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SCHOOL SERVICE RESILIENCE IN INDONESIA'S ARCHIPELAGIC REGIONS: A SYSTEMATIC REVIEW OF SPATIAL ACCESSIBILITY, DISTRIBUTION OF EDUCATIONAL PERSONNEL, AND EDUCATIONAL LOGISTICS

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Abstract

Education in archipelagic regions faces structural challenges distinct from those in continental areas, particularly due to geographic fragmentation, limited transportation, the maldistribution of teachers, and vulnerabilities in infrastructure and logistics. This study aims to synthesize the literature on strategic issues in archipelagic education in Indonesia and to identify the mechanisms influencing the stability of school service delivery. The study employs a Systematic Literature Review approach following PRISMA guidelines, drawing on searches of the Scopus and Web of Science databases and official policy documents published between 2015 and 2024. A theory-informed thematic synthesis was used to identify causal pathways and intervariable relationships. The findings indicate that disparities in spatial accessibility disrupt service continuity through mobility constraints, high transportation costs, and unstable attendance. The maldistribution and low retention of teachers in disadvantaged, frontier, and remote (3T) areas exacerbate pedagogical instability, while infrastructural vulnerability and logistical delays increase the risk of operational disruptions in schools. These three dimensions form a systemic configuration that determines the resilience of educational service delivery in archipelagic regions.

Keywords: archipelagic education, spatial accessibility Disparities, teacher distribution, educational infrastructure resilience, school service delivery resilience.

INTRODUCTION

In the last decade, global discourse on educational equity has increasingly emphasized the importance of geographical context in determining the quality and sustainability of school services. Countries with archipelagic characteristics face structural challenges that differ from continental education systems, particularly in terms of territorial fragmentation, limited transportation, and vulnerability to natural disruptions (Trinidad et al., 2023; Nusche et al., 2016). In the context of Indonesia as the world's largest archipelagic nation, this complexity becomes even more significant because population distribution, infrastructure, and educational resources are spread across thousands of islands with varying degrees of remoteness (Afkar et al., 2020; World Bank, 2018). Recent literature indicates that these spatial inequalities directly affect learning quality, teacher distribution, and the effectiveness of regional educational governance (Trinidad et al., 2023; Afkar et al., 2020).

Educational problems in archipelagic areas are not merely related to unequal access, but also concern the stability of school services under uncertain geographical conditions. Sea transportation that depends on weather conditions, long inter-island distances, high mobility costs, and limited basic infrastructure create systemic constraints that increase vulnerability to service disruptions (Amri et al., 2022; Afkar et al., 2020). Within the framework of educational governance theory and public service resilience, this condition represents a challenge to service delivery resilience, namely the ability of the education system to maintain learning continuity in the face of structural and environmental disturbances (Trinidad et al., 2023; Amri et al., 2022). Therefore, education in archipelagic regions should be understood not only as an issue of equity, but also as a matter of educational system resilience in a geographically fragmented and shock-prone context (Nusche et al., 2016; World Bank, 2018).

Literature from the past ten years shows that education in remote areas of Indonesia has been analyzed through three main streams: spatial accessibility, human resource governance, and educational infrastructure and logistics. Recent studies confirm that geographical factors not only affect participation but also create systemic risks to the sustainability of educational services. Although each cluster has developed significantly, conceptual integration among variables within an educational system resilience framework remains relatively limited. Recent literature on education in remote areas of Indonesia can be grouped into three major approaches. First, the spatial accessibility approach highlights distance, travel time, and mobility costs as determinants of school participation. Studies within this cluster indicate that transportation infrastructure limitations correlate with higher dropout risks and lower attendance rates (Wicaksono et al., 2024; Pramana & Suryadarma, 2022; Suryadarma et al., 2018). These findings demonstrate that geographical barriers interact with household poverty as well as the quality of road networks and maritime transportation, thereby reinforcing regional educational inequality.

Second, the educational human resource governance approach focuses on teacher distribution and retention. This literature emphasizes the maldistribution of teachers, high turnover in disadvantaged, frontier, and outermost regions (3T), and the limited effectiveness of incentive policies (Fahmi et al., 2023; Chang et al., 2019). Empirical studies show that special allowance policies have not fully reduced disparities in teacher quality across regions because working conditions, access to public facilities, and professional support are important factors in sustaining teacher placement.

