Alifbata: Jurnal Pendidikan Dasar
DOI: 10.51700/alifbata.v6i2.2050.

Mapping Multidimensional Disparities of Elementary School Carrying Capacity in Indonesia: A PCA-Based Provincial Analysis

Nifta Noor Halimah[1], Yusnita Putri[2], Indah Sari Ruhmana[3]
[123]Universitas Negeri Yogyakarta
Corresponding author: niftanoor.2025@student.uny.ac.id

Abstract : Educational feasibility at the elementary level in Indonesia remains uneven across regions despite sustained policy efforts to improve access and quality. This study aims to evaluate and map the feasibility of elementary education across all 38 Indonesian provinces by integrating indicators of human resources, physical infrastructure, and operational efficiency into a single evaluative framework. Employing a quantitative descriptive exploratory design using province level education statistics, five ratio based indicators, qualified teacher ratio, proper classroom ratio, teacher workload, class density, and dropout rate, were constructed. Data were analyzed using Principal Component Analysis (PCA) to reduce dimensionality and identify latent factors underlying inter-provincial disparities. Instrument suitability for factor analysis was validated using the Kaiser-Meyer-Olkin measure and Bartlett's test of sphericity. The analysis retained two principal components, collectively explaining 83.1 percent of the total variance. The first component represents operational efficiency and human resource quality, characterized by high teacher workload, dense class groupings, and an inverse relationship with teacher qualification. The second component reflects physical carrying capacity and student retention, dominated by classroom conditions and dropout rates. Interpretation of component scores through quadrant mapping reveals regional polarization: densely populated provinces show adequate physical facilities but severe capacity overload, while eastern regions face combined constraints in both infrastructure quality and human resource capacity. This study offers a novel PCA-based evaluative model, indicating that educational feasibility is multidimensional and cannot be inferred from infrastructure alone, highlighting the need for cluster-based policy interventions aligned with specific regional capacity profiles

Keywords : Educational evaluation; school feasibility; principal component analysis; regional disparity; elementary education

Abstrak: *Kelayakan pendidikan tingkat sekolah dasar di Indonesia masih belum merata antarwilayah, meskipun telah ada upaya kebijakan berkelanjutan untuk meningkatkan akses dan mutu. Penelitian ini bertujuan untuk mengevaluasi dan memetakan kelayakan pendidikan dasar di seluruh 38 provinsi di Indonesia dengan mengintegrasikan indikator sumber daya manusia, infrastruktur fisik, dan efisiensi operasional ke dalam satu kerangka evaluasi. Dengan menggunakan desain eksploratif deskriptif kuantitatif yang memanfaatkan statistik pendidikan tingkat provinsi, disusunlah lima indikator berbasis rasio: rasio guru berkualifikasi, rasio ruang kelas yang layak, beban kerja guru, kepadatan kelas, dan tingkat putus sekolah. Data dianalisis menggunakan Principal Component Analysis (PCA) untuk mereduksi dimensi dan mengidentifikasi faktor laten yang mendasari kesenjangan antarprovinsi. Kesesuaian instrumen untuk analisis faktor divalidasi menggunakan ukuran Kaiser-Meyer-Olkin dan uji sferisitas Bartlett. Analisis menghasilkan dua komponen utama yang secara kolektif menjelaskan 83,1 persen dari total varians. Komponen pertama merepresentasikan efisiensi operasional dan mutu sumber daya manusia, yang dicirikan oleh beban kerja guru yang tinggi, kepadatan kelas yang tinggi, serta hubungan terbalik dengan kualifikasi guru. Komponen kedua mencerminkan daya tampung fisik dan retensi siswa, yang didominasi oleh kondisi ruang kelas dan tingkat putus sekolah. Interpretasi skor komponen melalui pemetaan kuadran mengungkapkan adanya polarisasi wilayah: provinsi dengan kepadatan penduduk tinggi memiliki fasilitas fisik yang memadai namun mengalami kelebihan kapasitas yang parah, sementara wilayah timur menghadapi kendala gabungan baik dalam mutu infrastruktur maupun kapasitas sumber daya manusia. Penelitian ini menawarkan model evaluasi baru berbasis PCA yang menunjukkan bahwa kelayakan pendidikan bersifat multidimensi dan tidak dapat dinilai hanya dari infrastruktur semata, serta menyoroti perlunya intervensi kebijakan berbasis klaster yang selaras dengan profil kapasitas wilayah tertentu.*

Kata kunci: *Evaluasi pendidikan; kelayakan sekolah; analisis komponen utama; kesenjangan wilayah; pendidikan dasar.*

Introduction

Elementary education constitutes a fundamental foundation for human resource development and the achievement of sustainable development goals in Indonesia (Luthfi et al., 2025, p.187). However, efforts to ensure equitable access to and quality of elementary education continue to face substantial challenges in the form of regional disparities, both between urban and rural areas and between western and eastern regions of Indonesia. These inequalities are reflected in variations in infrastructure availability, teacher quality, and access to adequate educational facilities (Kawuryan et al., 2021, p. 824; Madhakomala et al., 2025, p. 1716; Suryani et al., 2025, p. 473)

