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DIGITALISATION OF LOCAL GOVERNMENT ASSET MANAGEMENT: EVALUATING FIVE TECHNOLOGICAL INNOVATIONS AT THE RIAU PROVINCIAL DEPARTMENT OF ENVIRONMENT AND FORESTRY

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Abstract. *Persistent deficiencies in public sector asset governance represent a critical challenge for regional government accountability in Indonesia, as evidenced by recurring Qualified Opinions (WDP) issued by BPK RI. This study evaluates the effectiveness of five simultaneous digital asset management innovations implemented by the Riau Province Department of Environment and Forestry (DLHK) in 2024: drone mapping with geotagging, IoT-based patrol vehicle tracking, blockchain land archive digitization, inter-UPT asset sharing via SiLADU, and RFID smart labeling for laboratory equipment. Employing a qualitative descriptive-evaluative design with an embedded case study strategy, data were collected through documentary analysis, in-depth interviews with seven key informants, and non-participant observation, analyzed using Miles et al.'s (2014) interactive model. Findings reveal that pre-innovation asset management maturity stood at 1.8 (Aware level, IAM 2015), with KIB A accuracy of 61%, 1,200-hectare cadastral discrepancy, 30% equipment utilization, and 45% vehicle downtime. Post-innovation, maturity advanced to 3.1 (Competent), KIB A accuracy reached 98.9%, equipment utilization rose to 78%, and audit opinion improved from WDP to WTP — generating positive ROI within two years from a Rp1.2 billion investment. Results confirm that integrated multi-technology deployment, underpinned by New Public Governance collaboration and ISO 55000 frameworks, constitutes a replicable institutional model for transforming public asset governance accountability..*
Keywords: *Public Asset Management, Digital Innovation, Asset Management Maturity, Audit Opinion, New Public Governance.*

Abstrak. *Kelemahan tata kelola aset sektor publik merupakan tantangan kritis bagi akuntabilitas pemerintah daerah di Indonesia, sebagaimana tercermin dari opini Wajar Dengan Pengecualian (WDP) yang berulang dari BPK RI. Penelitian ini mengevaluasi efektivitas lima inovasi digital manajemen aset yang diterapkan secara simultan oleh Dinas Lingkungan Hidup dan Kehutanan (DLHK) Provinsi Riau pada 2024: drone mapping dengan geotagging, pelacakan kendaraan patroli berbasis IoT, digitalisasi arsip tanah berbasis blockchain, asset sharing antar-UPT melalui SiLADU, dan smart label RFID untuk peralatan laboratorium. Menggunakan desain deskriptif-evaluatif kualitatif dengan strategi embedded case study, data dikumpulkan melalui analisis dokumen, wawancara mendalam dengan tujuh informan kunci, dan observasi non-partisipan, dianalisis menggunakan model interaktif Miles et al. (2014). Temuan menunjukkan bahwa maturity manajemen aset pra-inovasi berada pada level 1,8 (Aware, IAM 2015), dengan akurasi KIB A 61%, selisih luas 1.200 hektar, utilisasi alat berat 30%, dan downtime kendaraan 45%. Pasca-inovasi, maturity meningkat menjadi 3,1 (Competent), akurasi KIB A mencapai 98,9%, utilisasi alat berat naik menjadi 78%, dan opini audit meningkat dari WDP menjadi WTP — menghasilkan ROI positif dalam dua tahun dari investasi Rp1,2 miliar. Hasil penelitian mengkonfirmasi bahwa penerapan multi-teknologi terintegrasi, yang ditopang kolaborasi New Public Governance dan kerangka ISO 55000, merupakan model institusional yang dapat direplikasi untuk mentransformasi akuntabilitas tata kelola aset publik.*

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Katakunci **:** *Manajemen Aset Publik, Inovasi Digita, Maturity Manajemen Aset, Opini Audit, New Public Governance.*

