

SOCIAL SCIENCE AND EDUCATION | RESEARCH ARTICLE

Evaluating the Strategy of Diskominfostandi Mahakam Ulu in Bridging the Digital Divide in Border Areas: A Study of Telecommunications Policy in Indonesia's 3T Regions

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ARTICLE HISTORY

Received: April 30, 2026

Revised: July 13, 2026

Accepted: July 13, 2026

DOI

<https://doi.org/10.52970/grsse.v6i2.2250>

ABSTRACT

This study examines the policy strategies implemented by the Communications, Informatics, Statistics, and Cryptography Agency (Diskominfostandi) of Mahakam Ulu Regency in addressing the digital divide and promoting equitable access to telecommunications and internet services in border regions. As one of Indonesia's frontier, outermost, and underdeveloped (3T) regions, Mahakam Ulu faces persistent challenges related to geographical isolation, limited infrastructure, and unequal digital connectivity. Employing a descriptive qualitative approach, this study collected data through in-depth interviews with seven key informants, field observations, and document analysis conducted between March and April 2026. Data were analyzed thematically to identify policy strategies, implementation patterns, and institutional challenges in telecommunications governance. The findings reveal that significant disparities in digital connectivity persist across the region. Of the 49 BTS towers available, 15 (30.6%) remain inactive, while 35 of 50 villages continue to depend on satellite-based V-Sat connectivity. Diskominfostandi's policy strategy is structured around three key dimensions: collaborative infrastructure development, digital human resource capacity building, and regulatory governance strengthening. However, policy implementation remains constrained by systemic challenges, including fragmented intergovernmental coordination, dependence on the central government agency BAKTI, a regional funding gap exceeding IDR 70 billion, and limited institutional capacity. This study contributes to the growing literature on digital divide reduction, telecommunications governance, and place-based digital policy by demonstrating that standardized national approaches are insufficient to address the unique conditions of 3T border regions. The study recommends an integrated policy model combining Low Earth Orbit (LEO) satellite technology, strengthened inter-agency coordination mechanisms, and community-centered digital empowerment programs to achieve sustainable digital inclusion and equitable regional development.

Keywords: Digital Divide, Telecommunications Governance, Digital Inclusion.

I. Introduction

The equalization of access to telecommunications and internet services is one of the priority agendas of national development, as stipulated in the National Medium-Term Development Plan (RPJMN) 2020–2024. Notwithstanding the national commitment to universal digital connectivity, the realization of this objective continues to confront complex structural challenges, particularly in frontier, outermost, and underdeveloped regions collectively designated as 3T (Tertinggal, Terdepan, Terluar) areas that remain geographically isolated from economic growth centers and infrastructure development corridors. The persistence of this digital divide has profound socioeconomic implications: communities lacking reliable internet access are systematically



excluded from digital economic opportunities, quality educational resources, responsive public services, and full participation in democratic processes (van Dijk, 2020; Warschauer, 2003).

The equalization of access to telecommunications and internet services is one of the national development priorities as stipulated in the National Medium-Term Development Plan (RPJMN) 2020–2024. Despite the government's commitment to achieving equitable digital connectivity, the realization of this objective continues to face complex structural challenges, particularly in frontier, outermost, and underdeveloped (3T) regions that remain geographically isolated from economic growth centers and infrastructure development corridors. In addition to geographical constraints, the implementation of digital governance initiatives is often hindered by limited Information and Communication Technology (ICT) infrastructure, inadequate human resource capacity, insufficient socialization of digital services, and restricted internet access (Afriyanti et al., 2026). These challenges not only reduce the effectiveness of digital government policy implementation but also reinforce existing patterns of digital exclusion. Consequently, communities lacking adequate connectivity are systematically excluded from digital economic opportunities, access to quality educational resources, responsive public services, and meaningful participation in democratic processes.

Mahakam Ulu Regency, established as the youngest administrative district in East Kalimantan Province in 2013, represents a particularly acute manifestation of these structural challenges. Located in the upper reaches of the Mahakam River and covering an area of 15,315.11 km² larger than Lebanon the regency directly borders Malaysia (Sarawak State) to the north and administratively comprises 5 sub-districts and 50 villages with a total population of approximately 38,498 people (BPS Kab. Mahakam Hulu, 2023). The topography, dominated by dense tropical rainforests, steep mountain ranges, and river systems that serve as the primary transportation arteries, renders Mahakam Ulu among the most remote and physically isolated administrative territories in Indonesia. In this context, the provision of reliable telecommunications infrastructure is not merely a matter of convenience but an urgent prerequisite for national development equity, border sovereignty, and community welfare.