Third, the infrastructure and educational logistics approach examines school physical conditions, the distribution of learning facilities, and limited digital connectivity. Studies reveal that the vulnerability of coastal school buildings, limited electricity and internet access, and delays in the distribution of learning materials directly affect learning continuity (Sari et al., 2023; Kim & Nugroho, 2021). In the context of post-pandemic digital transformation, connectivity gaps have widened disparities in learning outcomes between remote and urban areas. Although these three clusters of literature have developed in parallel, conceptual integration among variables within a framework of educational service resilience in archipelagic regions remains limited and requires a more systemic interdisciplinary approach.

Cross-literature analysis reveals several important gaps in studies of education in remote and archipelagic areas. First, there is fragmentation of findings among studies on accessibility, teacher distribution, and infrastructure, without an integrative framework linking the three into a single systemic model (Fahmi et al., 2023; Pramana & Suryadarma, 2022). Second, most studies still treat these variables as independent factors rather than mechanisms that interact in shaping school service stability and learning sustainability (Trinidad et al., 2023; Kim & Nugroho, 2021). Third, archipelagic contexts are often simplified as ordinary rural areas, so dimensions such as maritime transportation, seasonal disruptions, and coastal disaster risks have not been adequately analyzed within a public service resilience framework (Amri et al., 2022; Sari et al., 2023). Conceptually, the absence of integration between geography, teacher governance, and educational logistics systems indicates the need for a synthesis based on the resilience of archipelagic education systems that combines multi-level governance approaches and a service delivery resilience perspective (Trinidad et al., 2023; Amri et al., 2022).

Given that the available literature is fragmented and dispersed across various conceptual approaches, a method capable of systematically identifying patterns, mechanisms, and structural relationships is required. The Systematic Literature Review (SLR) approach enables transparent and replicable mapping of the intellectual landscape while generating analytical syntheses beyond narrative summaries. Through SLR, this study not only inventories findings but also integrates spatial accessibility, teacher distribution, and infrastructure resilience within a framework of school service resilience in archipelagic regions.

This study aims to synthesize literature on strategic educational issues in Indonesia's archipelagic regions and to identify how spatial accessibility, the distribution of educational personnel, and infrastructure and educational logistics affect the stability of school services. Specifically, this study addresses the following questions: (1) how do spatial accessibility mechanisms affect the continuity of school services in archipelagic areas?; (2) how do teacher distribution and retention shape pedagogical stability in 3T regions?; and (3) how do infrastructure resilience and educational logistics determine the sustainability of learning processes in geographically vulnerable contexts?. Thus, this study contributes to the development of an integrated conceptual framework for archipelagic education based on system resilience.

Historical Context Of Education In Indonesia's Archipelagic Regions

The structural challenges faced by Indonesia's archipelagic education system today cannot be separated from the long historical dynamics that have shaped patterns of spatial inequality, teacher maldistribution, and infrastructure vulnerability. This historical review is not merely a chronological narrative, but an attempt to identify the causal roots of the problems that are the focus of this study namely, how the legacy of colonial policy, New Order centralism, and post-reform decentralization have cumulatively shaped the structural configuration of educational services in vulnerable and fragmented archipelagic regions.

During the Dutch colonial era, the education system in the Dutch East Indies was built with a selective orientation based on colonial administrative and economic interests. Formal schools were concentrated in administrative and commercial centers in Java, while the outer archipelagic regions particularly remote coastal areas and small islands were almost entirely unreached by formal education systems (Ricklefs, 2008). Geographic accessibility became a determining factor from the very beginning: inadequate maritime transportation, the absence of basic infrastructure, and policies that concentrated investment in strategically colonial territories created a spatially unequal pattern of educational service delivery that was structurally entrenched. This legacy laid the foundation for the spatial accessibility disparities that remain a central issue in Indonesian archipelagic education research today (Afkar et al., 2020).

After independence, the Indonesian government faced a colossal challenge in extending educational reach across the archipelago. School expansion programs in the 1970s–1980s, particularly through the SD Inpres (Presidential Instruction) elementary school policy, succeeded in dramatically increasing national participation rates, but their implementation continued to reproduce centralistic patterns in teacher distribution and infrastructure provision (Duflo, 2001). Teacher recruitment and placement were controlled by the central government through mechanisms that were not always responsive to the actual needs of archipelagic regions. As a result, teacher maldistribution between Java and outer islands, and between cities and remote islands, hardened as a structural problem beyond the capacity of sectoral policy alone. This is the historical root of the maldistribution and low teacher retention in 3T areas identified in contemporary studies (OECD, 2015; Fahmi et al., 2023).

