrastructure, and resource availability. As Indonesia progresses toward fully digital cadastral integration, embedding adaptive strategies within national guidelines could serve as a foundation for more inclusive, efficient, and resilient land-administration reform.

Table 8. Adaptive Strategies and Policy Implications

Office	Key Adaptive Strategies	Underlying Constraints Addressed	Policy Implications for National Rollout
Sleman	Weekly coordination meetings; validator redistribution; phased workflow refinement	High workload; validator shortages; inconsistent BTEL/SUEL	Introduce regional performance monitoring and flexible workflow adjustments
Bogor I	Ad-hoc scanning re-runs; manual synchronization notes	Degraded archives; low ICT capacity; vendor delays	Need targeted funding for archival restoration and dedicated ICT teams
Bogor II	Structured validator–surveyor communication; internal QA cycles	Duplicate NIB; spatial–text inconsistencies	Institutionalize cross-unit QA protocols and integrated validation teams
Buleleng	Participatory reconstruction; community triangulation; local taskforce	Post-disaster archival loss; missing BT/SU	Develop national standard for disaster-based cadastral reconstruction
Cross-site	Informal problem escalation; adaptive workaround of system errors	Network instability; algorithmic false validation	Expand Pusdatin technical support; implement diagnostic dashboards

Source: Field Survey 2024–2025

Overall, the adaptive strategies observed across the four land offices demonstrate that institutional agility is a prerequisite for overcoming the heterogeneity of Indonesia’s land-administration landscape. Scaling these practices through structured policy mechanisms such as the establishment of regional digital-transformation hubs, the integration of adaptive indicators into national KPIs, and the creation of standardized reconstruction procedures could significantly strengthen the long-term sustainability of the electronic land-certificate program.

D. Conclusion

This study examined the implementation of Indonesia’s electronic land-certification program across four priority land offices—Sleman, Bogor I, Bogor II, and Buleleng—using a comparative qualitative approach. The findings reveal four dominant cross-cutting challenges: (1) low-quality legacy cadastral data, (2) limited human resource and institutional capacity, (3) uneven ICT infrastructure performance, and (4) policy fluidity coupled with insufficient budget allocation. Although governed under a uniform regulatory framework, each office demonstrated distinct operational trajectories shaped by their historical, administrative, and socio-technical contexts. Sleman faced significant bottlenecks due to high service volume; Bogor I encountered persistent media-conversion constraints; Bogor II struggled with validator shortages and data-quality discrepancies; while Buleleng focused on reconstructing archival data lost due to the 1999 fire.

Despite these contextual differences, the analysis shows that implementation success is strongly correlated with internal leadership, inter-unit coordination, and adaptive strategies at the local level. Offices that institutionalized coordination mechanisms and collaborative workflows progressed more effectively than those relying solely on procedural directives. These findings underscore that digital

transformation in land administration requires not only technological upgrades but also organizational learning and adaptive governance.

Several limitations of this study must be acknowledged to contextualize its findings. First, the research is based on fieldwork in four selected pilot offices and does not cover the full diversity of Indonesia's more than 500 land offices; thus, the patterns identified may not fully represent conditions in remote or newly established regions. Second, the qualitative data rely heavily on interviews and observations conducted during the early phase of program implementation (2024–2025), which may not capture long-term behavioral or institutional changes. Third, access to certain internal performance dashboards and historical archives was restricted, limiting the depth of validation for some technical indicators. Fourth, the study did not incorporate quantitative system log analytics (e.g., KKP/SITATA error logs, latency metrics), which could provide additional precision in evaluating infrastructure constraints. These limitations provide opportunities for future research to broaden site coverage, extend longitudinal monitoring, and integrate mixed-method approaches for a more comprehensive assessment.

Recommendations

Based on the comparative findings, several concrete policy implications emerge:

a. Establish a National Data-Cleansing and Archival Restoration Program.

A centrally funded, multi-year initiative is required to systematically improve legacy cadastral data—prioritizing regions with low KW categories and historical data losses. This should include standard operating procedures, metadata protocols, and performance benchmarks.

b. Institutionalize Continuous Professional Development (CPD) for Land-Office Staff.

Digital transformation demands technical and analytical competence. ATR/BPN should mandate structured training modules (digital literacy, data governance, validation logic) integrated into annual staff appraisal cycles.

c. Strengthen ICT Infrastructure Through Local Caching and Edge-Computing Architecture.

To reduce downtime and bandwidth dependency, land offices should be equipped with local buffers or offline validation layers aligned with national security protocols.

d. Implement Stable, Sequenced Regulatory Guidelines.

Frequent procedural changes create operational uncertainty. ATR/BPN should adopt a phased guideline-issuance mechanism with transition periods, supported by visual workflow maps and helpdesk escalation protocols.

e. Adopt Performance-Based Budgeting for Digital Services.

E-certification requires dedicated funding beyond routine operational budgets. Introducing performance-based and multi-year expenditure frameworks would ensure resource predictability and accountability.

f. Strengthen Local Governance Autonomy in Problem-Solving and Innovation.

Offices like Buleleng demonstrate that adaptive, context-sensitive solutions (e.g., local reconstruction taskforces) enhance program sustainability. ATR/BPN should formally encourage such structured flexibility.

g. Develop an Integrated Monitoring and Evaluation (M&E) Dashboard.

Combining real-time system logs, human-resource indicators, and data-quality metrics would allow the central office to detect early failures and perform targeted interventions.

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