Table 1. Population, population growth rate by District in Mahakam Ulu Regency, 2024

District	Population (thousand)	Annual Population Growth Rate 2022-2023 (%)
Laham	3.125	3,78
Long Hubung	9.085	2,46
Long Bagun	16.289	2,06
Long Pahangai	5.353	3,20
Long Apari	4.646	3,10
Mahakam Ulu	38.498	3,16

Source: BPS Kabupaten Mahakam Ulu 2024

The telecommunications infrastructure deficit in Mahakam Ulu is empirically well-documented and deeply concerning. National internet penetration reached 77.02% in 2022 (APJII, 2022), yet only approximately 30% of Mahakam Ulu's population possessed adequate internet access in the same year (BPS Kab. Mahakam Hulu, 2023) a gap of nearly 47 percentage points that reflects the magnitude of digital exclusion in this border region. The construction of Base Transceiver Station (BTS) telecommunications towers in the regency commenced in 2013 through a tripartite arrangement involving the Mahakam Ulu Regency Government, the East Kalimantan Provincial Government, and the Central Government via the Telecommunication and Informatics Accessibility Agency (BAKTI) under the Ministry of Communication and Information Technology. However, as of 2023, field data reveals that of 49 BTS towers constructed, only 34 are actively operational, while 15 towers (30.6%) remain inactive a statistic that encapsulates a systemic governance failure in telecommunications infrastructure management (BPS Kab. Mahakam Hulu, 2023).

The socioeconomic consequences of telecommunications inequality are multidimensional. In the education sector, limited internet access constrains students' and teachers' ability to participate in digital learning environments, thereby widening educational disparities. Economically, inadequate connectivity

restricts MSMEs from engaging in e-commerce and digital markets, reducing opportunities for income diversification and local economic growth. In public service delivery, digital exclusion limits citizens' access to e-government services, particularly in remote areas where geographical barriers remain significant. Furthermore, in border regions, insufficient telecommunications infrastructure may weaken information access, surveillance capacity, and broader efforts to strengthen state presence and sovereignty (Kartiasih et al., 2023; Ningtias et al., 2018; Wulandari et al., 2025). The disparity in service quality is further stratified by technology type. The 15 villages (30% of total) located along the Sendawar–Long Bagun fiber optic corridor, with a combined population of 19,470 residents, enjoy comparatively adequate internet connectivity. In contrast, the remaining 35 villages (70%), populated by 16,683 residents, predominantly in the border sub-districts of Long Pahangai and Long Apari, continue to rely on radio frequency-based V-Sat satellite technology characterized by low bandwidth, high latency, and susceptibility to weather-induced disruptions (BPS Kab. Mahakam Hulu, 2023). This binary of service quality not only reflects geographic disadvantage but also an institutional failure to adapt national telecommunications policy to locally differentiated conditions.

This study evaluates the policy strategy of the Communications, Informatics, Statistics, and Cryptography Agency (Diskominfo) of Mahakam Ulu Regency in bridging this digital divide. The study pursues three specific research objectives: (1) to identify and critically assess Diskominfo's formulated policies for equalizing telecommunications and internet services in border areas; (2) to analyze the implementation of these strategies and the patterns of multi-stakeholder collaboration involved; and (3) to evaluate the impact and effectiveness of these policies on the equalization of telecommunications services and their broader socioeconomic consequences for border communities. By interrogating the interface between policy design, institutional capacity, and local contextual conditions, this study aims to generate actionable insights for policymakers, scholars, and development practitioners engaged with digital inclusion in remote and border regions.

II. Literature Review and Theoretical Framework

2.1. Collaborative Governance in Telecommunications Infrastructure Development

The theoretical foundation of collaborative governance, systematically developed by Ansell & Gash (2008), posits that the resolution of complex public problems particularly those characterized by multi-actor interdependencies and resource scarcity necessitates direct and formalized engagement of government agencies, private sector entities, and civil society in collective decision making processes oriented toward consensus. This framework has since been substantially elaborated by (Emerson et al., 2012) who conceptualize collaborative governance as a system in which the collaborative dynamics, principled engagement, shared motivation, and joint action capacity interact iteratively to generate collaborative outcomes. In the specific context of telecommunications development in remote areas, this theoretical lens positions cross-sector collaboration not merely as a desirable feature but as the foundational prerequisite for policy success given the magnitude of resource requirements and coordination challenges involved.

Empirical evidence from comparable Indonesian contexts corroborates this theoretical position. Research by (Juanda & Izzulhaq, 2023) demonstrate that Diskominfo's strategy for equalizing internet networks in Parigi Moutong Regency combining systematic blank-spot area mapping, targeted BTS construction, and proactive coordination with both central government and private telecommunications operators generated measurably improved connectivity outcomes compared to regions employing more centralized, supply-driven approaches. Their findings underscore that institutional capacity for multi-actor coordination constitutes the primary determinant of policy effectiveness in geographically constrained environments.

Network governance theory suggests that complex public service challenges are more effectively addressed through collaborative arrangements involving interdependent actors rather than through traditional hierarchical structures. Such governance networks facilitate resource sharing, joint problem-

solving, and adaptive decision-making across organizational boundaries, thereby enhancing policy effectiveness in complex environments. However, collaborative governance arrangements also require strong coordination mechanisms, institutional clarity, and accountability structures to prevent fragmentation, overlapping responsibilities, and policy incoherence (Aziz & Hikmawan, 2023; Christensen & Læg Reid, 2007; Klijn & Koppenjan, 2012). These challenges are particularly evident in the telecommunications governance landscape of Mahakam Ulu, where multiple governmental actors, state-owned enterprises, and private providers operate within a context characterized by geographical constraints, limited infrastructure, and uneven institutional coordination.

