

ADAPTIVE EDUCATIONAL RESOURCE MANAGEMENT IN REMOTE SCHOOLS: A CASE STUDY OF INFRASTRUCTURE AND ICT CHALLENGES AT SDN BATU TUNAU, INDONESIA

Muhammad Yahyadin¹; Muhammad Ahdar²; Rusidah³; Ahmad Suriansyah⁴; Aslamiyah⁵

^{1,2,3,4,5}Universitas Lambung Mangkurat, Indonesia

¹Corresponding E-mail: abduh7815@gmail.com

Abstract

This research investigates how adaptive educational resource management operates in remote school environments where infrastructure and information and communication technology (ICT) limitations create persistent managerial challenges. Focusing on SDN Batu Tunau, a public elementary school located on an island in South Kalimantan, Indonesia, the study explores the strategies administrators employ to sustain educational operations under physical and digital isolation. Using a qualitative descriptive case-study approach, data were collected through semi-structured interviews, field observations, and document analysis. The findings indicate that managerial functions are constrained by two critical external barriers: the physical inaccessibility of the school and the unreliability of internet connectivity. These barriers undermine logistical efficiency, routine maintenance, and digital administration such as Dapodik data reporting and ANBK assessment preparation. Nevertheless, the school demonstrates a form of reactive adaptive management characterized by local innovation, community collaboration, and an “offline-first” orientation in administrative and instructional processes. The study advances the theoretical understanding of adaptive management in education by framing it as a dual-layered system that links internal responsiveness to external policy environments. The paper concludes with practical and policy recommendations for strengthening infrastructure equity and managerial capacity in rural and island schools.

Keywords: *Educational Management, Adaptive Management, Infrastructure, ICT, Rural Education*

A. Introduction

Educational systems across the global South continue to confront persistent structural disparities, where the quality of schooling is fundamentally shaped by how effectively institutions manage their available resources amid chronic constraints. Educational resource management conceptualized as an integrated process of planning, allocating, utilizing, and evaluating institutional assets has increasingly become central to debates on school effectiveness, equity, and resilience (Bafadal, 2021; Siagian, 2019). Traditionally, the discourse focused on physical resources and human capital; however, in the twenty-first century, infrastructure quality and information and communication technology (ICT) capacity have emerged as decisive determinants of institutional

performance (Nguyen & Tran, 2022). Infrastructure forms the material environment that enables functional schooling, while ICT serves as the backbone of data administration, pedagogical innovation, and digital accountability systems (Arcaro, 2021).

Indonesia's complex geography an archipelago of more than 17,000 islands intensifies these challenges by producing uneven development trajectories and access to public services. National educational reforms such as *Merdeka Belajar*, *Asesmen Nasional Berbasis Komputer* (ANBK), and the *Platform Merdeka Mengajar* implicitly assume a baseline of digital connectivity, stable electricity, and adequate infrastructure. Yet empirical reports indicate that many schools in rural, island, and frontier (3T) regions operate with fragile road access, minimal maintenance capacity, unstable internet connectivity, and intermittent electric power (Warsihna, 2013; UNESCO, 2022). These conditions create what scholars identify as a dual-accessibility gap physical and digital that directly shapes managerial decision-making and institutional survival (Hassan et al., 2023).

Within such contexts, school leaders must navigate a structural mismatch between centralized policy expectations and local operational realities. Managerial practice becomes inherently adaptive, shaped by cycles of improvisation, situational prioritization, and collaborative problem-solving patterns that resonate with Holling's (1978) theory of adaptive persistence in complex systems. Rather than operating through linear planning models, principals in remote settings frequently engage in iterative, feedback-driven decision processes, adjusting strategies to environmental uncertainties and resource limitations (Lee, 1999; Dewi & Iskandar, 2021). Thus, remote schooling environments serve as natural laboratories for examining adaptive management as both a conceptual framework and a lived managerial practice.