The educational decentralization launched after the 1998–1999 reform through Law No. 22 of 1999 and subsequently Law No. 20 of 2003 on the National Education System granted greater authority to regional governments in managing education. Theoretically, decentralization was expected to improve policy responsiveness to local needs, including in archipelagic regions. However, in practice, uneven fiscal and institutional capacity across regions actually exacerbated disparities. Archipelagic regions with low tax bases, limited bureaucratic human resources, and logistical constraints in educational administration management faced difficulty in effectively utilizing this autonomy (World Bank, 2018; OECD, 2015). As a result, decentralization originally intended as a solution produced new inequalities in the provision of educational services in archipelagic regions.

From the perspective of infrastructure and logistics, the history of educational development in the Indonesian archipelago shows a pattern of disproportionate investment. School construction in coastal and remote island areas was often carried out without considering disaster risks, soil conditions, and long-term maintenance needs, making archipelagic school buildings historically more vulnerable to damage from environmental factors (Sari et al., 2023; BNPB, 2022). The distribution of teaching materials and learning equipment also faced endemic logistical challenges: limited maritime transport networks, dependence on irregular ship schedules, and the absence of an educational supply chain designed specifically for the archipelagic context. This historical legacy makes infrastructure vulnerability and the logistics system not merely contemporary technical problems, but an accumulation of long-term investment policy deficits that must be understood within the framework of archipelagic educational system resilience (Trinidad et al., 2023; Amri et al., 2022).

Thus, this historical review confirms that the issue of school service delivery resilience in Indonesia's archipelagic regions the focus of this systematic study is not a new phenomenon, but the result of overlapping layers of policy and structural legacies accumulated from the colonial era to the era of decentralization. Understanding this historical context provides an important foundation for interpreting the findings of the literature synthesis presented in the results and discussion section, while reinforcing the argument that a systems resilience approach is needed because the challenges faced are systemic and multi-layered, not merely technical problems solvable through a single intervention.

METHOD

1. Research Design

This study employed a Systematic Literature Review (SLR**)** approach to analyze strategic educational issues in Indonesia's archipelagic regions, focusing on disparities in spatial accessibility, resilience in the distribution of educational personnel, and the resilience of educational infrastructure and logistics. The SLR approach was selected because it enables a transparent, systematic, and replicable synthesis of literature, while supporting the development of a theory-based conceptual framework on school service delivery resilience. The review process followed the principles of the PRISMA protocol to ensure accountability in the identification and selection of studies.

2. Search Strategy

The literature search was conducted through Scopus and Web of Science as the primary sources of peer-reviewed articles, with Google Scholar used for additional verification. Official policy documents from the OECD**,** World Bank, BPS, Kemendikbud, and BNPB were also reviewed to strengthen the national context. Keywords were combined using Boolean operators, such as *"archipelagic education Indonesia," "remote islands education," "teacher distribution 3T Indonesia," "education logistics Indonesia,"* and *"school infrastructure resilience Indonesia."* The publication period was limited to 2015–2024 to ensure relevance to current educational policies and dynamics.

3. Inclusion and Exclusion Criteria

The inclusion criteria covered studies that explicitly discussed the Indonesian context, particularly archipelagic regions or disadvantaged, frontier, and outermost areas (3T regions), and demonstrated empirical relevance to educational accessibility, teacher distribution, or school infrastructure and logistics. Articles had to be indexed scientific publications or official policy reports with clearly identifiable data sources. Studies that were opinion-based, not focused on geographically remote areas, or lacking implications for school service delivery were excluded from the analysis. Time limitations and conceptual relevance were applied consistently.

4. Study Selection and Data Extraction

Study selection was conducted through three stages: title and abstract screening, full-text review, and final validation based on alignment with the analytical variables. Data were extracted using an analytical matrix covering regional context, conceptual focus, research methods, identified mechanisms, impacts on school services, and knowledge gaps. This process ensured consistency between the research objectives, research questions, and the structure of the synthesized findings.

5. Data Synthesis and Analytical Approach

The synthesis was carried out using a theory-informed thematic analysis approach. Themes were identified inductively from recurring patterns in the literature and then categorized according to the three main variables. The analysis focused on identifying causal pathways, inter-variable relationships, and knowledge structures shaping educational issues in archipelagic regions. This approach enabled the integration of geographical, institutional, and infrastructural dimensions within a single framework of school service resilience.

6. Rigor and Validity

Methodological rigor was maintained through cross-study comparisons to identify consistency, contextual differences, and fragmentation of findings. Documentation of the search strategy, selection criteria, and data extraction process was conducted systematically to ensure replicability.