2.2. Digital Divide Theory and Telecommunications Inequality

Digital divide theory, as foundationally articulated Schumann (2013) and expanded by van Dijk (2020), conceptualizes digital inequality across four sequential access dimensions: motivational access (the desire to engage with digital technology), material access (the availability of physical infrastructure and devices), skills access (the competence to use digital tools effectively), and usage access (the quality and diversity of digital engagement). This multi-dimensional framework is critically important because it reveals that the digital divide is not reducible to physical infrastructure provision alone a lesson directly applicable to the Mahakam Ulu context, where infrastructure expansion has been pursued without commensurate investment in digital skills development or locally relevant content creation. Research by Dimas & Fahlevvi (2024) in Sumbawa Regency a comparably remote region demonstrates that limited internet infrastructure, low digital literacy rates, and inadequate ICT capacity among local public servants collectively constitute the primary barriers to effective e-government implementation. Their findings reinforce that infrastructure provision, while necessary, is insufficient without parallel investment in human capacity and enabling ecosystem development.

Beyond physical access to information and communication technologies, digital inclusion requires attention to the social, cultural, and institutional contexts in which technology is embedded. Meaningful use of digital technologies depends not only on connectivity and infrastructure but also on users' capabilities, digital literacy, and the relevance of technology to local needs and practices. Consequently, digital inequalities may persist even when infrastructure is available. Empirical studies further demonstrate that digital exclusion in rural and remote regions constrains participation in the digital economy, limits access to education and public services, and reinforces existing socioeconomic disparities. In developing-country contexts, these conditions can hinder poverty reduction efforts and reduce opportunities for social mobility among marginalized populations (Duffett et al., 2019; Kartiasih et al., 2023; Warschauer, 2003).

2.3. Place-Based Policy and Border Region Development

The place-based policy paradigm, elaborated by Barca (2009) in the context of European Union cohesion policy and increasingly applied in developing country contexts, asserts that effective regional development policies must be designed in response to the specific geographical, social, economic, and institutional characteristics of targeted localities. This approach challenges the assumption of uniform, one-size-fits-all national policies, instead advocating for context-sensitive interventions that leverage local assets, address locally specific constraints, and involve local actors in design and implementation processes. The paradigm is particularly salient for border regions, which confront a distinctive combination of remoteness, multi-jurisdictional governance complexity, cultural diversity, and national security imperatives that differentiate them from both urban centers and non-border rural areas. Rikardus (2026) applies this framework to digital governance effectiveness in Merauke another Indonesian border district finding that policy success is strongly mediated by geographical conditions, human resource capacity, cultural context, and the responsiveness of local government institutions. The study's central conclusion that border telecommunications policies require contextual, locally differentiated approaches rather than the mechanical

application of uniform national standards has direct theoretical resonance with the Mahakam Ulu case. Purnomo, Rahmawati, and Setiadi (2022) similarly demonstrate that asymmetric policy approaches those that deliberately calibrate policy instruments to regional capacity and need differentials generate superior equity outcomes in border infrastructure development compared to symmetric national frameworks.

2.4. Smart Village Development as Digital Transformation of Border Village

The smart village concept, as theorized by Visvizi & Lytras (2018), extends smart city principles to rural contexts by emphasizing the transformative potential of digital technology to enhance the quality of life in village communities across dimensions of public services, education, economic activity, and governance effectiveness. This theoretical perspective crucially expands the function of telecommunications infrastructure from mere connectivity provision to an instrument of comprehensive socioeconomic village development repositioning digital infrastructure as a development lever rather than a passive utility. The success of digital transformation in village administration is recognized as highly dependent on the stability and quality of internet connectivity, the capacity of village officials to utilize digital tools, and the enabling environment created by supportive local government policies and regulatory frameworks. Adds an important institutional dimension by demonstrating that the regulatory framework providing legal certainty for private investment including clear asset management protocols and maintenance accountability mechanisms is a key determinant of private sector engagement in commercially unattractive markets. This insight bears directly on the Mahakam Ulu context, where the absence of clear maintenance accountability frameworks for BAKTI owned infrastructure has contributed to the chronic inactivity of 11 of 33 centrally provided BTS towers.

III. Research Method

3.1. Research Design and Justification

This study employs a descriptive qualitative research design, a methodological choice grounded in the epistemological requirements of the research questions posed (Aspers & Corte, 2019). Qualitative approaches are uniquely suited to contextual public policy studies where the objective is to achieve in-depth understanding of complex policy dynamics, institutional relationships, and social processes within specific socio-geographical settings that cannot be adequately captured through quantitative measurement alone. The descriptive dimension of the design aims to systematically document and characterize Diskominforstandi's policy strategies, implementation processes, and observable outcomes, providing a rich empirical foundation for analytical interpretation.