1. Introduction

Public sector asset governance represents a fundamental pillar of state financial accountability and transparency, within the paradigm of New Public Management (NPM), which demands that governments manage public resources with efficiency, effectiveness, and responsibility comparable to private sector standards (Hood, 1991; Osborne, 2010; Christiaens et al., 2015). Despite two decades of public sector accounting reforms in Indonesia, persistent structural challenges remain in fixed asset recording accuracy, reconciliation between administrative records and physical field conditions, and inadequate human resource capacity in asset management units (Harun et al., 2019; Ritonga et al., 2022; Mardiasmo, 2018). These challenges are empirically evident in the audit findings of BPK RI against DLHK Riau, which consistently received a Qualified Opinion (WDP) in 2022–2023, with recurring findings including 17 undetected patrol vehicles, a discrepancy of over 1,200 hectares between inventory records and field data, eight missing land certificates, and 2,300 hectares of KPH Tasik Besar Serkap without demarcation markers undermining fiscal accountability and public trust in regional government institutions (BPK RI Perwakilan Riau, 2023; Guthrie et al., 2020; Mardiasmo, 2018). Furthermore, BPKP's self-assessment placed DLHK Riau's asset management maturity at 1.8 out of 4.0 (Aware level) far below the required Competent standard signaling systemic governance failure that extends beyond procedural non-compliance into institutional incapacity (BPKP, 2022; Phua et al., 2021; Amadi-Echendu et al., 2017).

This study is theoretically grounded in three complementary frameworks. *Stewardship Theory* establishes the normative obligation of public officials to manage state assets responsibly and transparently on behalf of the public as principal (Donaldson & Davis, 1991; Schillemans & Bjurstrøm, 2020; Grossi et al., 2020). The *ISO 55000:2014 Asset Management Framework* provides the operational architecture, defining asset management as coordinated whole-of-life activities requiring reliable information systems, cross-unit data integration, and risk-based approaches all of which are demonstrably deficient in DLHK Riau's current governance structure (ISO, 2014; Amadi-Echendu et al., 2017; Phua et al., 2021). The *Unified Theory of Acceptance and Use of Technology* (UTAUT) further explains how digital innovations are adopted and institutionalized within public organizations to enhance governance outcomes (Venkatesh et al., 2003; Khairi et al., 2022; Hastings, 2021). Contemporary evidence supports the transformative potential of these innovations: IoT-based tracking has generated operational cost savings of 15–25% through preventive maintenance paradigms (Kurniawan et al., 2023; Khairi et al., 2022; Hastings, 2021); RTK drone mapping compresses cadastral surveys from months to days at 2 cm spatial accuracy (Colomina & Molina, 2014; Toth & Jóźków, 2016; Darusman & Kuncoro, 2020); blockchain archiving produces immutable audit trails resistant to manipulation (Ølnes et al., 2017; Gatteschi et al., 2018; Ritonga et al., 2022); and RFID smart labeling enables real-time asset identification with minimal human error (Khairi et al., 2022; Kurniawan et al., 2023; Phua et al., 2021). Responding to these deficiencies, DLHK Riau in 2024 simultaneously deployed five digital asset management innovations across UPT KPH Tasik Besar Serkap and UPT Laboratorium Lingkungan: drone mapping with geotagging, IoT-based patrol vehicle tracking, blockchain land archive digitization, inter-UPT asset sharing via

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SiLADU, and RFID smart labeling for laboratory equipment (BPK RI Perwakilan Riau, 2023; BPKP, 2022; Kurniawan et al., 2023).

Despite the growing body of literature on individual digital technologies in public asset management, no study has systematically evaluated the simultaneous, integrated deployment of five technological innovations within a single regional government agency characterized by heterogeneous asset typologies encompassing state forest areas, patrol vehicles, environmental laboratories, and remote UPT infrastructure an institutional context amplified by non-excludable asset characteristics, tenurial conflict susceptibility, and geographic dispersion unique to forestry governance (Hastings, 2021; Darusman & Kuncoro, 2020; Gatteschi et al., 2018). This critical research gap, compounded by the absence of evidence-based evaluation of how organizational maturity moderates technology-governance effectiveness relationships, constitutes the primary justification for this study (Phua et al., 2021; Amadi-Echendu et al., 2017; Harun et al., 2019). Accordingly, this study aims to: (1) analyze pre-innovation asset governance conditions of DLHK Riau as an evaluative baseline; (2) examine the relevance and implementation quality of the five digital innovations; and (3) evaluate their effectiveness in improving asset accountability, operational efficiency, utilization optimization, and asset security guided by the following research questions: **(RQ1)** To what extent have the five digital innovations improved asset accountability outcomes in DLHK Riau as reflected in BPK RI audit findings? **(RQ2)** What organizational and technical factors moderate the effectiveness of digital asset management innovations in a regional agency with heterogeneous asset typologies? **(RQ3)** How do the implemented innovations contribute to advancing DLHK Riau's asset management maturity toward the Competent standard required by BPKP? The findings are expected to contribute to the academic literature on digital transformation in public sector asset management and provide evidence-based policy recommendations for sustaining an Unqualified Opinion (WTP) from BPK RI (Ritonga et al., 2022; Guthrie et al., 2020; Osborne, 2010).

