

Income Inequality, Sanitation, Internet Access, and Human Development: The Mediating Role of Poverty in Indonesia

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Article Info	ABSTRACT
Article history: Received Aug, 2026 Revised Aug, 2026 Accepted Aug, 2026	This study examines the direct and indirect effects of income inequality, access to adequate sanitation, and household internet access on human development through poverty across Indonesian provinces. Using a balanced panel of 33 provinces from 2010 to 2025, the study applies panel data regression and bootstrap mediation analysis. The poverty model is estimated using a Random Effects Model with time effects and an AR(1) residual structure, while the Human Development Index (HDI) model uses a Fixed Effects Model with province and time effects and an AR(1) residual structure. The results show that the Gini Ratio significantly increases poverty, whereas access to adequate sanitation significantly reduces poverty. Household internet access has no significant effect on poverty. The Gini Ratio, sanitation, internet access, and poverty do not significantly affect HDI. Bootstrap results further show that poverty does not mediate the effects of the three structural variables on HDI. These findings indicate that inequality reduction and sanitation improvement are more directly relevant to poverty alleviation, while improvements in human development require interventions that directly strengthen health, education, and living standards.
Keywords: Adequate Sanitation; Gini ratio; Household Internet Access; Human Development Index; Poverty	
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1. INTRODUCTION

Human development remains a central objective of economic development because it reflects people’s ability to live healthy lives, obtain education, and achieve a decent standard of living. Indonesia’s Human Development Index (HDI) increased from 75.02 in 2024 to 75.90 in 2025. However, this national improvement has not eliminated disparities across provinces. In 2025, DKI Jakarta recorded the highest HDI at 85.05, while Papua Pegunungan recorded the lowest at 54.91 [1]. This gap indicates that national

progress does not necessarily represent an equal distribution of development outcomes. From the capability perspective, development should therefore be assessed not only through improvements in average achievement but also through the distribution of opportunities and capabilities across regions and population groups [2], [3]. Which emphasizes that improvements in national HDI coexist with substantial differences in human development across Indonesian provinces.

Differences in provincial HDI may be associated with income inequality, access to basic services, digital connectivity, and

poverty. A high Gini Ratio reflects an unequal distribution of income or expenditure and may limit access to education, health services, productive employment, and adequate living standards. Previous studies generally found that income inequality negatively affected human development, although positive or statistically insignificant effects have also been reported [4]–[7]. Access to adequate sanitation can support human development by reducing exposure to environmentally related diseases, lowering health costs, and improving productivity [8]–[11]. Household internet access can expand opportunities to obtain information, education, public services, health services, employment, and participation in digital economic activities [12]–[15]. However, access alone does not necessarily generate better development outcomes because its benefits may depend on service quality, affordability, educational capacity, digital literacy, and productive use.

Poverty provides a plausible socioeconomic pathway connecting these structural conditions with human development. Greater inequality can increase the vulnerability of lower-income groups [16], [17], while inadequate sanitation can increase health- and productivity-related vulnerability [18], [19]. Limited digital access may further restrict information, public services, employment, and income-generating opportunities [28]–[30]. Poverty, in turn, constrains households' ability to obtain education, health care, adequate nutrition, housing, and a decent standard of living, thereby limiting the capabilities represented by HDI [20]–[23]. This mechanism integrates Structural Poverty Theory, which explains how structural conditions shape poverty, with the Capability Approach, which explains how economic deprivation can restrict human development.

The empirical evidence remains inconclusive. Studies examining the Gini Ratio, sanitation, internet access, poverty, and HDI have reported different directions and levels of statistical significance. More importantly, much of the available evidence examines these relationships separately or emphasizes direct effects, leaving the

mechanisms connecting structural conditions to human development less clearly understood. Evidence on whether poverty mediates the effects of income inequality, access to adequate sanitation, and household internet access on human development remains limited, particularly in provincial-level studies covering an extended period in Indonesia. The research gap therefore concerns not only inconsistent findings on direct relationships but also whether poverty functions as a socioeconomic pathway through which these structural conditions influence human development.

This study addresses the gap by examining the direct effects of the Gini Ratio, access to adequate sanitation, and household internet access on poverty and the Human Development Index (HDI), together with their indirect effects on HDI through poverty. Using a balanced panel of 33 provinces from 2010 to 2025, the study applies panel data regression to account for differences across provinces and over time. This design enables the analysis to distinguish relationships associated with poverty from those linked to human development while testing whether poverty operates as a mediating mechanism. Examining the three structural factors simultaneously provides a more integrated assessment than approaches that consider each relationship separately.