The Indonesian government has consistently allocated at least 20 percent of the national budget to education each year (Subianto, 2025). Nevertheless, increased budget allocation has not fully guaranteed equitable educational quality across regions (Suryani et al., 2025, p. 377). Empirical data indicate that provinces such as DKI Jakarta and Yogyakarta exhibit significantly higher average years of schooling and student literacy competence compared to provinces such as Papua and East Nusa Tenggara (Haidir & Putu, 2023, p.442; Suryani et al., 2025, p.389). Furthermore, educational quality in remote and underdeveloped regions, commonly referred to as 3T areas (frontier, outermost, and disadvantaged), remains constrained by limited infrastructure, low teacher qualifications, and difficult geographical access (Iskandar, 2025, P.86; Madhakomala et al., 2025, p.1716).

Disparities in access to and quality of elementary education are also influenced by school-level managerial factors, including principal leadership and the adequacy of physical facilities. Studies conducted in various regions demonstrate that principal competence and the adequacy of school infrastructure significantly contribute to the quality of elementary schools (Inayah et al., 2025, p. 433; Laela et al., 2023, p. 158; Refudin et al., 2024, p. 136). In addition, efficient school management and equitable distribution of educational facilities are critical factors in improving both educational quality and equity (Ibnu et al., 2023, p. 113; Rokhmaniyah et al., 2023, p. 563).

The persistent imbalance indicates that policy interventions based only on infrastructure provision or general budget increases are insufficient to solve the multidimensional challenge. Addressing this requires a comprehensive evaluation of elementary education feasibility based on school carrying capacity indicators, encompassing physical resources, human resources, and operational efficiency (Winaryo & Palangka Raya, 2020, p.8). However, most existing studies tend to analyze these indicators separately or rely on simple descriptive statistics, often failing to construct a unified, multidimensional index that captures the latent structure of educational capacity across different regions. Crucially, there remains a lack of an operational evaluative model that systematically integrates these varied metrics to comprehensively map the operational feasibility profile at the provincial level.

To fill this critical gap, a robust quantitative approach is necessary. Principal Component Analysis (PCA) is an appropriate technique to reduce data dimensionality and identify the underlying latent factors influencing elementary education feasibility across regions (Ramadhany et al., 2024, p.9; Wangge, 2021, p.976). Through the resulting data-driven mapping, policy interventions can be more precisely targeted to address the specific needs of different regional clusters (Rachelia et al., 2021, p.2088). Therefore, this study aims

to evaluate and map the feasibility of elementary education across all Indonesian provinces by applying Principal Component Analysis (PCA) to construct and analyze the latent dimensions underlying provincial-level educational capacity.

Method

This section describes the methodological approach employed in the study to evaluate the feasibility of elementary education across Indonesian provinces. It outlines the type and design of the research, data sources and units of analysis, indicators used to operationalize educational feasibility, analytical procedures, and interpretation techniques. The methodological framework is presented to ensure transparency and replicability, and to clarify how the research objectives were systematically addressed in accordance with established standards in educational evaluation research.

Research Design

This study employed a quantitative descriptive research design. According to (Creswell & Creswell, 2014) quantitative research is an approach for testing objective theories by examining the relationship among variables that can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures (p. 32). Specifically, the descriptive nature of this study aligns with Sugiono (2013) framework, which defines descriptive statistics as a method to analyze data as it exists without the intention of making generalizations applicable to a broader population (p.147). Since this research utilized a Total Sampling (Census) technique covering all 38 provinces in Indonesia, the analysis does not aim to generalize findings from a sample, but rather to describe the actual conditions, visualized through quadrant mapping, of these 38 provinces. This design was selected to allow a systematic examination of regional disparities while simultaneously identifying latent structural patterns among multiple educational indicators without imposing prior assumptions regarding their underlying relationships.

Data Source and Unit of Analysis

The analysis utilized secondary data derived from province-level education statistics covering the entire population of 38 provinces in Indonesia for the 2023–2024 academic year. The dataset was obtained from the official education statistics managed by the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek, 2024), accessed via a curated public repository (Pastika, 2024). The unit of analysis was the province, enabling comparative assessment of educational feasibility at the macro-regional level. By employing a census (total sampling) approach, this study ensures that the dataset represents the complete educational landscape of the country without sampling bias. This level of aggregation aligns with national education planning and policy formulation, where provinces serve as key administrative units. The dataset consisted of standardized indicators related to elementary education conditions, ensuring consistency, reliability, and comparability across regions during the analysis period.