However, scholarly attention remains uneven and disproportionately centered on urban or peri-urban cases. Studies in Indonesia and comparable developing countries mainly document digital transformation and infrastructure management in relatively connected regions (Komba et al., 2022; Mulenga & Daka, 2020). Conversely, managerial experiences within geographically isolated primary schools particularly how they adapt to infrastructural and ICT constraints remain underexamined. Global ICT literature extensively discusses the *digital divide*, yet rarely integrates it with leadership studies, organizational learning, or adaptive governance at the basic-education level (Van Dijk, 2020; Adebayo et al., 2021). Moreover, empirical research often lacks qualitative depth, limiting theoretical understanding of how principals and teachers interpret, negotiate, and respond to systemic inequity (Rahman et al., 2024).

The case of SDN Batu Tunau offers a strategically significant site for addressing this gap. Geographically isolated, accessible only through unpaved coastal roads, and characterized by unstable electricity and limited internet, the school nevertheless complies with national administrative and digital mandates including ANBK participation, digital data submission via Dapodik, and mandatory involvement in online professional-development platforms. This paradox severe infrastructural marginality alongside compliance with digital governance positions SDN Batu Tunau as an exemplary case of adaptive educational resource management. The school's ability to operate within extreme

constraints suggests the presence of context-specific strategies that accommodate both physical and ICT limitations through iterative learning, flexible planning, community involvement, and the use of offline-first digital practices (Nguyen et al., 2023; Hidayat & Assegaf, 2023).

Anchoring the study within adaptive-management theory strengthens its methodological and analytical interpretation. Adaptive management, originating in ecological systems theory (Holling, 1978), emphasizes iterative cycles of planning, action, monitoring, and adjustment in response to environmental feedback. Applied to education, the framework underscores institutional learning, distributed leadership, and real-time responsiveness to contextual change (Arcaro, 2021; Khan & Ahmed, 2022). In remote school environments, managerial adaptation does not merely reflect administrative competence but constitutes an essential mechanism for organizational resilience.

Beyond theoretical alignment, this study contributes empirically to underdeveloped domains within the educational-management literature. First, it provides micro-level evidence of infrastructure and ICT governance under dual constraints areas commonly treated separately in prior studies. Second, it foregrounds the lived realities of school leaders and teachers in geographically marginalized contexts, where managerial agency is inseparable from community partnership, socio-cultural systems, and logistical constraints. Third, the study demonstrates how adaptive-management cycles manifest organically within resource-poor settings, offering conceptual refinement to existing frameworks often developed in well-resourced environments.

The objective of this research is therefore to analyze the adaptive strategies employed by SDN Batu Tunau in the management of educational resources, with specific attention to infrastructure and ICT. Through an interpretive qualitative approach, the study seeks to illuminate how environmental constraints shape managerial cognition, decision-making, and organizational learning. By situating these findings within broader theoretical debates on adaptive governance and educational equity, the study aims to advance multidimensional understanding of how schools sustain operations under systemic inequality.

The significance of this research extends to both policy and practice. For policymakers, the findings underscore the need for differentiated governance models that accommodate infrastructural disparities across Indonesia's diverse regions. Standardized digital mandates risk deepening inequality when they do not consider local connectivity conditions (UNESCO, 2022; Rahman et al., 2024). For practitioners, particularly principals and district supervisors, the study offers empirically grounded strategies for low-resource management, including hybrid offline-online systems, collaborative maintenance models, and expanded community involvement.

Positioned at the intersection of educational management, adaptive governance, and rural education studies, this research reframes remote schools not merely as deficit spaces but as environments where resilience, contextualized leadership, and adaptive capacity shape everyday educational survival. Such reframing is essential for developing inclusive,

evidence-based policy and strengthening theoretical accounts of educational management within developing countries

B. Method

Research Design

This study employed a qualitative descriptive case-study design to explore adaptive educational resource management practices at SDN Batu Tunau, a remote elementary school in Pulau Laut Timur District, Kotabaru Regency, South Kalimantan, Indonesia. The qualitative approach was chosen to capture contextual depth, interpret meaning, and understand managerial strategies as experienced by school stakeholders (Creswell & Poth, 2018). A single-case design was adopted following Yin (2018), as the site represents a *typical case* of remote school conditions in Indonesia's 3T (frontier, outermost, least-developed) areas. The case study's boundary focused on the school's managerial processes related to physical infrastructure and information technology (TI) between February and April 2025.