2. Literature Review

Public sector asset management is defined as a systematic process governing the entire asset lifecycle from planning, acquisition, and operation through maintenance and disposal with the primary objective of maximizing value for public service delivery rather than return on investment (Hastings, 2021; Guthrie et al., 2020; ISO, 2014). ISO 55000:2014, as the global reference standard comprising three integrated documents (ISO 55000: principles; ISO 55001: requirements; ISO 55002: guidelines), establishes four critical success elements: leadership commitment, risk-based planning, integrated information systems, and continuous evaluation — all of which must be calibrated to the regulatory complexity and accountability demands inherent in public sector contexts (ISO, 2014; Amadi-Echendu et al., 2017; Phua et al., 2021). From a paradigmatic standpoint, public asset governance has evolved across three successive frameworks: Traditional Public Administration emphasizing procedural compliance, New Public Management (NPM) prioritizing efficiency and performance measurement, and New Public Governance (NPG) promoting cross-sectoral collaboration and transparency (Hood, 1991; Osborne, 2010; Guthrie et al., 2020). In the Indonesian context, the regulatory hierarchy governing Regional Government Asset (BMD) management — anchored in Law No. 1/2004, elaborated through Government Regulation No. 27/2014 as amended by PP 28/2020, and operationalized via Permendagri No. 19/2016 across ten BMD lifecycle stages — creates a complex compliance environment wherein weaknesses

in bookkeeping, inventory, and reporting have been empirically shown to increase the probability of non-WTP audit opinions by 3.2 times, with 60% of opinion downgrades attributable to fixed asset problems including recording inaccuracy, physical non-existence, and incomplete documentation (Mardiasmo, 2018; Ritonga et al., 2022; Harun et al., 2019).

Assets managed by environment and forestry agencies exhibit fundamentally distinct characteristics that render conventional governance approaches inadequate across five critical dimensions: heterogeneous asset typology spanning state forest areas, patrol vehicles, heavy equipment, and environmental laboratories; spatial dispersion across remote UPT KPH locations that impedes periodic physical census; inalienable legal status under Law No. 41/1999 requiring robust administrative evidence; high physical deterioration risk from intensive field operations where corrective maintenance paradigms have proven systemically inefficient; and acute vulnerability to tenurial conflicts necessitating immutable digital evidentiary records (Hastings, 2021; Kurniawan et al., 2023; Ølnes et al., 2017). These characteristics collectively elevate the governance complexity of forestry assets beyond standard administrative settings, demanding technologically advanced solutions that address both spatial verification and documentary integrity challenges simultaneously (Darusman & Kuncoro, 2020; Toth & Jóźków, 2016; Khairi et al., 2022). Furthermore, the Asset Management Maturity Scale developed by the Institute of Asset Management (IAM, 2015) — categorizing organizational maturity into Aware (1.0–2.0), Developing (2.0–3.0), Competent (3.0–3.5), and Excellent (3.5–4.0) across dimensions of policy, planning, risk-based decision-making, lifecycle management, information systems, and leadership — identifies Information Management as the weakest dimension in developing regional governments, yet simultaneously the dimension delivering the greatest performance improvement when enhanced through digitalization, with each maturity level increment increasing the probability of achieving WTP audit opinion by 42% (IAM, 2015; Amadi-Echendu et al., 2017; Pratama, 2020).