Indicators of Educational Feasibility

To eliminate population bias resulting from demographic disparities across provinces, all raw data were converted into ratio-based indicators. In this study, "Educational Feasibility" is operationalized as School Carrying Capacity, measured through five primary

ratio variables: (1) Qualified Teacher Ratio, measured as the percentage of teachers holding a Bachelor's degree (S1/D4) relative to the total teaching workforce, representing Human Resource (HR) quality; (2) Proper Classroom Ratio, measured as the percentage of classrooms in "good condition" relative to the total number of classrooms, representing physical infrastructure quality; (3) Teacher Workload, measured as the ratio of total students to total teachers (Student-Teacher Ratio), representing educator efficiency; (4) Study Group Density, measured as the ratio of study groups (rombongan belajar) to available classrooms, representing physical carrying capacity (accommodation capacity); and (5) Dropout Rate, measured as the percentage of dropout students relative to total student enrollment, representing the failure output of educational services.

Data Analysis Technique

The data were analyzed using Principal Component Analysis (PCA) assisted by JASP software. As described by Gewers et al., (2022) PCA is a linear dimensionality reduction technique that identifies orthogonal directions of maximum variance in the original data, projecting it into a lower-dimensional space while preserving essential information (p.73). This method is particularly effective for simplifying complex datasets with highly correlated variables into a smaller set of independent components. In this study, PCA was applied to identify latent components that summarize the interrelationships among the selected educational indicators. Prior to component extraction, the suitability of the data for factor analysis was assessed using the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. Components were retained based on the Latent Root Criterion (eigenvalues > 1.0) and cumulative explained variance. Varimax rotation was then applied to enhance the interpretability of component loadings. Finally, component scores were generated to map the relative position of each province, serving as the basis for the quadrant visualization.

Interpretation and Mapping Procedure

Component scores generated from the retained principal components were used to interpret provincial feasibility profiles. These scores, calculated as standardized Z-scores with a mean of zero, represent the relative position of each province along the identified feasibility dimensions (Windhani & Hardoyono, 2017, p.22). Quadrant mapping was conducted by plotting provinces onto a Cartesian coordinate system, setting the origin point (0,0) as the threshold to delineate the clusters. Consequently, positive scores indicate performance above the national average, while negative scores indicate performance below the average for each dimension. Based on the intersection of PC1 and PC2 axes, regions were classified into four distinct feasibility typologies: Ideal Zone, Efficiency Crisis Zone, Critical Zone, and Infrastructure Deficit Zone. This procedure enabled the visualization of inter-provincial patterns and facilitated the interpretation of relative strengths and constraints across regions. The resulting typologies provide an analytical basis for identifying region-specific policy priorities and targeted interventions aimed at improving elementary education feasibility.

Findings And Discussion

Findings

The analysis of basic education feasibility in this study was conducted using the multivariate statistical approach of Principal Component Analysis (PCA) with the aid of JASP software. This analysis reduced five indicators of school carrying capacity (Qualified Teacher Ratio, Proper Classroom Ratio, Teacher Workload, Study Group Density, and Dropout Rates) into simpler principal components to map the disparity in education quality across provinces in Indonesia.

Prerequisite Test of Factor Analysis

The initial step in PCA analysis is ensuring the data's suitability by conducting the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. Prior to this, all indicator data were standardized using the Z-Score method to equalize the unit of measurement across variables. The test results are presented in Table 1 and Table 2.

Table 1. Results of the KMO Test

Kaiser-Meyer-Olkin Test

	MSA
Overall MSA	0.626
Teacher Workload	0.567
Class Density	0.711
Qualified Teacher Ratio	0.617
Dropout Rate	0.660
Proper Classroom Ratio	0.560

Based on Table 1 (The Kaiser-Meyer-Olkin Test, as shown in the uploaded image), the overall KMO value obtained is 0.626. This value exceeds the minimum threshold of 0.5, which indicates that the sample size (provinces) and data variation meet the requirement for sampling adequacy (considered 'mediocre') for factor analysis. Specifically, the MSA values for most individual variables are also acceptable.

Table 2. Results of the Bartlett's Test

Bartlett's Test

X^2	df	p
100.544	10.000	< .001

Subsequently, the Bartlett's Test of Sphericity yielded a Chi-Square (X^2) value of 100.544 with a significance level of $p < 0.001$. Since the significance value is far below the critical threshold of 0.05, it indicates a strong correlation among the variables of the school carrying capacity indicators. This result confirms that the data is appropriate for continuing with the factor analysis (PCA).

Principal Component Extraction

The extraction process was performed using the Principal Component method with Varimax rotation2. Based on the Eigenvalue > 1 criterion and the pattern of decline in the Scree Plot, only two principal components were retained, as they explain the majority of the data variability. The characteristics of the PCA principal components are shown in Table 3, which contains the Eigenvalue and the proportion of variance for each component.