Research Site and Context

SDN Batu Tunau is a small public elementary school located approximately 90 kilometers from the capital of Kotabaru Regency. Access to the school requires traversing unpaved coastal roads and crossing hilly terrain, which becomes impassable during heavy rain. The school consists of six classrooms, a teacher's office, a small library, and a multipurpose room shared for computer-based assessments (ANBK). Electricity is available but unstable; power outages occur weekly. Internet access relies on a mobile router using prepaid data, which fluctuates due to weak signal strength. These physical and digital barriers significantly influence how the school manages logistics, teaching materials, and digital administration. Despite the constraints, SDN Batu Tunau serves 98 students and employs seven teachers (including the principal). It participates in national data systems such as *Dapodik* (Educational Data Center) and ANBK (Computer-Based National Assessment), fulfilling administrative mandates while adapting to infrastructural limitations.

Participants

Participants were selected through purposive sampling (Miles et al., 2020) to ensure diversity of managerial perspectives. They included:

- a. The Principal : as the primary decision-maker in planning and administration.
 - b. Three Teachers: representing instructional management and ICT utilization.
 - c. One Administrative Staff: responsible for data entry and reporting.
- a. All participants had served at the school for more than three years, providing longitudinal insight into adaptive management evolution.

Data Collection Techniques

- Data were gathered through triangulated methods to ensure validity and richness:
1. Semi-structured Interviews Conducted individually in the school office, each lasting 45–60 minutes. Topics included: planning and maintenance of facilities, ICT utilization, digital challenges, and adaptation strategies. Interviews were audio-

recorded (with consent) and transcribed verbatim in Bahasa Indonesia, later translated into English for analysis.

2. **Direct Observations** The researcher spent one week at the site observing classrooms, the computer lab, and administrative work. Field notes documented real-time adaptations such as paper-based backups for digital reporting and improvised use of smartphones for data upload.
3. **Document Analysis** Reviewed school budgets (*Rencana Kegiatan dan Anggaran Sekolah*), maintenance logs, *Dapodik* synchronization records, and local education office correspondence.

This triangulation of interviews, observation, and documentation enhanced credibility (Lincoln & Guba, 1985) and ensured that interpretations reflected reality from multiple perspectives.

Data Analysis Procedures

Thematic analysis was used following Braun and Clarke's (2019) six-phase model:

- a. **Familiarization:** repeated reading of transcripts and field notes.
 - b. **Coding:** assigning labels to key managerial actions, challenges, and responses.
 - c. **Theme Development:** clustering similar codes into higher-order categories (e.g., "infrastructure logistics," "digital improvisation").
 - d. **Reviewing Themes:** cross-checking themes against raw data for coherence.
 - e. **Defining and Naming:** refining definitions (e.g., "reactive adaptation," "community maintenance").
 - f. **Reporting:** synthesizing findings into coherent narrative descriptions.
- a. NVivo 14 software was employed to organize transcripts, codes, and memos, facilitating transparency in analytic decisions.

Trustworthiness and Ethical Considerations

Trustworthiness was ensured through credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985):

- a. **Credibility:** achieved through prolonged engagement and member checking—participants reviewed summaries of interpreted data.
- b. **Transferability:** thick description of context enables potential application to similar settings.
- c. **Dependability:** maintained via an audit trail documenting decisions during analysis.
- d. **Confirmability:** ensured through peer debriefing with two educational management experts from Universitas Lambung Mangkurat.

Ethical clearance was obtained from the Kotabaru District Education Office. Participants provided written informed consent, and pseudonyms were used to protect anonymity.

C. Finding and Discussion

1. Finding

a. Operational Adaptation: Managing Daily Limitations

Operational adaptation refers to how the school modifies daily routines to ensure administrative continuity despite infrastructural deficits. Observation and interview data

indicate that the administrative staff employs an offline-first strategy: all *Dapodik* forms are completed offline using Excel templates before being synchronized in town once or twice a month.

“When the signal drops, we keep working with the offline files,” said the administrative staff. “Then, when I go to the district office, I upload everything at once.”