The qualitative approach is specifically advantageous in the Mahakam Ulu context for three reasons. First, the phenomenon under investigation the governance of telecommunications infrastructure in a remote border district is characterized by institutional complexity, political dynamics, and locally specific contextual factors that resist reductive quantification. Second, the primary analytical interest lies in the perspectives, motivations, and experiential accounts of key informants who possess direct insider knowledge of policy processes that would be inaccessible through survey instruments. Third, as (Sugiyono, 2021) affirms, qualitative research methods are particularly appropriate when the phenomenon under study is complex, contextual, and requires a holistic understanding. This study adopts a content analysis approach supplemented by data triangulation to ensure rigor and validity in interpreting qualitative data sources.

3.2. Data Sources, Informant Selection, and Data Collection

Primary data were collected through three systematic techniques. First, in depth semi structured interviews were conducted with six key informants selected through purposive sampling a non-probability sampling strategy appropriate when the research objective is to access information-rich participants with

direct knowledge of the phenomenon under investigation. Informants were selected based on three criteria: (1) direct involvement in telecommunications policy formulation or implementation at Diskominfo standi Mahakam Ulu; (2) direct experience of telecommunications service conditions in border sub-districts; or (3) institutional responsibility for coordinating telecommunications infrastructure at central or regional government levels. The informant set comprised: the Head of Diskominfo standi Mahakam Ulu, the Head of the ICT Infrastructure Division Diskominfo standi, the ICT Infrastructure Computer Administrator Diskominfo standi, a head of the planning and finance subsection Diskominfo standi Mahakam Ulu; and community leaders (sub-district heads) from Long Pahangai and Long Apari sub-districts.

Interview sessions were conducted between March and April 2026, Interviews were conducted in Indonesian, subsequently transcribed verbatim by the principal researcher. An interview guide covering five thematic domains was employed: (a) policy formulation processes and strategic priorities; (b) implementation challenges and inter-institutional coordination; (c) infrastructure conditions and maintenance mechanisms; (d) community experiences of telecommunications services; and (e) assessments of policy effectiveness and recommendations. Follow-up questions were employed to probe and clarify responses, and key informants were provided the opportunity to review their interview transcripts for accuracy. Second, field observations were conducted at BTS tower sites across Long Pahangai and Long Apari sub-districts over a combined period of seven field days. Observations were structured to document: the physical condition and activation status of BTS towers; accessibility conditions at tower locations; observable patterns of community internet usage; and the physical infrastructure environment in border villages. Field notes were recorded in standardized observation forms and supplemented by photographic documentation. Third, systematic document analysis was undertaken, encompassing: official BTS tower data and internet coverage records from Diskominfo standi Mahakam Ulu; the Diskominfo standi Strategic Plan (Renstra) 2021–2026; BPS Kabupaten Mahakam Ulu statistical publications for 2021–2023; RPJMD Mahakam Ulu 2021–2026; and relevant national regulations and policy frameworks. Secondary data were systematically coded and cross referenced with primary interview and observation data.

3.3. Data Analysis and Validation

Data analysis followed a systematic content analysis procedure comprising five sequential stages: (1) data familiarization through repeated reading of interview transcripts and field notes; (2) initial coding to identify recurring themes, patterns, and analytical categories; (3) thematic clustering to consolidate initial codes into higher order themes aligned with the research objectives and theoretical framework; (4) interpretive analysis to construct explanatory accounts of observed patterns and connect empirical findings to relevant theoretical propositions; and (5) member-checking to validate analytical interpretations with key informants. Triangulation was applied across three dimensions: data source triangulation (interview, observation, and document data were cross-referenced to identify convergences and divergences); informant triangulation (accounts from agency officials were triangulated against community leader perspectives to identify potential institutional biases); and theoretical triangulation (findings were interpreted through multiple theoretical lenses as reviewed in Section 2). The combination of these validation strategies substantially enhances the trustworthiness, credibility, and transferability of the study's findings.

IV. Result and Discussion

4.1. Policy Strategy for Equalizing Telecommunications and Internet Services

Diskominfo standi of Mahakam Ulu Regency formulates its telecommunications and internet equalization policies in response to the complex and intersecting geographical, institutional, and resource constraints characterizing the regency's border context. The regulatory mandate for these policies derives from the Universal Service Obligation (USO) stipulated in Law No. 36 of 1999 on Telecommunications, which

establishes the state's obligation to ensure universal access to telecommunications services across the national territory. This mandate is operationalized at the regional level through the Mahakam Ulu RPJMD 2021–2026, which identifies telecommunications infrastructure development as a strategic priority across two primary objectives: (1) extending physical infrastructure coverage to all 50 villages, with particular urgency in the Long Pahangai and Long Apari sub-districts bordering Malaysia; and (2) improving internet service quality to achieve parity between border communities and more accessible regions. Conventional top down policy approaches have demonstrated consistent ineffectiveness in areas characterized by complex geographical conditions and diverse local needs, a finding that has informed Diskominfo's adoption of a collaborative, multi-stakeholder approach responsive to local conditions. Markus Wan, S.Sos., M.Si, The Head of Diskominfo stated:

"We cannot work alone here. The geographical conditions of Mahakam Ulu inevitably force us to partner with all parties — central government, provincial government, and the private sector. The telecommunications equalization policy here is not merely about building towers, but about ensuring those towers are operational and their benefits are truly felt by our communities in remote villages that have long been isolated and difficult to reach." (Head of Diskominfo Mahakam Ulu, March 10, 2026)

The main strategies established encompass three channels of infrastructure development. First, the construction and maintenance of BTS towers through the regional budget, with the Mahakam Ulu Regency Government allocating IDR 12.7 billion during 2021–2023 for the construction of 2 new BTS towers and the maintenance and operation of 7 existing government-owned BTS towers. Second, collaboration with third parties, namely the private telecommunications operator Telkomsel for commercial services and BAKTI of the Ministry of Communication and Information Technology as a partner for large-scale infrastructure provision. Third, utilization of national programs through synergy with BAKTI's programs that construct BTS towers and V-Sat-based internet networks in remote villages. The existing infrastructure conditions forming the basis for policy formulation are illustrated in the following table:

Table 2. Distribution and Activation Status of BTS Towers in Mahakam Ulu Regency, 2023

No.	BTS Tower Ownership	Total Towers	Active Towers	Inactive Towers	Activation Rate (%)
1	Telkomsel (Private)	5	5	0	100%
2	Mahakam Ulu Regency Government	11	7	4	63.6%
3	BAKTI – Ministry of Communication and IT	33	22	11	66.7%
	Total	49	34	15	69.4%

Table 2 reveals a critical finding underpinning the urgency of Diskominfo's policy intervention: of the total 49 BTS towers, 15 (30.6%) are inactive, with the inactivity concentrated predominantly in BAKTI-owned infrastructure (11 of 33 towers, or 33.3%) and regency government towers (4 of 11, or 36.4%). Notably, all 5 Telkomsel-operated towers maintain 100% activation rates, a contrast that highlights the differential effectiveness of private sector versus public sector infrastructure management mechanisms. These figures align with H1, supporting the theoretical expectation that weaknesses in collaborative governance specifically in vertical coordination between central and regional government generate measurable infrastructure governance failures. This finding local governments bear service delivery responsibilities without proportional authority or resources to intervene in centrally owned infrastructure assets.

Table 3. Internet Service Coverage by Technology Type in Mahakam Ulu Regency, 2023

No.	Infrastructure Type	Villages Covered	Population Served	Service Quality & Remarks
1	Fiber Optic Cable (Sendawar–Long Bagun)	15 (30%)	19,470	Reasonably adequate; supports e-government, e-learning, and digital commerce
2	Radio Frequency (V-Sat Satellite)	35 (70%)	16,683	Limited; weather-dependent; insufficient bandwidth for video/data-intensive apps; predominantly border sub-districts
	Total	50 (100%)	36,153	

Table 3 reveals a significant and structurally entrenched service quality disparity: while 30% of villages enjoy fiber optic-based connectivity adequate for e-government, e-learning, and digital commerce applications, 70% of villages disproportionately concentrated in border sub-districts depend on V-Sat technology characterized by bandwidth limitations, high latency, and weather-induced instability. This bimodal distribution of service quality constitutes a manifestation of the digital divide operating at the intra-district level, creating what van Dijk (2020) terms a "digital inequality gradient" that compounds spatial marginalization with reduced opportunities for socioeconomic advancement. The findings strongly support H2 and H3, confirming that infrastructure only policies have been insufficient to address the multi-dimensional character of digital access inequality, and that the persistent reliance on V-Sat reflects an inadequate response to the place specific characteristics of border communities.

4.2. Implementation of Strategy and Multi-Stakeholder Collaboration Patterns

The implementation of Diskominfo's Mahakam Ulu's telecommunications policy strategy is structured around a network governance model (Klijn & Koppenjan, 2012) in which three primary actors perform distinct but complementary roles. Diskominfo, as the regional telecommunications authority, serves as facilitator, local regulator, and inter institutional coordinator. This role is operationalized through cross sector advocacy to the central government, issuance of regional regulatory instruments including a draft Regional Regulation (Perda) on the ICT Infrastructure Master Plan and a Regent's Regulation (Perbup) on BTS tower management, and direct technical oversight of regency owned infrastructure. The central government, through BAKTI under the Ministry of Communication and Information Technology, functions as the largest infrastructure provider, owning 33 of 49 BTS towers (67.3%). However, the effectiveness of this relationship is substantially compromised by structural weaknesses in vertical coordination. The inactivity of 11 of BAKTI's 33 towers represents a critical governance failure, as the regional government lacks the legal authority to directly intervene in, repair, or modify centrally owned infrastructure assets creating a situation of responsibility without authority that directly harms border communities. Bernadus Juk, S.T.,M.I.P, The Head of the ICT Infrastructure Division stated:

"We have repeatedly reported the condition of the inactive BAKTI towers to the central level. But the process is lengthy there are specific mechanisms that must be followed because the assets do not belong to the regional government. The regional government cannot directly intervene to repair them or provide the necessary facilities, even though communities in the field continue to pressure us as the agency held responsible, despite our limited authority." (Head of ICT Infrastructure Division, March 15, 2026)