Contemporary empirical evidence demonstrates that five categories of digital technology innovation constitute transformative interventions across the distinct governance failure dimensions of public asset management. First, UAV drone mapping integrated with GNSS-RTK achieves spatial accuracy of 2–5 cm per pixel and boundary demarcation precision below 5 cm, improving government asset data accuracy from 67% to 96% while reducing physical census time by 78% — directly addressing spatial verification deficiencies in remote forest areas (Colomina & Molina, 2014; Toth & Jóźków, 2016; Phua et al., 2021). Second, IoT-based asset tracking systems utilizing GPS sensors and engine hour monitoring transform maintenance paradigms from corrective to preventive approaches, generating 30–45% reductions in vehicle downtime and 15–25% operational cost savings in Indonesian government fleet management, while simultaneously producing auditable trip histories as supervisory instruments (Kurniawan et al., 2023; Khairi et al., 2022; Hastings, 2021). Third, blockchain as a distributed ledger technology guarantees data integrity, transparency, and immutability of archived asset documents, with smart contracts accelerating ownership verification processes and demonstrating particular relevance for recovering from lost asset certificates in developing country contexts (Ølnes et al., 2017; Gatteschi et al., 2018; Khairi et al., 2022). Fourth, UHF RFID technology enables simultaneous reading of hundreds of asset tags without line-of-sight requirements at ranges up to 10 meters, compressing laboratory inventory time from 10–14 days to under 4 hours at approximately 100% accuracy, with gate-integrated configurations further strengthening physical asset security (Khairi et al.,

2022; Hastings, 2021; Phua et al., 2021). Fifth, public asset sharing platforms grounded in NPG collaboration principles have empirically demonstrated increases in heavy equipment utilization rates from 28% to 71% while deferring new procurement expenditures — a mechanism legally enabled by Permendagri 19/2016 Article 296 governing inter-UPT asset utilization arrangements (Osborne, 2010; Guthrie et al., 2020; Mardiasmo, 2018).

Synthesizing the theoretical and empirical landscape, this study's conceptual framework positions four systemic governance weaknesses of DLHK Riau — deficient asset inventorying, inadequate physical security, suboptimal asset utilization, and incomplete administrative documentation — as the proximate causes of its low asset management maturity score (1.8/Aware level) and recurring WDP audit opinions, rooted in non-compliance with both Permendagri 19/2016 lifecycle requirements and ISO 55000:2014 operational standards (BPKP, 2022; Mardiasmo, 2018; Amadi-Echendu et al., 2017). The five digital innovations — drone mapping, IoT tracking, blockchain archiving, RFID smart labeling, and SiLADU asset sharing — are theoretically positioned as targeted technological interventions corresponding to each governance failure dimension, grounded in the integration of Stewardship Theory's accountability obligations, ISO 55000's operational framework, and UTAUT's technology adoption dynamics within public organizational contexts (Donaldson & Davis, 1991; Venkatesh et al., 2003; Hastings, 2021). Effectiveness is operationalized through four measurable outcomes — enhanced financial accountability, improved budget efficiency, optimized asset utilization, and strengthened asset security — which in aggregate are hypothesized to advance DLHK Riau's maturity level toward the Competent standard (≥3.0) and create the conditions necessary for sustained WTP opinion achievement, thereby filling the identified research gap regarding integrated multi-technology governance interventions in heterogeneous public asset environments (Phua et al., 2021; Ritonga et al., 2022; Guthrie et al., 2020).

3. Research Methodology

This study employs a qualitative approach with a descriptive-evaluative design, selected to facilitate deep understanding of the implementation processes, institutional contexts, and governance change mechanisms of DLHK Riau's digital asset innovations — rather than testing statistical relationships between variables (Creswell & Poth, 2018; Denzin & Lincoln, 2018; Patton, 2015). The descriptive dimension systematically captures pre- and post-innovation governance conditions across four operational domains — asset inventorying, physical security, utilization optimization, and administrative documentation — while the evaluative dimension assesses innovation effectiveness against verified performance indicators derived from ISO 55000:2014 and IAM (2015) maturity dimensions (Patton, 2015; ISO, 2014; IAM, 2015). The research strategy is an *embedded case study* (Yin, 2018), with DLHK Riau as the primary case unit and UPT KPH Tasik Besar Serkap as the embedded sub-unit — a design justified by three factors: the revelatory nature of simultaneous five-technology deployment within a single fiscal year unprecedented in regional forestry agencies; the need for granular operational-level analysis at the field unit; and the inherently "how" and "why" nature of the research questions that case study methodology is uniquely equipped to address (Yin, 2018; Creswell & Poth, 2018; Denzin & Lincoln, 2018). The embedded sub-unit was selected based on its highest asset complexity profile — encompassing 513,276 hectares of managed forest area, 28 patrol vehicles, 12 units of heavy equipment, 4 guard posts, and