RESULTS AND DISCUSSION

- *Spatial Accessibility Disparities in Education*

The literature on education in Indonesia's archipelagic regions consistently identifies spatial accessibility as a structural determinant of the sustainability of school services. Geographical fragmentation, inter-island distances, limited maritime transportation, long travel times, and high mobility costs create systemic barriers to educational participation. The studies reviewed indicate that spatial factors not only affect student and teacher attendance, but also have implications for the stability of learning processes and the overall effectiveness of school service delivery.

Table 1. Analytical Synthesis of the Literature on Spatial Accessibility Disparities in Education in Indonesia's Archipelagic Regions

Study	Archipelagic/3T Context	Specific Focus	Identified Mechanism	Impact on School Services	Knowledge Gap
Suraharta (2021)	Remote areas of Indonesia	Road infrastructure and school access	Poor infrastructure → Mobility barriers → Reduced attencance	Increases dropout rick and loss of instructional time	Does not specifically analyze maritime transportation
OECD (2015)	Remote regions of Indonesia	Inequality in educational access	Geographical distance → Participation inequality	Unequal service provision across regions	Not based on an archipelagic spatial model
World Bank (2020)	3T regions	School access and costs	High mobility costs → Participation barriers	Inequality in access to services	Limited analysis of seasonal disruptions
BPS (2022)	Archipelagic regions	Distance and travel time disparities	Long travel time → Reduced concentration and attedance	Reduced learning effectiveness	Not integrated with school service varibles

The analyzed literature indicates that spatial accessibility disparities in Indonesia's archipelagic and disadvantaged, frontier, and outermost **(**3T**)** regions are positioned as structural determinants of inequality in educational service delivery. Educational disparities in remote and island regions of Indonesia are consistently associated with spatial barriers and limitations in basic infrastructure. Suraharta emphasizes that unequal road infrastructure development in remote areas directly contributes to mobility barriers for students and teachers. OECD (2015), in its review of Indonesia's education system, identified geographical distance as a key factor widening disparities in educational participation across regions. Meanwhile, World Bank (2020) highlighted high mobility costs as a barrier to school access in 3T areas, particularly for low-income households. Statistical data from BPS (2022) reinforce these findings by showing that long travel times in archipelagic regions correlate with lower attendance and reduced learning effectiveness. These findings are consistent with the analyses of Suryadarma et al. and Pramana and Suryadarma, which show that geographical isolation and distance to school are significantly associated with lower educational participation and achievement, and are further supported by Wicaksono et al., who found that spatial inequalities in eastern Indonesia contribute to disparities in educational access. Overall, these studies focus on the dimensions of distance, cost, and travel time, but have not explicitly framed the issue within an integrated archipelagic education framework.

Cross-study synthesis identifies that spatial barriers operate through layered mechanisms linking geography to the stability of school services. Suraharta shows that poor infrastructure limits mobility, which in turn reduces student attendance and increases dropout risk. OECD (2015) confirms that long geographical distances create participation inequality, especially in remote areas with limited transportation access. World Bank (2020) extends this finding by emphasizing that high mobility costs not only restrict participation but also intensify service inequality across socioeconomic groups. BPS (2022) shows that long travel times lead to physical fatigue and reduced learning concentration. This perspective is further expanded by Fahmi et al., who linked geographical conditions to teacher distribution difficulties; Kim and Nugroho, who highlighted the digital connectivity gap as a new form of spatial barrier; and Amri et al., who positioned disaster risk and environmental disruptions as additional factors affecting the sustainability of educational services in vulnerable regions. Conceptually, these findings form the following causal pathway:

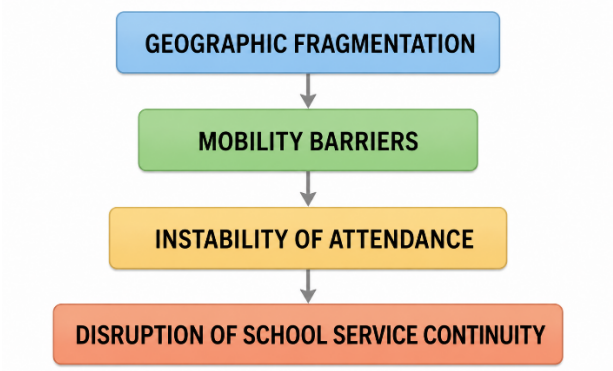

Figure 1. Causal Pathway of Geographic Fragmentation on the Disruption of School Service Continuity in Archipelagic Regions