Teachers also demonstrated innovation in ICT usage. Without stable internet, they download teaching materials and video lessons while visiting relatives in the city, saving them on flash drives for classroom use. This proactive preparation allows the continuation of ICT-based learning despite network unreliability, mirroring findings by Rahman et al. (2024) on hybrid offline resource utilization. Maintenance operations also show adaptation. Instead of waiting for contractors, the school community—teachers and parents—undertake small repairs, a reflection of *gotong royong* (mutual aid) culture. Such community-led maintenance aligns with Mulenga and Daka’s (2020) argument that collective participation compensates for fiscal and logistical deficits.

b. Strategic Adaptation: Reconfiguring Plans and Budgets

Strategic adaptation is observed in how the principal redefines priorities within budget limitations. The annual *Rencana Kerja Sekolah* (RKS) shows a deliberate shift: funds previously allocated for extracurricular programs are redirected toward transportation and data costs. The principal explained:

“Transporting supplies costs more than the items themselves. We must prioritize what keeps the school functional.”

This reallocation illustrates adaptive budgeting an iterative response to external constraints. It reflects Arcaro’s (2021) concept of “feedback-based resource alignment,” where managerial planning evolves according to environmental feedback. In ICT management, the school adopted a *rotational access* schedule: each teacher has assigned time slots for using the limited data router to minimize signal congestion. Moreover, all digital assessment preparations (ANBK) are conducted two weeks in advance, anticipating potential power outages.

c. Collaborative Adaptation: Networks and Partnerships

Collaboration emerges as a critical adaptive mechanism. The school leverages community networks and local institutions to fill logistical and technical gaps. Parents contribute through voluntary labor and donations of materials, while the village government provides occasional support for generator fuel. The principal also maintains communication with the district education office to negotiate deadline extensions for data reporting when connectivity fails.

An interesting example of *adaptive networking* is the informal cooperation with a nearby telecommunication officer who assists in reconfiguring routers during signal drops. This relational strategy demonstrates how leadership extends beyond formal authority into social capital mobilization (Nguyen et al., 2023). Teachers, too, form peer networks across WhatsApp groups with colleagues from other schools to share

downloadable teaching media. Such peer support constitutes a *distributed leadership practice* (Bass & Riggio, 2006), where innovation is collectively produced rather than individually initiated.

d. Managerial Tensions and Learning Loops

While adaptation allows continuity, it also generates managerial tensions. Teachers often feel overburdened as they juggle instructional tasks and technical troubleshooting. Moreover, delayed maintenance and expensive logistics create psychological stress on the principal, who must constantly negotiate priorities. Yet these challenges also foster institutional learning. As one teacher reflected:

“We have learned to plan differently always have Plan B, and sometimes Plan C.”

This learning-oriented mindset embodies Holling’s (1978) adaptive cycle, where disturbance prompts innovation, leading to new equilibrium states. Through reflection and adjustment, SDN Batu Tunau gradually transforms constraints into opportunities for collective problem-solving.

e. Emergent Themes

From the analysis, five dominant themes emerged (Table 1 summarizes them):

Theme	Description	Illustrative Evidence
Dual Access Constraints	Physical remoteness and digital instability jointly hinder operations.	“Sometimes we can’t even send reports because both road and signal fail.”
Offline-First Management	Prioritizing offline documentation, later synchronized online.	“We keep Excel backups to upload later in town.”
Adaptive Budgeting	Shifting financial priorities toward operational survival.	“We cut extracurriculars to pay for fuel and transport.”
Community Maintenance	Utilizing parents and local labor for minor repairs.	Observation: parents fixing classroom ceiling.
Collaborative Networking	Building informal support with local technicians and nearby schools.	“The telco officer helps when the router fails.”

These themes together illustrate the micro-dynamics of adaptive educational resource management, wherein leadership, culture, and environment interact continuously to sustain school functionality.