The private sector, represented by Telkomsel, demonstrates the superior operational effectiveness of corporate governance mechanisms in asset management: all 5 commercially operated towers maintain active status, reflecting stringent maintenance protocols and clear accountability frameworks. The findings reveal a

fundamental contrast between the accountability mechanisms governing telecommunications infrastructure managed by private providers and those associated with publicly owned assets. While private providers tend to operate under clearer maintenance responsibilities and performance accountability standards, public telecommunications infrastructure is often characterized by more complex administrative procedures and fragmented institutional responsibilities. This condition has significant implications for infrastructure sustainability and maintenance effectiveness in remote and commercially marginal regions such as Mahakam Ulu. The study further indicates that limited digital literacy, uneven infrastructure distribution, and institutional capacity constraints continue to impede the effectiveness of digital governance initiatives in border areas. These challenges are compounded by weak inter-agency coordination and the limited availability of technical human resources, which reduce the government's ability to respond effectively to infrastructure disruptions. Consequently, successful digital transformation in Mahakam Ulu requires not only investments in telecommunications infrastructure but also integrated institutional support, strengthened governance mechanisms, and continuous competency development for public sector personnel.



Figure 1. BAKTI BTS Tower in Muara Ratah Village

At the field level, Jusfrans, S.Kom, the ICT Infrastructure Computer Administrator stated:

"Of the 11 regency-owned towers we manage, the 4 inactive ones have different problems some have damaged solar panels, some have antennas broken by strong winds, some were struck by lightning, and others due to the unwillingness of service providers to invest in those towers. Additionally, the procurement and replacement process for spare parts takes a long time because it must follow tender procedures. Meanwhile, some tower locations can only be reached by speedboat or boat along the river, then on foot up hills. So even when the budget is available, execution is not as straightforward as one might think." (ICT Infrastructure Computer Administrator, March 20, 2026)

In practice, four main challenges are encountered. First, geographical and accessibility constraints: Mahakam Ulu's topography, dominated by tropical rainforest traversed primarily by river transport, creates fundamental barriers to both infrastructure construction and routine maintenance. Operational costs for transporting materials and technical personnel to remote tower sites are extraordinarily high, making regular preventive maintenance economically unfeasible within existing budget envelopes. Rizal et al., (2026) identify this cost structure as the primary determinant of digital infrastructure inequality in 3T areas. Second, central budget dependency: the regional budget allocation of IDR 12.7 billion for 2021–2023 represents approximately 12–15% of the estimated actual infrastructure need of IDR 85–120 billion a structural funding gap that fundamentally limits regional autonomy and implementation capacity. Third, human resource limitations: Diskominfostandi Mahakam Ulu operates with a staff of only 23 personnel responsible for managing telecommunications infrastructure across an area of 15,315.11 km² a structural imbalance. Fourth, ecosystem development deficit: absence of offline capable e-government applications adapted to low bandwidth environments, and low community purchasing power for commercial internet subscriptions collectively hinder technology adoption even where physical infrastructure has been successfully deployed.

In response to these challenges, Diskominfo standi has implemented a phased digital literacy and capacity building program encompassing: structured training workshops for village government officials on digital administration tools; e-government operation training for sub-district and regency level civil servants; and digital business workshops oriented toward local wisdom based MSME development. Demonstrates that digital literacy programs tailored to specific local needs and delivered through participatory modalities generate significantly higher technology adoption rates compared to generic, standardized training programs a finding that reinforces the value of Diskominfo standi's localized programming approach, while also highlighting the current program's insufficient scale and reach. Complementing this, establishes that regulatory challenges in digital governance originate from outdated legal frameworks, fragmented institutional mandates, and limited digital literacy among civil servants precisely the constellation of barriers observable within Diskominfo standi Mahakam Ulu's policy environment, where interagency coordination deficits and limited civil servant digital proficiency compound the structural constraints of geographical remoteness.



Figure 1. Mahakam Ulu Regent Angela Idang Belawan opened the 2025 Dynamic Archives Management and Village Management Information System (SIPEKA) Workshop.

In a previous study conducted by (Harun, 2025) on digital governance, it was found that the success of digital governance depends on the continuous interaction between policy innovation, regulatory adaptability, and institutional learning. This finding is consistent with the efforts of Diskominfo standi Mahakam Ulu, which has implemented digital literacy programs for government officials and local communities to support regional digital transformation. Previous research also indicates that digital literacy programs tailored to local needs tend to achieve higher technology adoption rates than generic and standardized approaches. However, the effectiveness of these programs continues to face challenges related to limited human resource capacity, interagency coordination issues, and the remote geographical characteristics of the region.

4.3. Impact, Effectiveness, and Comparative Analysis

The evaluation of Diskominfo standi Mahakam Ulu's policy effectiveness reveals a complex and contradictory picture: measurable progress has been achieved in connectivity expansion and institutional capacity building, yet the fundamental digital divide between downstream and upstream communities remains structurally intact and socioeconomically consequential. In assessing impact across sectors, three domains warrant systematic analysis

In the education sector, the 15 villages covered by fiber optic connectivity have witnessed improved capacity for students and teachers to access digital learning platforms, online educational resources, and remote training opportunities a finding consistent observation that internet access quality is significantly positively correlated with educational service access. However, the 35 villages dependent on V-Sat technology face serious constraints in utilizing video based educational applications or data intensive learning platforms, effectively creating a two tier educational technology environment within a single administrative district.