Research trends indicate the dominance of macro-level approaches centered on regional inequality and statistics of educational participation (OECD, 2015; BPS, 2022), as well as evaluations of educational access policies (World Bank, 2020). However, the literature tends to treat accessibility as a single independent variable without integrating it with the dimension of school service resilience. Suraharta (2021), for example, focuses on road infrastructure but does not discuss the relationship between accessibility and the long-term operational stability of schools. Studies on geographical isolation and school participation show that distance and spatial barriers are strongly associated with inequalities in learning outcomes (Suryadarma et al., 2018; Pramana & Suryadarma, 2022), while recent analyses of spatial inequality confirm that eastern Indonesia faces more complex access burdens due to geographic fragmentation (Wicaksono et al., 2024). On the other hand, studies on educational governance in fragmented regions emphasize the importance of integrating geographical factors into policy design (Trinidad et al., 2023). Nevertheless, the main conceptual gap remains the absence of a model that integrates maritime transportation, seasonal disruptions, and geographical vulnerability as part of the archipelagic education system. As a result, spatial accessibility has not yet been positioned as a component of the resilience of school service delivery, but merely as an issue of unequal access.

Theoretically, the existing literature indicates the need for a shift from an access inequality approach toward a resilience framework for archipelagic education systems. Spatial accessibility should be understood as a factor that mediates the stability of school services, rather than merely a determinant of participation. Practically, the findings of Suraharta (2021) and the World Bank (2020) imply the importance of integrating transportation policies and mobility subsidies into educational planning for 3T regions. A public service resilience perspective in the context of disaster risk also suggests that environmental disruptions may weaken learning continuity if not anticipated through adaptive system design (Amri et al., 2022). In addition, unequal teacher distribution in remote areas demonstrates that geographical barriers interact with the institutional capacity of schools (Fahmi et al., 2023). However, limitations in the literature remain evident in the lack of longitudinal studies and the minimal analysis of the effects of weather disruptions on learning continuity. Therefore, future research should develop archipelagic spatial models based on island-region data that connect distance, cost, travel time, seasonal disruptions, and indicators of school service sustainability and learning outcomes.

- Resilience and Stability of Educational Personnel Distribution

The distribution and retention of educational personnel in archipelagic regions and disadvantaged, frontier, and outermost (3T) areas represent an institutional dimension that determines the resilience of educational services. The literature shows that teacher maldistribution, high turnover rates, and the limited effectiveness of special placement incentives create instability in the learning process. In the archipelagic context, geographical challenges intensify problems in teacher distribution governance, making the sustainability of school services highly dependent on the system's capacity to maintain the stability of educational personnel.

Table 2. Analytical Synthesis of the Literature on the Resilience and Stability of Educational Personnel Distribution in Indonesia

Study	Archipelagic/3T Context	Specific Focus	Identified Mechanism	Impact on School Services	Knowledge Gap
de Ree et al. (2018)	National (including remote areas)	Teacher salary increases	Finnacial incentives → Did not improve teacher effort	Stability of educational quality did not improve	Does not focus on tetention in archipelagic regions
Fahmi et al. (2019)	National	Teacher certification	Certification → Limited impact on learning quality	Reforms have not improved services in marginal regions	Does not distinguish urban areas vs small islands
OECD (2015)	Indonesia	Teacher distribution	Decentralization→ Placement inewuality	Teacher shortages in 3T regions	Not based on a resilience framework
World Bank (2020)	Indonesia	Educational personnel managemenet	Urban oversupply + remote shortages	Discontinuity of learning processes	No analysis of multi-grade teaching
Kemdikbud (2021)	3T regions	Teacher retention and rotation	Temporary placement → High turnover	Instability in learning processes	Limited longitudinal studies

The analyzed literature shows that the issue of teacher distribution in Indonesia is not merely related to quantitative shortages, but rather to structural maldistribution across regions, particularly in disadvantaged, frontier, and outermost (3T) areas and archipelagic regions. OECD (2015) identified inequalities in teacher placement as a consequence of decentralization governance that has not yet fully responded to geographical disparities. World Bank (2020) reinforced this finding by showing an oversupply of teachers in urban areas and significant shortages in remote regions. Cross-national analyses in developing countries also indicate that teacher distribution challenges in remote areas are closely linked to local governance capacity and needs-based recruitment mechanisms (UNESCO, 2023; Tournier et al., 2019). In the Indonesian context, studies on teacher management reform emphasize that the placement system has not yet been fully based on spatial mapping of schools' actual needs (Chang et al., 2019).