Table 3. Characteristics of Principal PCA Components (Eigenvalue and Proportion of Variance)

Component Characteristics

	Unrotated solution			Rotated solution		
	Eigenvalue	Proportion var.	Cumulative	SumSq. Loadings	Proportion var.	Cumulative
Component 1	2.792	0.558	0.558	2.263	0.453	0.453
Component 2	1.363	0.273	0.831	1.891	0.378	0.831

Table 3 shows that the first component (PC1) has an Eigenvalue of 2.792 with a proportion of variance of 55.8%, while the second component (PC2) has an Eigenvalue of 1.363 with a proportion of variance of 27.3%. These two components cumulatively explain approximately 83.1% of the total data variability. Since this cumulative variance is high, the two components are considered adequately representative to summarize the five school carrying capacity indicators. The decision to retain only two components is further supported by the visual inspection of the Scree Plot, which typically shows a sharp drop (elbow point) after the second component.

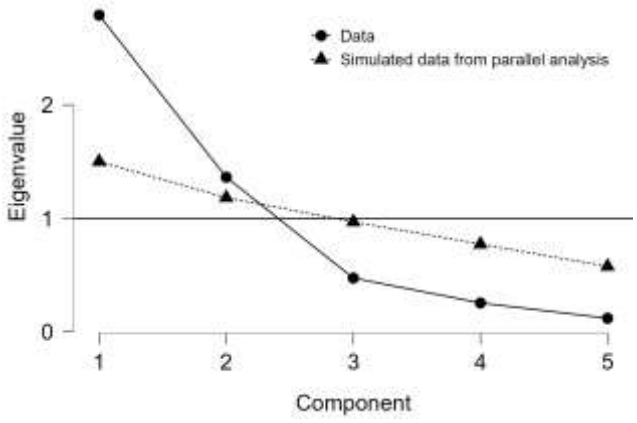

Figure 1. Scree Plot of Principal Component Analysis

The visualization of the Eigenvalue decline is presented in Figure 1. Scree Plot of Principal Component Analysis , which plots the Eigenvalue (Y-axis) against the component number (X-axis). From the graph, it is evident that the Eigenvalue drops sharply from the first component (PC1) to the second component (PC2). After the second component, the

line starts to flatten significantly, forming what is known as the 'elbow' point. This elbow point confirms that only the first two components (PC1 and PC2) substantially contribute to explaining the data variability, hence only these two components are retained for further factor rotation and interpretation.

Factor Rotation Using the Varimax Method (Orthogonal)

To achieve a clearer and simpler interpretation of the variable groupings, Factor Rotation using the Varimax (Orthogonal) Method was applied. This rotation aims to maximize the variance of loadings on each component, ensuring that each variable tends to have a high loading on one factor and a loading close to zero on the other factors, thereby yielding a more interpretable factor structure. The results of the principal component rotation (Rotated Component Matrix) are detailed in Table 4.

Table 4. Rotated Component Matrix

Component Loadings

	PC1	PC2	Uniqueness
Teacher Workload	0.936		0.120
Class Density	0.884		0.212
Qualified Teacher Ratio	-0.616	0.711	0.115
Dropout Rate	0.412	-0.797	0.195
Proper Classroom Ratio		0.861	0.203

Note. Applied rotation method is varimax.

The factor rotation results presented in Table 4. Rotated Component Matrix established two principal dimensions by clustering the five school carrying capacity variables. The components are named based on the dominant factor loadings:

1. Component 1 (PC1): Operational Efficiency and Workload Factor : This component is strongly defined by the positive loadings of Teacher Workload (0.936) and Study Group Density (0.884), and the negative loading of the Qualified Teacher Ratio (-0.616). The strong positive loadings signify a high level of operational burden and congestion in schools. Conversely, the negative loading on the Qualified Teacher Ratio suggests that provinces with a high burden (high PC1 score) tend to simultaneously have a lower percentage of qualified teachers. Therefore, Component 1 is labeled the Operational Efficiency and Workload Factor. A higher score on this component implies greater operational inefficiency and heavy burden.
2. Component 2 (PC2): Physical Carrying Capacity and Retention Factor : This component is primarily defined by the Proper Classroom Ratio (0.861), Dropout Rate (-0.797), and the Qualified Teacher Ratio (0.711). The high positive loading of the Proper Classroom Ratio represents good physical infrastructure and facility adequacy. The dominant negative loading on the Dropout Rate indicates an inverse relationship: better physical conditions and higher teacher qualifications (positive score) are associated with a lower student dropout rate. This component is consequently named the Physical Carrying Capacity and Retention Factor. A higher

score on this component signifies better physical facilities and a higher capacity for student retention.