Figure 2. Teaching and learning process for students at State Junior High School 5 Long Bagun using digital media

In public service delivery, improved connectivity at sub-district and regency government levels has facilitated administrative service processing and reduced reliance on in-person document submission but since most e-government platforms require stable connections and adequate bandwidth to function effectively, their utility in V-Sat-dependent areas remains severely constrained. Corroborates this dynamic by demonstrating that while digital marketing and digital platforms in public administration generate significant positive impacts on transparency and public satisfaction, their effectiveness is fundamentally conditional on adequate infrastructure and sufficient digital literacy conditions that remain unmet in Mahakam Ulu's V-Sat dependent border villages. Enduring government legitimacy in the digital era requires adaptive institutions that align data transparency and meaningful digital participation with citizen expectations a standard that Mahakam Ulu's border communities cannot experience so long as 70% of villages lack the connectivity quality necessary to access open government platforms.

Thomas Ding, A community leader from Long Pahangai stated:

"In some areas of Long Pahangai sub-district, cellular and 4G internet networks do exist, but signal quality is unstable with limited coverage, and internet speeds are still inadequate especially with so many users. Many areas also lack signal access entirely due to the absence of towers, and even where towers exist, they are not lit up or active." (Community Leader, Long Pahangai Sub-district, April 27, 2026)



Figure 3. Inactive Tower in Long Pakaq Village, Long Pahangai District

Petrus Ngo, A community leader from Long Apari similarly stated:

"Almost all villages in Long Apari sub-district have limited network coverage. Only the sub-district center has a reasonably adequate connection, and even that depends on weather and electricity. For villages far from the sub-district center, when there is a network outage or during the dry season, it becomes very difficult because fuel supplies and technicians need time to arrive here, as access to Long Apari sub-district is still by water." (Community Leader, Long Apari Sub-district, April 22, 2026)



Figure 4. Access to Long Apari District Still Uses River Routes

To contextualize these findings comparatively, Table 3 presents a systematic benchmarking analysis against findings from analogous border and remote district studies in Indonesia.

Table 4. Comparative Analysis of Telecommunications Policy Strategies Across Border/Remote Districts in Indonesia

Dimension	Mahakam Ulu (This Study)	Parigi Moutong – Juanda & Izzulhaq (2023)	Merauke Border – Rikardus (2026)
Primary Strategy	Multi-stakeholder collaboration + LEO satellite exploration	Blank-spot mapping + BTS construction + private partnerships	Contextual digital governance + local institutional strengthening
Key Challenge	Vertical coordination failure; 31% inactive towers	Budget constraints; uneven institutional capacity	Geographic isolation; human resource scarcity
Digital Literacy	Phased workshops; MSME focus; limited reach	Integrated community training programs	Localized programs aligned with cultural context
Outcome	Partial progress; persistent divide upstream	Improved penetration in district capital areas	Improved governance responsiveness
Policy Model	Place-based; adaptive technology	Supply-driven; central government-led	Demand-responsive; bottom-up participation

Table 3 reveals that Mahakam Ulu shares core challenges geographical barriers, budget constraints, and human resource scarcity with comparable districts, but is distinctive in the severity of its vertical coordination failure and the extent of its infrastructure inactivity rate. While Parigi Moutong achieved better connectivity outcomes through a more supply driven, centrally supported approach, and Merauke generated governance responsiveness through bottom up participation, Mahakam Ulu's experience suggests that neither approach alone is sufficient: a synthesis of adaptive technology solutions, institutionalized coordination mechanisms, and community-centered digital empowerment is required. The budget analysis presented in Table 4 further illuminates the structural resource gap constraining policy effectiveness.

Table 5. Budget Allocation and Infrastructure Investment Analysis, Diskominfostandi Mahakam Ulu, 2021–2023

No.	Program / Activity	Budget Allocated (IDR)	Period	Outcome
1	BTS Tower Construction (2 towers)	8,400,000,000	2021–2023	Completed; operational
2	BTS Maintenance & Operations (7 towers)	4,300,000,000	2021–2023	Ongoing; 4 towers inactive

3	Digital Literacy & Capacity Building	520,000,000	2022–2023	Phase 1 completed
4	Estimated Infrastructure Deficit	72,300,000,000–107,300,000,000	2021–2023	Unfunded gap