1 administrative office — and its status as the locus of the three most material BPK audit findings and three primary innovations (drone mapping, IoT tracking, and blockchain archiving), thereby maximizing analytical depth and theoretical relevance (Yin, 2018; Patton, 2015; BPK RI Perwakilan Riau, 2023).

Data collection employs a triangulation strategy combining three complementary and mutually verifying methods to enhance the validity and credibility of findings (Denzin & Lincoln, 2018; Creswell & Poth, 2018; Yin, 2018). First, documentary analysis (*content analysis*) examines primary official documents including LKPD Riau 2022–2023, LHP BPK RI Perwakilan Riau 2022–2023, DLHK Performance Reports 2024, Physical Inspection Records (*Berita Acara Opname*) 2023–2024, SiLADU dashboard data (January–December 2024), Regional Governor Regulation No. 12/2024 on Integrated Asset Data, KIB A–F records 2022–2024, and technical documentation of drone, IoT, and blockchain systems — analyzed through systematic content analysis protocols (Bowen, 2009; Yin, 2018; Creswell & Poth, 2018). Second, in-depth semi-structured interviews of 60–90 minutes are conducted with seven purposively selected key informants — the Head of DLHK, Head of Asset Division, Head of UPT KPH, two UPT Asset Administrators, a drone/IoT technician, and a BPK RI auditor — guided by IAM (2015) maturity dimensions and ISO 55000:2014 operational standards, with recordings made under informed consent (Creswell & Poth, 2018; Patton, 2015; IAM, 2015). Third, non-participant observation is conducted at DLHK offices and KPH field areas, focused on IoT tracking operations, drone mapping and geotagging procedures, blockchain QR verification at boundary markers, and physical asset conditions — with systematic field notes recorded according to standardized observation protocols (Yin, 2018; Denzin & Lincoln, 2018; Patton, 2015).

Data analysis follows the interactive model of Miles et al. (2014), comprising four cyclical and iterative stages: data collection with dual-level coding referenced to Permendagri 19/2016 lifecycle stages and the four output dimensions; data condensation through selection, simplification, and thematic categorization of relevant patterns; data display via before-after comparative matrices, performance indicator tables at both DLHK and UPT levels, and analytical narratives; and conclusion drawing with verification through systematic cross-checking between DLHK-level and UPT KPH-level findings, where cross-level consistency serves as the primary indicator of conclusion validity (Miles et al., 2014; Yin, 2018; Patton, 2015). Data validity and trustworthiness are ensured through four criteria established by Lincoln and Guba (1985) as operationalized by Creswell and Poth (2018): *credibility* through source triangulation requiring minimum three independent sources per finding, member checking with informants, and prolonged field engagement; *transferability* through thick description of DLHK's institutional context, KPH asset characteristics, and regulatory environment enabling replication in analogous agencies; *dependability* through a systematic audit trail of all methodological decisions ensuring consistency and replicability; and *confirmability* through researcher reflexivity to minimize interpretive bias, supported by systematic archiving of all raw data, interview transcripts, and field notes for independent audit purposes (Lincoln & Guba, 1985; Creswell & Poth, 2018; Denzin & Lincoln, 2018).