Meanwhile, de Ree et al., through an experimental evaluation of teacher salary reform, found that increased financial incentives do not automatically improve teacher performance or student learning outcomes. Fahmi et al. (2019) also found that teacher certification policies had only limited effects on classroom pedagogical practices. At the national policy level, Kemdikbud (2021) reported high teacher turnover and low retention rates in remote 3T regions. Recent studies on teacher distribution in remote Indonesia show that geographical barriers and limited public facilities are significant factors affecting the sustainability of teacher assignments Fahmi et al., while analyses of education systems in fragmented regions emphasize the importance of integrating teacher distribution policies with public service resilience strategies (Trinidad et al., 2023). Overall, these studies highlight dimensions of incentives, distribution governance, and placement stability, but have not yet fully connected them to an archipelagic education

service resilience framework that considers the interaction between geography, human resource policy, and the operational sustainability of schools. Thematic synthesis identifies three main mechanisms affecting the resilience of educational personnel distribution. First, the mechanism of ineffective financial incentives. de Ree et al. found that salary increases without structural changes in the accountability system did not lead to greater teaching effort. Fahmi et al. found that certification improved teacher welfare but did not significantly enhance learning quality. This indicates that monetary incentives alone are insufficient to ensure stable service quality in remote areas.

Second, the mechanism of structural maldistribution due to decentralization governance. OECD (2015) and World Bank (2020) show that recruitment authority at the local level often results in unequal teacher placement, with excessive concentration in urban areas and shortages in archipelagic regions. Third, the mechanism of high turnover and low retention in 3T regions. Kemdikbud (2021) confirms that teacher placements in remote areas are often temporary, creating pedagogical discontinuity. This condition encourages multi-grade teaching practices that are not always supported by adequate training. Conceptually, these mechanisms form the following pathway:

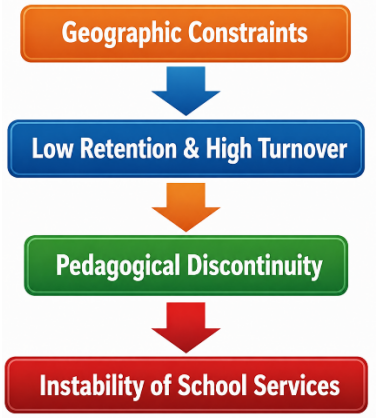

Figure 2. Causal Pathway of Geographic Remoteness toward the Instability of School Services

Research trends indicate the dominance of macro-policy approaches and evaluations of teacher reforms (de Ree et al., 2018; Fahmi et al., 2019). However, the literature tends to separate teacher distribution issues from the geographical context of archipelagic regions. OECD (2015) and the World Bank (2020) acknowledge regional disparities, but have not yet developed an analytical framework based on the resilience of education systems in maritime regions. Comparative studies on teacher distribution in developing countries emphasize that placement inequality is often correlated with spatial remoteness and local governance capacity (Béteille et al., 2020; Tournier et al., 2019). In addition, the global UNESCO report (2023) highlights that the crisis of teacher shortages and unequal distribution requires a systemic approach that takes geographical context and working conditions into account. The main conceptual gap remains the absence of a model that integrates teacher distribution with variables of spatial accessibility and logistical infrastructure. Longitudinal research on teacher retention in small islands is also still very limited. As a result, teacher distribution has not yet been positioned as part of the resilience of school service delivery, but rather as a matter of human resource management.

Theoretically, the literature indicates the need for a resilience-based approach in teacher distribution policies, particularly for archipelagic regions. The distribution of educational personnel should be understood as a systemic component that interacts with spatial barriers and logistical infrastructure. Practically, the findings of OECD (2015) and the World Bank (2020) imply the importance of governance reforms that are more adaptive to geographical conditions, including location-based incentive schemes and continuous professional support for teachers in remote areas. Studies on teacher labor market dynamics also show that non-financial factors, such as community support and career development opportunities, play an important role in teacher retention in remote regions (See et al., 2020). However, limitations in the literature still include the lack of analysis on the long-term impact of teacher turnover on learning outcomes, as well as the shortage of studies that explicitly examine the context of small islands and maritime regions. Future research needs to develop an integrative model linking teacher retention, geographical remoteness, and the stability of school services within a single framework of archipelagic education.