Table 4 reveals that total regional budget allocations for telecommunications infrastructure (IDR 12.72 billion) represent a mere 11–15% of the estimated actual need (IDR 85–120 billion). This funding gap reflects a structural constraint that cannot be resolved through regional fiscal means alone, reinforcing the imperative for more robust vertical fiscal transfers and central government co financing arrangements. Transparent and evidence based budget advocacy supported by systematic documentation of infrastructure deficits and their socioeconomic consequences constitutes an important institutional capacity that Diskominfo standi must further develop to effectively compete for expanded national budget allocations. Theoretically, these findings present a complex relationship with the study's hypotheses. H1 is supported: collaborative governance failures specifically in vertical central regional coordination are demonstrably associated with infrastructure inactivity and service delivery gaps, confirming the theoretical primacy of institutional coordination mechanisms. H2 is partially supported: while Diskominfo standi has extended physical infrastructure and initiated digital literacy programming, the four dimensional framework of digital access reveals persistent deficits in skills development, usage quality, and motivational engagement particularly in V-Sat dependent communities. H3 is supported: the evidence strongly indicates that uniform national policy frameworks exemplified by BAKTI's infrastructure provision without commensurate maintenance accountability are inadequate to address Mahakam Ulu's place specific challenges. H4 is supported: the contrast between Telkomsel's 100% tower activation rate and BAKTI's 66.7% rate empirically validates the theoretical proposition that clear maintenance accountability frameworks are determinants of infrastructure operational effectiveness.

The recommended future policy model for the 3T telecommunications context, must simultaneously integrate three strategic pillars: (1) Adaptive Infrastructure in the short term, prioritizing the deployment of Low Earth Orbit (LEO) satellite technologies such as Starlink to provide immediate broadband quality connectivity to border villages, while pursuing medium term fiber optic extension planning; (2) Institutional Capacity strengthening Diskominfo standi's technical human resource capacity, establishing IoT based remote monitoring systems for BTS towers, and formalizing inter agency coordination protocols with legally binding maintenance accountability provisions; and (3) Inclusive Digital Ecosystem developing local language digital content, offline capable e-government applications adapted to low bandwidth environments, and structured digital economic empowerment programs that directly generate measurable income improvements for border community MSMEs. Consistent with recent digital governance studies, digital participation fosters more inclusive and responsive governance by strengthening citizen engagement, improving access to public services, and enhancing the government's ability to respond to local need (Prasodjo, 2025). Therefore, the development of an inclusive digital ecosystem should become a central component of telecommunications policy in Mahakam Ulu, ensuring that investments in infrastructure are translated into meaningful social and economic outcomes for local communities.

V. Conclusion

This study has evaluated the strategy of Diskominfo standi Mahakam Ulu in bridging the digital divide in border areas through a comprehensive qualitative analysis integrating primary interview data, field observations, document analysis, and comparative benchmarking against analogous regional contexts. The findings yield several significant conclusions with theoretical and practical implications for digital inclusion policy in Indonesia's 3T border regions. This study concludes that Diskominfo standi Mahakam Ulu has implemented a reasonably comprehensive policy strategy to improve the equalization of telecommunications and internet services in border areas, encompassing strategies for collaborative

infrastructure development, digital human resource capacity building, and strengthening of regional telecommunications regulations. However, the effectiveness of implementing these strategies remains highly limited due to extreme geographical constraints, financial and institutional dependence on the central government, and limited regional institutional capacity. The research findings indicate a serious infrastructure governance failure, evidenced by the non operation of 15 of 49 BTS towers (31%) and the continued reliance of 70% of villages on the limited V-Sat technology. The sharp digital divide between downstream areas (Long Bagun and surroundings) and upstream border areas (Long Pahangai and Long Apari) requires more targeted, locally contextualized policy responses.

The study confirms that the digital divide in Mahakam Ulu is not a narrowly technical problem resolvable through infrastructure construction alone, but a complex governance challenge rooted in coordination failures, resource misalignments, and the inadequacy of uniform national policy frameworks in place-specific border contexts. This finding has broader implications for national telecommunications policy, suggesting that the standard BAKTI model infrastructure provision without embedded maintenance accountability is structurally insufficient for 3T border regions. Based on these findings, this study advances six specific, actionable recommendations for relevant stakeholders. First, the central government should develop and institutionalize a formal inter agency coordination framework governing BAKTI infrastructure in border districts, with legally binding maintenance service level agreements, performance monitoring mechanisms, and clearly delineated accountability for inactive towers. Second, Diskominfo Mahakam Ulu should pilot the deployment of LEO satellite technology (notably Starlink) in Long Pahangai and Long Apari sub-districts as an emergency connectivity solution while longer-term fiber optic extension planning proceeds. Third, the Ministry of Finance and Ministry of Home Affairs should collaboratively develop an asymmetric fiscal transfer mechanism specifically for 3T border districts to address structural funding gaps in telecommunications infrastructure. Fourth, Diskominfo should develop a structured multi-year human resource capacity building program aligned with ICT infrastructure management competency frameworks, in partnership with relevant universities and professional institutions. Fifth, digital empowerment programs should be redesigned on a community co-design basis actively involving border community leaders in identifying content priorities, service modalities, and program implementation approaches to maximize local relevance and technology adoption rates. Sixth, future research should pursue longitudinal assessment of connectivity changes in Mahakam Ulu following the national Palapa Ring and LEO satellite expansion programs, and comparative analysis across all 3T border districts in Indonesian Borneo to identify systematic regional patterns and scalable policy solutions.

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