4. Results and Discussion

Pre-innovation baseline analysis of DLHK Riau's asset governance — derived from LKPD 2022–2023 documentary analysis, physical inspection records, and in-depth interviews — reveals a systemic maturity deficit of 1.8 (Aware level) on the IAM (2015)

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scale, manifesting across four pathological dimensions that collectively constitute the causal architecture of recurring WDP audit opinions (IAM, 2015; Amadi-Echendu et al., 2017; BPK RI Perwakilan Riau, 2023). In the inventorying dimension, ground-based cadastral surveys requiring six months and 24 personnel verified only 61% of 847 boundary markers, with 73% of points lacking valid coordinates, producing a 1,200-hectare discrepancy between KIB A records and actual field conditions, 17 untracked patrol vehicles, and an operational cost of Rp620 million per census cycle — constituting direct violations of Permendagri 19/2016 Article 44 and the primary basis for BPK's qualified opinion (Mardiasmo, 2018; Ritonga et al., 2022; Harun et al., 2019). In the asset security dimension, 2,300 hectares lacked physical boundary markers and eight land certificates valued at Rp47.3 billion were lost, with vehicle monitoring dependent solely on manual mutation logs, generating estimated legal exposure of Rp34.5–103.5 billion and violating Permendagri 19/2016 Articles 42–43 (Ølnes et al., 2017; Darusman & Kuncoro, 2020; Mardiasmo, 2018).

Asset utilization was critically suboptimal at 30% for heavy equipment due to inter-UPT information silos driving procurement duplication, while vehicle downtime reached 45% through corrective-only maintenance paradigms at an annual cost of Rp1.86 billion — conditions directly attributable to the absence of sharing platforms and data-driven maintenance systems (Osborne, 2010; Kurniawan et al., 2023; Hastings, 2021). Administrative documentation suffered four-month data lag between KPH field records and SIMDA BMD, duplicate entries across systems, and complete absence of digital audit trails — rendering balance sheet data unreliable for evidence-based decision-making and compounding all upstream governance failures into systematically deficient financial reporting (Miles et al., 2014; Christiaens et al., 2015; Guthrie et al., 2020).

In 2024, DLHK Riau deployed five simultaneous digital innovations whose effectiveness, evaluated against ISO 55000:2014 value creation framework and IAM maturity dimensions, demonstrates transformative and empirically quantifiable governance improvements across all four pathological dimensions (ISO, 2014; IAM, 2015; Phua et al., 2021). In the inventorying dimension, deployment of DJI Matrice 300 RTK drone through three sequential phases — 50 km boundary mapping in five days producing 2 cm/pixel orthophotos, overlay with KIB A via Avenza Maps, and automatic QR code-linked API push to e-BMD — reduced census time by 83% (six months to one month), saved Rp413 million per cycle, elevated KIB A accuracy from 61% to 98.9% surpassing the PSAP 07 threshold of 95%, compressed area discrepancy from 1,200 hectares to 12 hectares, and eliminated all nine previously recurring BPK findings on unverified assets to zero — empirically confirming Colomina and Molina (2014) and Toth and Jóźków (2016) on UAV superiority for large-scale spatial inventorying while extending their findings by demonstrating that geotagging transforms asset data epistemology from descriptive-subjective to geospatially-objective and audit-immutable (Colomina & Molina, 2014; Toth & Jóźków, 2016; Phua et al., 2021).

In the asset security dimension, installation of Teltonika FMB920 IoT devices on all 28 patrol vehicles integrated with Antares platform and e-BMD achieved zero untracked vehicles, 100% reduction in vehicle misuse through technological deterrence, and 99% reduction in document verification time from three days to 15 minutes — while parallel blockchain archiving of land legality documents on the Polygon network linked via QR codes to boundary markers eliminated all document losses since implementation, validating Ølnes et al. (2017) and Gatteschi et al. (2018) on blockchain's immutable evidentiary strength while extending their application domain from financial services to

forest area governance (Ølnes et al., 2017; Gatteschi et al., 2018; Khairi et al., 2022). In the utilization dimension, the SiLADU asset sharing platform with automated PNBP calculation elevated heavy equipment utilization from 30% to 78% — surpassing the Southeast Asian benchmark of 55–65% reported by Guthrie et al. (2020) — successfully deferring a Rp4.8 billion excavator procurement and generating Rp275 million in new regional revenue annually, while IoT preventive maintenance reduced vehicle downtime from 45% to 8% and maintenance costs by Rp410 million per year (22%), exceeding the 15–25% savings reported by Kurniawan et al. (2023) and providing the first empirical evidence that sharing economy principles can be institutionalized in public forestry sector asset management without compromising accountability (Kurniawan et al., 2023; Osborne, 2010; Guthrie et al., 2020).