- **Infrastructure Resilience and Educational Logistics Chains**

The resilience of infrastructure and educational logistics systems in archipelagic regions determines the continuity of school operations in the face of geographical disruptions and disasters. The literature indicates that the

condition of coastal school buildings, delays in the distribution of learning materials, limited access to electricity and the internet, and vulnerability to natural disasters form a framework of structural vulnerability in educational services. This dimension demonstrates that the quality of school services is determined not only by pedagogical factors, but also by the capacity of logistics systems and infrastructure to ensure the sustainability of the learning process.

Table 3. Analytical Synthesis of the Literature on Infrastructure Resilience and Educational Logistics Chains in Indonesia's Archipelagic Regions

Study	Archipelagic/3T Context	Specific Focus	Identified Mechanism	Impact on School Services	Knowledge Gap
Barrett et al. (2013)	Classroom quality impacts	Physical school conditions	Learning space quality → Significant influence on learning outcomes	Learning quality is affected by facilities and infrastructure	Not specific to Indonesia's archipelagic context
World Bank (2020)	Indonesia	School infrastructure	Damaged buildings → Operational disruptions	Learning disruption	Does not examine coastal disaster resilience
Lestari et al. (2024)	Rural schools in Indonesia	Digital infrastructure	Limited internet → Barries to digital learning	Service quality gap	Minimal integration with physical logitics
BNPB (2022)	Disaster prone regions	School building resilience	Disaster → School damage → Relocationi	Long term disruption of learning	Lacks a disater education resilience model
Kemendikbud (2022)	3T regions	Distributin of books and facilities	Logistics delays → Shortage of learning materials	Learning process not optimal	No archipelagic education supply chain model

The analyzed literature shows that the resilience of infrastructure and educational logistics systems in Indonesia's archipelagic regions is an important determinant of the sustainability of school services. Barrett et al. (2013) emphasized that the physical quality of classrooms has a significant influence on students' learning outcomes, indicating that the condition of facilities and infrastructure cannot be separated from the quality of learning. In the Indonesian context, World Bank (2020) noted that a significant proportion of schools still have damaged buildings, particularly in remote areas. This finding is consistent with studies on the vulnerability of coastal school infrastructure, which indicate a high risk of damage due to environmental factors and non-adaptive construction designs (Sari et al., 2023).

The dimension of educational logistics also emerges as a structural issue. Lestari et al. (2024) found that limited internet access and digital infrastructure in rural schools widen disparities in learning services, particularly in the implementation of technology-based learning, consistent with the findings of Kim and Nugroho (2021) regarding the post-pandemic digital divide. In addition, BNPB (2022) data indicate that coastal and island regions are vulnerable to natural disasters that directly affect school buildings and disrupt school operations. International literature on education in emergency situations also emphasizes that education systems in disaster-prone areas require adaptive infrastructure designs to maintain service continuity (UNESCO, 2021).

A report by Kemendikbud (2022), based on Dapodik data, shows that the distribution of books and learning facilities in Indonesia's 3T regions frequently experiences delays due to logistical constraints. Overall, these studies highlight the dimensions of physical conditions, the distribution of facilities and infrastructure, energy and digital connectivity, and vulnerability to disasters as key components of sustainable school services. A cross-study synthesis identifies four main mechanisms that influence the resilience of school services through infrastructure and logistics dimensions. First, the mechanism of the physical vulnerability of school buildings. Barrett et al. (2013) showed that

the quality of learning spaces directly affects academic performance, while in the Indonesian context, World Bank (2020) confirmed that damaged or unusable buildings contribute to operational disruptions and reduced effective learning time, reinforced by the findings of Sari et al. (2023) regarding the structural risks faced by coastal schools.

Second, the mechanism of logistical disruption in the distribution of educational resources. Kemendikbud (2022) data show that delays in the delivery of books and learning materials to 3T regions cause schools to be unprepared at the beginning of the semester, which in geographically fragmented regions is also influenced by the capacity of local distribution governance (OECD, 2019).

Third, the mechanism of disparities in digital and energy infrastructure. Lestari et al. (2024) found that limited internet and electricity access hinder the implementation of digital learning, consistent with the analysis of Kim and Nugroho (2021), which showed that connectivity gaps directly affect disparities in learning outcomes.