Interpretation and Quadrant Mapping

This stage aims to connect the results of the PCA component extraction with the mapping of provincial positions onto a quadrant diagram. Following the factor rotation, each province obtains a score on the two principal components: PC1 (Operational Efficiency and HR Quality Factor) and PC2 (Physical Carrying Capacity and Student Retention Factor). These scores serve as the basis for determining the specific characteristics of each province, whether they are in an ideal condition, an efficiency crisis, or a priority zone.The position of each province is visualized in a Cartesian diagram (Table 5. Quadrant Map of Basic Education Carrying Capacity in Indonesia), where the x-axis represents PC1 (Efficiency/Workload) and the y-axis represents PC2 (Physical/Retention). This mapping visualizes the disparities in education quality and divides the provinces into four distinct clusters:

Table 5. Quadrant Map of Basic Education Carrying Capacity in Indonesia

Component Score

	PC1 (SDM/Beban)	PC2 (Fisik/Output)
Prov. D.K.I. Jakarta	1.304105239	2.824021827
Prov. Jawa Barat	1.066994583	0.7352909451
Prov. Jawa Tengah	-0.4714062246	0.4350656377
Prov. D.I. Yogyakarta	-0.2122488877	1.46371138
Prov. Jawa Timur	-0.4582665685	0.5059598357

...

To visualize the disparity in education quality, provincial positions were mapped onto a scatter plot based on the component scores generated from PC1 and PC2. The resulting provincial distribution map is displayed in Figure 2.

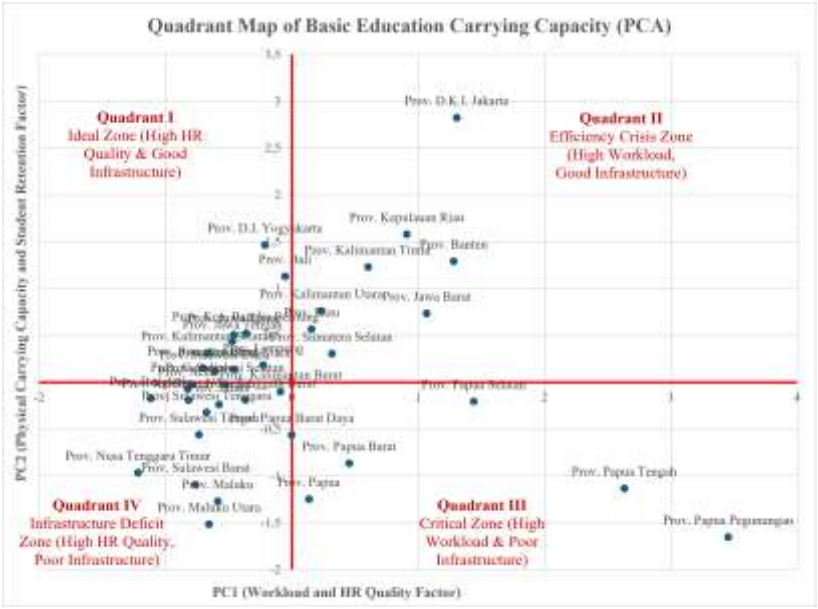

Figure 2. Quadrant Map of Basic Education Carrying Capacity in Indonesia

Figure 2 illustrates the polarization of education quality in Indonesia, divided into four distinct characteristic quadrants:

1. Quadrant I (Ideal Zone): Regions characterized by low PC1 scores (negative) and high PC2 scores (positive). Provinces in this zone, such as D.I. Yogyakarta and Bali, exhibit ideal conditions with manageable teacher workloads/class densities alongside adequate physical infrastructure and minimal dropout rates. The provinces included in this cluster are Central Java, D.I. Yogyakarta, East Java, North Sumatra, West Sumatra, Lampung, South Kalimantan, North Sulawesi, Bali, and Bangka Belitung Islands.
2. Quadrant II (Efficiency Crisis Zone): Regions characterized by high PC1 scores (positive) and high PC2 scores (positive). Densely populated provinces like DKI Jakarta and West Java are positioned here. Although they possess the best physical infrastructure (very high PC2 scores), these regions suffer from extreme pressure on teacher workloads and study group densities due to high student populations (capacity overload). The provinces in this cluster are DKI Jakarta, West Java, Riau, South Sumatra, East Kalimantan, Banten, Riau Islands, and North Kalimantan.
3. Quadrant III (Critical Zone): Regions characterized by high PC1 scores (positive) and low PC2 scores (negative). Eastern regions, specifically the Papua expansion provinces, are identified in this zone. The primary characteristic is a "double burden": a severe lack of proper physical facilities (infrastructure deficit) combined with low teacher quality or high workloads, which correlates directly with high dropout rates. The provinces in this cluster are Papua, West Papua, Central Papua, South Papua, and Highland Papua.
4. Quadrant IV (Infrastructure Deficit Zone): Regions characterized by low PC1 scores (negative) and low PC2 scores (negative). Provinces in this zone have relatively good management efficiency (light teacher workloads, controlled class density) but face significant limitations in physical facilities and relatively high dropout rates. This indicates that while Human Resources (HR) ratios may be adequate, the school's physical carrying capacity remains a major obstacle. The provinces in this cluster

include Aceh, Jambi, West Kalimantan, Central Kalimantan, Central Sulawesi, South Sulawesi, Southeast Sulawesi, Maluku, West Nusa Tenggara, East Nusa Tenggara, Bengkulu, North Maluku, Gorontalo, West Sulawesi, and Southwest Papua.