In the administrative dimension, API integration eliminated the four-month data lag to near real-time synchronization, while UHF RFID deployment on 143 laboratory instruments compressed physical inspection time from 14 days to two hours at 100% accuracy, halting the previously recurring loss of five instruments annually — confirming Hastings (2021) and Khairi et al. (2022) on RFID's transformative inventory efficiency while demonstrating the critical value of closed-loop IoT-e-BMD data architecture as an institutional governance mechanism (Khairi et al., 2022; Hastings, 2021; Phua et al., 2021).

The aggregate impact of five simultaneous innovations produced an accelerated maturity advancement from 1.8 (Aware, 2022) to 3.1 (Competent, 2024) on the IAM scale — with the largest gains in Information Management (1.5→3.4) and Decision Making (1.7→3.2) dimensions — a progression classified by Amadi-Echendu et al. (2017) as accelerated improvement given that equivalent advancement typically requires five to seven years under conventional governance trajectories (IAM, 2015; Amadi-Echendu et al., 2017; Phua et al., 2021). This maturity advancement directly correlates with DLHK Riau's achievement of an Unqualified Opinion (WTP) without asset emphasis paragraphs on its 2024 LKPD — empirically validating Pratama's (2020) causal proposition linking maturity levels to audit opinion outcomes and demonstrating that with a total investment of Rp1.2 billion, the innovations generated Rp1.03 billion in annual operational savings and deferred Rp4.8 billion in capital expenditure, producing a positive return on investment within less than two years (Pratama, 2020; Mardiasmo, 2018; Ritonga et al., 2022). Implementation success was driven by four enabling factors consistent with New Public Governance theory: leadership commitment formalized through an Acceleration Team decree, regulatory grounding through Governor Regulation No. 12/2024 on Integrated Asset Data, pentahelix collaboration with Diskominfo, Politeknik Caltex Riau, and Telkom Indonesia, and an adaptive human resource demographic with 70% of staff under 35 years of age — while three socio-technical barriers emerged including 4G infrastructure absence in four KPH areas resolved through local buffering, driver resistance to GPS monitoring resolved through maintenance-centric rather than punitive socialization, and semi-manual interoperability between e-BMD and SIMPONI KLHK systems (Osborne, 2010; Venkatesh et al., 2003; Hood, 1991).

Theoretically, this study makes three contributions to the public asset management literature: first, it extends ISO 55000:2014 by demonstrating that simultaneous integration of geospatial-UAV, IoT, and blockchain technologies can accelerate governance maturity in regional forestry contexts — a domain minimally represented in Q1 literature; second, it confirms NPG as a superior implementation framework wherein state capacity is strengthened through network orchestration rather than hierarchical

control; and third, it establishes empirical transferability of sharing economy principles to public sector asset governance, generating economic value without new capital expenditure — collectively demonstrating that public asset management effectiveness is determined not by expensive technology ownership, but by institutional design that transforms data into audit evidence, idle assets into revenue sources, and manual oversight into automated deterrence (ISO, 2014; Osborne, 2010; Guthrie et al., 2020).

5. Conclusion

This study demonstrates that DLHK Riau's pre-innovation asset governance (2022–2023) was characterized by a systemic maturity deficit of 1.8 (Aware level) on the IAM (2015) scale, rooted in the compound interaction of geodetic technology absence, a critically disproportionate human resource ratio of 3 asset administrators per 15,000 inventory items, standalone SIMDA BMD architecture, and chronic KPH-e-BMD data fragmentation — collectively producing four pathological dimensions that constituted the direct causal basis of recurring WDP audit opinions (IAM, 2015; Amadi-Echendu et al., 2017; BPK RI Perwakilan Riau, 2023). Manual inventorying yielded KIB A accuracy of only 61%, a six-month census cycle costing Rp620 million, a 1,200-hectare area discrepancy, and 17 untracked patrol vehicles in direct violation of Permendagri 19/2016 Article 44; asset security failures encompassed 2,300 hectares without boundary demarcation and eight lost land certificates valued at Rp47.3 billion generating legal exposure of Rp34.5–103.5 billion; heavy equipment utilization remained critically suboptimal at 30% with 45% vehicle downtime at Rp1.86 billion annual maintenance cost; and administrative documentation suffered four-month data lag with complete absence of digital audit trails rendering balance sheet data unreliable for evidence-based governance (Mardiasmo, 2018; Ritonga et al., 2022; Harun et al., 2019).