2. Discussion

The findings of this study reveal a multilayered pattern of adaptation enacted by SDN Batu Tunau in response to physical and digital constraints. These results contribute to the broader discourse on resource management in remote schools by illustrating how actors transform structural limitations into operational strategies. In addition, this section clarifies how these practices may be transferable to other 3T contexts, addressing the reviewer’s concern about external applicability.

a. Interpretation of Key Findings

The results demonstrate that SDN Batu Tunau's operations are profoundly shaped by two external constraints limited physical access and unstable digital connectivity but these constraints have not led to managerial paralysis. Instead, the principal and teachers have institutionalized a repertoire of adaptive practices that correspond to the stages of the management cycle identified by Bafadal (2021): planning, procurement, utilization, and maintenance. This confirms Arcaro's (2021) assertion that quality management in education depends on an ongoing dialogue between environmental conditions and managerial feedback loops. The "offline-first" documentation system represents a contextual innovation that allows continuity of administrative functions even when technological resources are inconsistent. Similar hybrid solutions have been reported in other low-resource settings: Mulenga and Daka (2020) observed that Zambian rural schools used paper-digital synchronization to circumvent poor networks; Rahman et al. (2024) documented comparable practices in Bangladesh. These convergent findings highlight that adaptive management is not a reactive improvisation but a systematic learning process derived from repeated encounters with disruption.

Adaptive budgeting redirecting funds from extracurricular activities to logistics illustrates strategic realignment within Siagian's (2019) framework of resource prioritization. Rather than reflecting financial mismanagement, such reallocation reveals a managerial understanding of sustainability: schools first secure operational viability before pursuing enrichment programs. This echoes OECD (2021) analyses that effective school leaders prioritize "core process maintenance" during resource shocks.

b. Adaptive Management and Educational Leadership

Leadership emerged as the keystone of adaptation. The principal's decision-making behavior exemplifies transformational leadership (Bass & Riggio, 2006) because it inspires collective ownership of the school's problems. Teachers described the principal as "working with us, not above us," a relational stance consistent with Nguyen et al. (2023), who link distributed leadership to successful digital transformation in Southeast-Asian schools. The continuous reflection and adjustment observed at SDN Batu Tunau mirror the adaptive-cycle model of Holling (1978): exploitation → conservation → release → reorganization. Each budget cycle begins with experimentation, experiences constraint, and culminates in institutional learning. Lee (1999) emphasized that adaptive systems thrive through feedback; the school's quarterly meetings function as feedback nodes where teachers evaluate outcomes and plan modifications. This participatory reflection exemplifies Arcaro's (2021) "learning-organization" principle within educational management.

Crucially, adaptive management here extends beyond formal structures into **social** networks. The collaboration with the local telecommunications officer and parental volunteers broadens managerial boundaries to include community expertise. Dewi and

Iskandar (2021) similarly found that Indonesian principals during the COVID-19 pandemic relied on informal community linkages to sustain blended learning. Such networks reconfigure leadership as a **collective agency** that transcends hierarchical limits (Nguyen et al., 2023).

c. Strategic Resource Re-allocation and Policy Feedback

The study also uncovers how micro-level adjustments generate policy feedback loops (Khan & Ahmed, 2022). For example, when the principal negotiates deadline extensions with district officials, these interactions gradually sensitize policymakers to infrastructural realities on the periphery. Over time, such communication can stimulate adaptive policy reform—aligning with UNESCO’s (2022) call for multi-scalar feedback between local practice and national regulation. Comparatively, Mulenga and Daka (2020) reported that participatory planning in rural Zambia produced similar upward feedback, influencing district-budget guidelines. Thus, SDN Batu Tunau’s experience demonstrates that adaptive management can act as a bottom-up innovation mechanism, complementing top-down policy directives. Rather than perceiving deviations from national plans as non-compliance, policymakers should interpret them as *contextual calibration* necessary for systemic resilience.

The practice of reallocating funds for transportation and fuel aligns with strategic-alignment theory in public-sector management, which stresses the dynamic fit between internal capacities and external contingencies (OECD, 2021). By embedding flexibility into planning, the school ensures that financial management remains responsive without breaching accountability standards.

d. Community Engagement and Cultural Capital

A distinctive element in the Indonesian context is the principle of collective mutual aid which underpins community-based maintenance at SDN Batu Tunau. This socio-cultural asset converts limited fiscal resources into labor capital, reinforcing the argument by Hasanah et al. (2023) that cultural capital can substitute for economic capital in sustaining rural schools. Parents’ voluntary participation also enhances social trust and ownership, outcomes that international literature identifies as critical for long-term infrastructure care (World Bank, 2021). Community engagement thus serves as both a practical resource strategy and an ethical dimension of educational leadership. It legitimizes the school as a communal institution rather than an isolated bureaucratic entity. The synergy between formal management and informal culture supports Arcaro’s (2021) proposition that quality education flourishes where institutional processes align with local values.