These findings confirm that educational "feasibility" is not singular. Provinces in Java, often considered physically advanced, reveal significant vulnerabilities regarding the efficiency of teacher-student ratios (overcapacity). Conversely, provinces in the 3T (Frontier, Outermost, Disadvantaged) regions require fundamental interventions in physical revitalization and teacher qualification improvements to suppress dropout rates.

Discussion

This section aims to discuss in depth the key findings from the Principal Component Analysis (PCA) and the interpretation of the provincial quadrant mapping. This analysis has reduced the complexity of five school carrying capacity indicators into two main factors: PC1 (Workload and HR Quality Factor) and PC2 (Physical Carrying Capacity and Student Retention Factor). Through visualization on the Cartesian diagram (Figure 2), this discussion outlines how these two main components interact to create a distinct polarization in the quality of education in Indonesia, positioning each province into unique characteristic clusters, Ideal, Efficiency Crisis, Infrastructure Deficit, or Critical, to provide specific and targeted policy recommendations.

Implications of PCA Results on Educational Feasibility Disparities

The Principal Component Analysis (PCA) successfully reduced the five school carrying capacity indicators into two main factors. The mapping of provinces into quadrants reveals a distinct polarization, confirming that educational feasibility in Indonesia is not singular but influenced by the balance between facilities and user ratios.

1. Quadrant I: Ideal Model and Managed Efficiency Provinces such as D.I. Yogyakarta and Bali are located in Quadrant I (Ideal Zone). This zone is characterized by negative PC1 scores (low teacher workload, controlled study group density) and positive PC2 scores (good physical facilities, minimal dropout rates). These findings indicate good resource management (efficiency) alongside adequate infrastructure availability. This balance serves as an ideal model that other regions should strive to achieve, emphasizing that HR quality and physical carrying capacity must go hand in hand to create high student retention.
2. Quadrant II: Efficiency Crisis in Developed Regions Densely populated provinces such as DKI Jakarta and West Java are identified in Quadrant II (Efficiency Crisis Zone). Although these regions possess very high PC2 scores, indicating the best physical infrastructure, their high (positive) PC1 scores reveal extreme teacher workloads and study group densities. This confirms that provinces considered physically advanced have significant vulnerabilities regarding the efficiency of teacher-student ratios due to high student populations (capacity overload). The primary issue in this cluster is operational efficiency and carrying capacity, not a lack of physical facilities.
3. Quadrant III: Double Burden in Priority Regions Eastern regions, such as the provinces in Papua (e.g., Central Papua, Highland Papua), fall into Quadrant III (Critical Zone). The main characteristic of this zone is a high PC1 score (heavy

workload, low HR quality) and a low PC2 score (lack of physical facilities, low student retention). Provinces in this cluster face a double burden: a deficit in proper physical facilities (infrastructure damage) and low teacher quality, which correlates directly with high dropout rates. These findings reinforce the urgency of fundamental interventions in physical improvements and teacher qualification upgrades in 3T (Frontier, Outermost, Disadvantaged) regions to suppress dropout rates.

4. Quadrant IV: Infrastructure Deficit Regions with low (negative) PC1 scores and low (negative) PC2 scores fall into Quadrant IV (Infrastructure Deficit Zone). Provinces in this zone have good management efficiency (light teacher workloads, controlled study group density) but face limitations in physical facilities and relatively high dropout rates. This condition indicates that while HR quality is adequate, the school's physical carrying capacity remains a major obstacle. Maluku province is included in this cluster, signaling that although teacher burdens and class densities are controlled, school infrastructure still requires revitalization. Policy interventions in this quadrant should focus on infrastructure repair and increasing physical carrying capacity to improve student retention.

Cluster-Based Policy Recommendations

These policy recommendations are based on the provincial positions in the PCA quadrant diagram, identifying the main source of problems in each cluster, whether it is an efficiency issue (PC1) or physical carrying capacity/retention issue (PC2).

1. Quadrant I (Ideal): Provinces like D.I. Yogyakarta and Bali are in the ideal zone with good management efficiency and adequate physical facilities. The recommendation for this cluster is to maintain existing quality through continuous quality assurance programs, learning innovations, and teacher competence development to prevent quality decline.
2. Quadrant II (Efficiency Crisis): Densely populated provinces like DKI Jakarta and West Java have adequate physical facilities but suffer from capacity overload and high teacher burdens. The recommendation is classroom extensification and the construction of new school units in dense areas, as well as massive teacher recruitment to lower the student-teacher ratio and decongest study groups.
3. Quadrant III (Critical/Double Burden): Provinces in Eastern regions like Papua face a double deficit: low HR quality and poor physical facilities. The recommendation is a fundamental intervention in the form of total school physical revitalization and teacher quality affirmation through incentives, training, and special recruitment for 3T regions to reduce dropout rates.
4. Quadrant IV (Infrastructure Deficit): Provinces like Maluku are in this zone, with good management efficiency but weak school physical carrying capacity. The recommendation is infrastructure revitalization, including classroom rehabilitation and the provision of supporting facilities, to improve student retention and reduce dropout rates.