The five digital innovations deployed in 2024 demonstrated precise contextual relevance to forestry asset characteristics — drone mapping addressing spatial dispersion and boundary accuracy, IoT tracking addressing patrol vehicle mobility, blockchain archiving addressing legal document vulnerability of inalienable assets, SiLADU addressing inter-UPT utilization silos, and RFID addressing rapid inventory requirements for high-value laboratory instruments — producing transformative and quantifiable effectiveness across all four output dimensions: accountability (KIB A accuracy 61%→98.9% surpassing PSAP 07 threshold, area discrepancy 1,200 ha→12 ha, BPK unverified asset findings 9→0, audit opinion WDP→WTP without emphasis paragraphs); efficiency (census time −83%, document verification −99%, laboratory inspection −99%, fleet maintenance cost −Rp410 million/year); utilization optimization (heavy equipment utilization 30%→78% surpassing ASEAN benchmark of 55–65%, generating Rp275 million annual regional revenue and deferring Rp4.8 billion capital expenditure); and asset security (100% real-time vehicle tracking, zero document loss, zero laboratory instrument loss from a previous rate of five units annually) (Colomina & Molina, 2014; Ølnes et al., 2017; Kurniawan et al., 2023).

The aggregate impact of five simultaneous innovations produced an accelerated maturity advancement from 1.8 (Aware) to 3.1 (Competent) within a single two-year period — a progression classified as accelerated improvement by Amadi-Echendu et al. (2017) given that equivalent advancement conventionally requires five to seven years — with the largest gains recorded in Information Management (1.5→3.4) and Decision Making (1.7→3.2) dimensions, directly correlating with DLHK Riau's achievement of an Unqualified Opinion (WTP) without asset emphasis paragraphs on its 2024 LKPD and

generating a positive return on investment within less than two years from a total outlay of Rp1.2 billion against Rp1.03 billion in annual operational savings and Rp4.8 billion in deferred capital expenditure (IAM, 2015; Pratama, 2020; Phua et al., 2021). Implementation success was structurally enabled by four New Public Governance factors — leadership commitment formalized through an Acceleration Team decree, regulatory grounding through Governor Regulation No. 12/2024, pentahelix collaboration with Diskominfo, Politeknik Caltex Riau, and Telkom Indonesia, and an adaptive workforce demographic of 70% staff under 35 years — while three socio-technical barriers (4G infrastructure gaps in four KPH areas, driver resistance to GPS monitoring, and semi-manual e-BMD-SIMPONI KLHK interoperability) confirmed that digital asset transformation is fundamentally a socio-technical rather than purely technical challenge (Osborne, 2010; Venkatesh et al., 2003; Hood, 1991).

Theoretically, this study makes three original contributions to the Q1 public asset management literature: it extends ISO 55000:2014 by demonstrating that simultaneous geospatial-UAV, IoT, and blockchain integration can accelerate governance maturity in regional forestry contexts minimally represented in extant literature; it confirms NPG as a superior implementation framework wherein state capacity is strengthened through network orchestration rather than hierarchical control; and it establishes the first empirical evidence of sharing economy transferability to public forestry asset governance generating economic value without new capital expenditure — collectively demonstrating that public asset management effectiveness is determined not by expensive technology ownership, but by institutional design that transforms data into audit evidence, idle assets into revenue sources, and manual oversight into automated deterrence (ISO, 2014; Osborne, 2010; Guthrie et al., 2020). Future research is recommended to examine the moderating role of organizational maturity on technology-governance effectiveness relationships across multi-agency comparative settings, and to develop standardized measurement instruments for digital innovation impact assessment in heterogeneous public asset environments (Amadi-Echendu et al., 2017; Hastings, 2021; Ritonga et al., 2022).

6. References

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