e. Adaptive Management and Educational Equity

From a macro perspective, the case underscores structural inequities in Indonesia’s education system. National digital initiatives such as ANBK and *Dapodik* presuppose stable infrastructure, inadvertently marginalizing remote schools. UNESCO (2022) and van Dijk (2020) caution that technology-driven reforms can widen inequalities when access gaps

persist. The evidence from SDN Batu Tunau confirms this risk: digital mandates without infrastructural parity compel schools to divert scarce resources toward connectivity rather than pedagogy. However, the same constraints also generate institutional creativity. Offline-first administration, local data caching, and peer-sharing networks represent low-cost innovations that maintain inclusion. These findings reinforce Adebayo et al. (2021), who documented similar creative resilience among Kenyan rural educators. Consequently, adaptive management becomes both a *mitigation strategy* against inequality and a *critique* of policies that assume uniform readiness.

f. Toward a Dual-Constraint Adaptive-Cycle Model

Integrating these insights, the study proposes the Dual-Constraint Adaptive-Cycle Model (DCACM) (Figure 4 to be inserted). The model posits that remote schools operate within two interdependent feedback loops:

- a) Physical-Access Loop: concerns logistics, maintenance, and budgetary adjustments;
- b) Digital-Access Loop: concerns connectivity, data synchronization, and pedagogical technology.

When disruption occurs in either loop, the school activates a learning cycle consisting of: sensing → interpreting → acting → reflecting. Through repeated cycles, the institution develops *adaptive capacity*—the ability to anticipate future constraints. This theoretical refinement extends Holling's (1978) adaptive-cycle concept into organizational education, offering a framework for future empirical testing.

g. International Comparison and Generalization

Although rooted in Indonesia, the findings resonate with global scholarship on rural education. In the Philippines, Bautista and Manalo (2021) identified comparable adaptive responses community repair programs and local ICT pooling. In Nigeria, Nwosu et al. (2023) observed that principals who practiced flexible budgeting achieved better facility longevity. Such convergences suggest that adaptive educational management is an emerging *global south paradigm* characterized by improvisation, social capital, and iterative learning. Nevertheless, contextual differences remain. The Indonesian emphasis on *gotong royong* provides a cultural foundation for collaboration rarely institutionalized elsewhere. This cultural embeddedness transforms adaptation from a managerial necessity into a collective moral practice. As Arcaro (2021) argues, enduring educational quality depends on values as much as on systems.

h. Implications for Theory and Practice

Theoretically, this study advances educational-management discourse in three ways:

1. Contextualization: It situates adaptive management within the micro-politics of a rural primary school, enriching largely macro-level discussions.
2. Integration: It fuses infrastructural and digital dimensions into a unified dual-constraint model.

3. Process Orientation: It illustrates that adaptation unfolds through iterative reflection, confirming education as a *learning organization* (Arcaro, 2021).

Practically, the findings recommend that school leaders in resource-poor settings institutionalize feedback mechanisms regular reviews, community consultations, and peer exchanges to transform short-term coping into long-term learning. Policymakers should recognize adaptive variance as a marker of competence rather than deviation, adjusting evaluation metrics accordingly.

E. Conclusion

This study examined how SDN Batu Tunau an isolated Indonesian primary school manages its educational resources amid the twin pressures of physical remoteness and digital fragility. The evidence shows that instead of succumbing to structural disadvantage, the school continuously reorganizes its managerial routines. Through offline-first administration, adaptive budgeting, community participation, and informal networking, the institution maintains operational stability and educational continuity. These findings confirm that adaptive educational management is not merely an emergency reaction but a systemic learning mechanism. Each cycle of constraint generates new procedural knowledge, gradually institutionalized as local best practice. In Arcaro's (2021) terminology, SDN Batu Tunau functions as a "learning organization" in which feedback, reflection, and participation form the core of managerial quality.

G. Bibliography

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