Conclusion

This study aims to evaluate and map the feasibility of Elementary School (SD) education in Indonesia based on school carrying capacity indicators. It successfully reduced

five indicators into two principal components: PC1 (Workload and HR Quality Factor) and PC2 (Physical Carrying Capacity and Student Retention Factor). The hypothesis regarding the existence of multidimensional inter-regional education quality disparities is confirmed through quadrant mapping. Quadrant II, occupied by densely populated provinces like DKI Jakarta and West Java, indicates an Efficiency Crisis where regions possess adequate infrastructure but suffer from capacity overload and pressure on teacher/study group ratios. Meanwhile, Quadrant III, inhabited by Eastern regions like Papua, faces a double deficit in terms of physical damage and low teacher quality, which correlates directly with high dropout rates. The key findings confirm that school feasibility is not singular but influenced by the balance between facility availability and user ratios. Therefore, this study recommends cluster-based policy interventions: classroom extensification and massive teacher recruitment for dense areas in Java, and total physical revitalization combined with teacher quality affirmation for 3T (Frontier, Outermost, Disadvantaged) regions. For further research, it is suggested to test the effectiveness of these recommended cluster interventions and incorporate qualitative variables, such as principal competence or parental involvement, into the PCA model for more comprehensive mapping.

Acknowledgments

The author would like to thank the Yogyakarta State University for the support and facilities provided during this research. The author also expresses gratitude to the Ministry of Education, Culture, Research, and Technology (Kemendikbudristek) for providing open access to the education statistics data used in this study.

Disclosure Statement

The author declares that there is no conflict of interest regarding the publication of this article. This research was conducted independently for academic purposes using public secondary data.

REFERENCES

Creswell, J. W. , & Creswell, J. D. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches*.

Gewers, F. L., Ferreira, G. R., De Arruda, H. F., Silva, F. N., Comin, C. H., Amancio, D. R., & Costa, L. D. F. (2022). Principal component analysis: A natural approach to data exploration. *ACM Computing Surveys*, *54*(4). https://doi.org/10.1145/3447755

Haidir, A. A., & Putu, N. S. W. (2023). Indonesia social progress: the role of access to basic education in escaping from poverty trap. *Jurnal Ekonomi & Studi Pembangunan*, *24*(2), 428–457. https://doi.org/10.18196/JESP.V24I2.19810

Ibnu, M., Saputra, I. A., Maliki, R. Z., Budianta, A., & Ali, Z. (2023). Carrying Capacity of Education Facilities in Banawa Sub-District, Central Sulawesi Province. *Tunas Geografi*, *12*(2), 103–115. https://doi.org/10.24114/TGEO.V12I2.50934

Inayah, I., Nurkolis, N., & Wuryandini, E. (2025). Pengaruh Kepemimpinan Instruksional Kepala Sekolah Dan Iklim Sekolah Terhadap Kualitas Pembelajaran di SD Negeri Sekecamatan Suruh. *Cetta: Jurnal Ilmu Pendidikan*, *8*(4), 424–434. https://doi.org/10.37329/CETTA.V8I4.4830

Iskandar, D. (2025). Evaluation of Regional Policy Capacity in Improving Access and Quality of Education: Comparative Analysis of Region in Southwest Papua Province. *International Journal of Administration and Education*, 79–87. https://doi.org/10.70188/82CGJ609

Kawuryan, S. P., Sayuti, S. A., Aman, & Dwiningrum, S. I. A. (2021). Teachers Quality and Educational Equality Achievements in Indonesia. *International Journal of Instruction*, *14*(2), 811–830. https://doi.org/10.29333/iji.2021.14245a

Kemendikbudristek. (2024). *Dataset Pendidikan SD Indonesia Tahun 2023-2024*. https://www.kaggle.com/datasets/puanbeningpastika/dataset-pendidikan-sd-indonesia-2023-2024/data

Laela, S., Hanafi, S., & Sudadio, S. (2023). The nexus between principal competence, learning leadership, facility feasibility, and public elementary school quality in Cikande, Serang District, Indonesia. *International Journal of Advanced and Applied Sciences*, *10*(9), 158–164. https://doi.org/10.21833/IJAAS.2023.09.018

Luthfi, A., Poespitohadi, W., Made Arie Widyasthana Wartana Putra, I., Iga Mawarni, D., & Redaksi, D. (2025). QUALITY EDUCATION IN ACHIEVING THE SDGS IN INDONESIA. *Jurnal Mediasosian : Jurnal Ilmu Sosial Dan Administrasi Negara*, *9*(1), 175–190. https://doi.org/10.30737/MEDIASOSIAN.V9I1.6396