Fourth, the mechanism of vulnerability to disasters. BNPB (2022) showed that disasters such as tidal floods, earthquakes, and coastal storms cause damage to schools and temporary student relocation, resulting in long-term learning loss. This strengthens UNESCO's (2021) argument regarding the importance of integrating risk mitigation into the planning of education systems in vulnerable regions. Conceptually, these mechanisms form the following pathway:

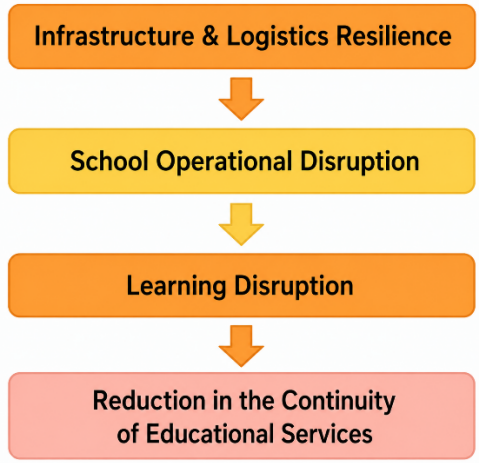

Figure 3. Causal Pathway of Infrastructure and Logistics Vulnerability toward the Decline of Educational Service Continuity

Research trends indicate that most of the literature separates issues of physical infrastructure (Barrett et al., 2013) from issues of distribution logistics and disaster resilience (BNPB, 2022; Kemendikbud, 2022). The World Bank (2020) provides a macro-level overview of school infrastructure conditions, but has not yet integrated the dimensions of archipelagic logistics in a systemic manner. Studies on public sector supply chain management emphasize that distribution design in fragmented regions requires a risk-based approach that accounts for geographical uncertainty (Paul & Chowdhury, 2020). In the context of education in remote areas, studies on the resilience of education systems in small island states highlight the importance of integrating maritime transportation and seasonal planning to maintain service continuity (Bray, 2016). In addition, global reports on education in crisis situations emphasize that infrastructure and logistics must be positioned as core components of system resilience, rather than merely supporting factors (UNESCO, 2023). The main gap remains the absence of an archipelagic education supply chain model that takes into account maritime transportation, seasonal distribution schedules, and coastal disaster risks. Infrastructure is still more often understood as a supporting factor rather than as a core component of the resilience of school service delivery.

Theoretically, the literature indicates that the resilience of school services in archipelagic regions should be understood through the integration of physical infrastructure, logistics systems, and disaster vulnerability. Infrastructure is not merely a facility, but part of the resilience architecture of the education system. Practically, the findings of the World Bank (2020) and Kemendikbud (2022) imply the need for planning the distribution of educational facilities based on the geographical context of archipelagic regions. Lestari et al. (2024) also highlight the importance of investing in digital connectivity and electricity as part of strategies for equalizing service provision. A disaster risk management perspective in education systems emphasizes that predictive and spatial data-based

approaches are required to minimize disruptions to school operations (UNDRR, 2022). However, limitations in the literature still include the lack of longitudinal empirical studies on the impact of logistical disruptions on learning outcomes, as well as the absence of predictive models integrating disaster risk with the sustainability of school services. Future research needs to develop an archipelagic education framework that combines maritime logistics, infrastructure resilience, and the operational stability of schools within a single integrated conceptual model.

CONCLUSION

This Systematic Literature Review shows that strategic educational issues in Indonesia's archipelagic regions are the result of interactions among geographical constraints, the stability of educational personnel distribution, and the resilience of educational infrastructure and logistics. Spatial accessibility disparities operate through mechanisms such as mobility barriers, high transportation costs, and long travel times, which lead to unstable attendance and reduced effective learning hours. At the same time, teacher maldistribution and low retention in disadvantaged, frontier, and outermost (3T) regions intensify pedagogical instability through high turnover and discontinuity in the learning process. The vulnerability of school infrastructure, delays in the distribution of educational resources, and the risk of coastal disasters further increase the cumulative potential for disruptions in educational services. The synthesis demonstrates that these three dimensions form a systemic relationship. Geographic fragmentation not only limits access, but also weakens the stability of teacher distribution and complicates educational logistics systems. Therefore, education in archipelagic regions needs to be understood within a framework of school service resilience, rather than merely through the paradigm of equal access.

The theoretical contribution of this study lies in the integration of literature on spatial accessibility, teacher distribution governance, and educational infrastructure into a single conceptual model based on system resilience. Methodologically, the SLR approach enables the identification of recurring mechanisms and fragmented bodies of knowledge that were previously examined separately. Practically, these findings imply the need for educational policies integrated with maritime transportation systems, the strengthening of location-based teacher retention strategies, and adaptive logistics planning and disaster mitigation suited to archipelagic characteristics. Future research should develop empirical models based on longitudinal data to test causal relationships among variables and strengthen policy strategies capable of ensuring the sustainability of school services in Indonesia's archipelagic regions.

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