Madhakomala, R., Ayu, P. P., Septiani, T., & Butarbutar, P. H. (2025). Education for All: A Systematic Analysis of Equity Policies and Challenges in Indonesia. *International Journal Of Humanities Education and Social Sciences*, *4*(4), 1706–1717. https://doi.org/10.55227/IJHESS.V4I4.1453

Pastika, P. B. (2024). *Dataset Pendidikan SD Indonesia Tahun 2023-2024*. https://www.kaggle.com/datasets/puanbeningpastika/dataset-pendidikan-sd-indonesia-2023-2024/data

Rachelia, R. S. S., Rahayu, W., A, N. S. S., Senida, V. D., Z, I. P., & Ginanjar, I. (2021). Pemetaan Provinsi Di Indonesia Berdasarkan Indikator Kualitas Layanan Pendidikan. *Prosiding Seminar Nasional Statistika*, 5–5. https://doi.org/10.1234/PNS.VI.17

Ramadhany, D. I., Jois Pradani, A., Wulandari, S. P., Studi, P., & Terapan, S. (2024). ANALISIS FAKTOR PADA VARIABEL YANG BERKAITAN DENGAN INDEKS PEMBANGUNAN MANUSIA MENGGUNAKAN PRINCIPAL COMPONENT ANALYSIS DI JAWA TIMUR TAHUN 2022. *Scientist: Journal of Natural Science* , *2*(1), 8–17. https://journal.alshobar.or.id/index.php/scientist/article/view/297

Refudin, A., Maliki, B. I., & Suparmoko, M. (2024). PENGARUH KEPEMIMPINAN KEPALA SEKOLAH DAN KUALITAS GURU TERHADAP KINERJA GURU

UNTUK MENINGKATKAN PRESTASI SEKOLAH DASAR SWASTA DI KECAMATAN JOMBANG KOTA CILEGON. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, *9*(04), 121–140. https://doi.org/10.23969/JP.V9I04.20744

Rokhmaniyah, Mahmudah, U., & Fatimah, S. (2023). Performance Efficiency Measurement in Managing Elementary Schools by Using a Robust Data Envelopment Analysis. *JPI (Jurnal Pendidikan Indonesia)*, *12*(3), 556–565. https://doi.org/10.23887/JPIUNDIKSHA.V12I3.53489

Subianto, P. (2025). *Address of the President of the Republic of Indonesia on the Presentation of the Government Statement on the Bill on the State Budget for the 2026 Fiscal Year and Its Financial Note Before the Plenary Session of the House of Representatives of the Republic of Indonesia*. Sekretariat Kabinet Republik Indonesia. https://setkab.go.id/en/address-of-the-president-of-the-republic-of-indonesia-on-the-presentation-of-the-government-statement-on-the-bill-on-the-state-budget-for-the-2026-fiscal-year-and-its-financial-note-before-the-plenar/

Sugiono. (2013). *METODE PENELITIAN KUANTITATIF, KUALITATIF DAN R &. D*. Alfabeta Bandung. https://digi-lib.stekom.ac.id/assets/dokumen/ebook/feb_35efe6a47227d6031a75569c2f3f39d44fe2db43_1652079047.pdf

Suryani, Y., Pertiwi, I. I., Mustafa, I. A., Mulawarman, W. G., & Haryaka, U. (2025a). Pendidikan Berkualitas Tanpa Diskriminasi: Studi Efektivitas Performance-Based Financing dalam Menutup Kesenjangan Mutu antara SD Negeri dan Swasta. *ALSYS*, *5*(3), 460–475. https://doi.org/10.58578/ALSYS.V5I3.5545

Suryani, Y., Pertiwi, I. I., Mustafa, I. A., Mulawarman, W. G., & Haryaka, U. (2025b). Peran Pemerintah Daerah dalam Pengelolaan Anggaran Pendidikan untuk Meningkatkan Akses dan Kualitas Pendidikan. *ALSYS*, *5*(3), 376–391. https://doi.org/10.58578/ALSYS.V5I3.5461

Wangge, M. (2021). *Penerapan Metode Principal Component Analysis (PCA) Terhadap Faktor-faktor yang Mempengaruhi Lamanya Penyelesaian Skripsi Mahasiswa Program Studi Pendidikan Matematika FKIP UNDANA*. *05*(02), 974–988.

Winaryo, S., & Palangka Raya, U. (2020). EVALUASI PROGRAM PENYELENGGARAAN PENDIDIKAN BERKUALITAS DAN TERAKSES JENJANG PENDIDIKAN DASAR DI PROVINSI KALIMANTAN TENGAH. *Equity In Education Journal*, *2*(1), 1–10. https://doi.org/10.37304/EEJ.V2I1.1679

Windhani, K. (Kikin), & Hardoyono, F. (Fajar). (2017). Regional Inequality Based on Infrastructure Indicators Using Principal Component Analysis (PCA). *Eko-Regional*, *12*(2), 266574. https://doi.org/10.20884/1.ERJPE.2017.12.2.1136