It positions poverty both as an outcome of structural conditions and as a pathway linking those conditions to human development. The framework combines Structural Poverty Theory, which emphasizes constraints arising from unequal access to resources and opportunities, with the Capability Approach, which focuses on people's ability to achieve valued states of health, education, and decent living. This integration provides empirical evidence on the direct and indirect relationships among inequality, sanitation, internet access, poverty, and HDI. It also clarifies whether inequality reduction, sanitation improvement, digital inclusion, and poverty alleviation share a pathway or require complementary strategies for human development across Indonesian provinces.

2. LITERATURE REVIEW

2.1 *Structural Poverty Theory*

Structural poverty theory explains that poverty is not solely caused by individual limitations but also by social, economic, and institutional structures that restrict access to resources, productive employment, basic services, and opportunities for improving welfare [27]–[30]. Differences in poverty across regions may therefore reflect variations in economic structures, public policies, infrastructure, demographic conditions, and institutional capacity. Within this perspective, income distribution, access to basic sanitation, and digital connectivity represent structural conditions that can influence households' capacity to obtain resources and participate in productive economic activities.

A higher Gini Ratio reflects greater income inequality and may constrain the economic mobility of lower-income groups by limiting their access to productive resources, decent employment, and opportunities to improve income. Empirical evidence indicates that greater inequality is associated with higher poverty [16], [17]. Accordingly, greater income inequality is expected to increase the poverty rate.

H1: The Gini Ratio has a positive effect on the poverty rate.

Access to adequate sanitation represents another structural condition affecting household vulnerability. Inadequate sanitation can increase exposure to disease, raise health expenditures, reduce working time, and lower productivity, thereby placing a greater economic burden on poorer households. Conversely, broader access to adequate sanitation can reduce health-related vulnerability and household costs, contributing to poverty reduction [18], [19]. Therefore, improved sanitation access is expected to reduce the poverty rate.

H2: Access to adequate sanitation has a negative effect on the poverty rate.

Household internet access can reduce structural barriers to information, education, public services, employment opportunities, and participation in digital economic activities. Greater connectivity may improve access to knowledge and income-generating opportunities and thereby strengthen households' capacity to move out of economic vulnerability [28], [29]. However, evidence also indicates that connectivity does not necessarily reduce poverty when access is not accompanied by productive use and complementary capabilities [30]. Despite these differing empirical findings, the structural poverty perspective suggests that broader household internet access should expand economic opportunities and reduce poverty.

H3: Household internet access has a negative effect on the poverty rate.

2.2 *Capability Approach and Human Development*

The Capability Approach defines development as the expansion of people's real opportunities to live healthy, educated, and decent lives rather than merely an increase in income or ownership of resources [2], [3]. This perspective provides the conceptual basis for HDI because human development is assessed through achievements in health, education, and a decent standard of living. Within this framework, economic inequality, access to basic services, digital connectivity, and poverty may either constrain or expand people's capabilities.

A high Gini Ratio reflects unequal income distribution and may reduce the ability of lower-income groups to benefit equally from development. Greater inequality can restrict access to education, health services, decent employment, and economic opportunities, thereby limiting the capabilities represented by HDI. Empirical studies generally report a negative relationship between income inequality and human development, although different findings have also been documented [4]–[7]. Accordingly,

greater income inequality is expected to reduce human development.

H4: The Gini Ratio has a negative effect on HDI.

Access to adequate sanitation can expand human capabilities by reducing exposure to disease, lowering health-related burdens, maintaining productivity, and supporting healthier living conditions. These benefits are closely related to the health and living-standard dimensions of human development. Empirical evidence has shown that greater access to adequate sanitation is associated with higher human development [8]–[11]. Therefore, broader sanitation access is expected to improve HDI.

H5: Access to adequate sanitation has a positive effect on HDI.

Household internet access may also expand capabilities by improving access to information, education, health services, public services, employment opportunities, and digital economic activities. As digital connectivity becomes increasingly integrated into learning, work, and service delivery, broader internet access can support knowledge acquisition, productivity, and quality of life [12]–[15]. Therefore, greater household internet access is expected to improve human development.

H6: Household internet access has a positive effect on HDI.

Poverty constrains human capabilities because households with limited economic resources face greater difficulty in meeting basic needs and obtaining education, health care, adequate nutrition, housing, and other conditions required for a decent life. Higher poverty can therefore restrict achievements across all three dimensions of HDI. Previous evidence generally indicates a negative relationship between poverty and human development [20]–[23]. Accordingly, higher poverty is expected to reduce HDI.

H7: The poverty rate has a negative effect on HDI.

2.3 Poverty Mediation and Research Model

Poverty may serve as a socioeconomic mechanism through which structural conditions influence human development. From the structural poverty perspective, greater income inequality can increase the economic vulnerability of lower-income groups by restricting access to productive resources, employment, and income opportunities. Higher poverty can subsequently constrain people's capabilities to obtain education, health services, and adequate living standards. Empirical evidence indicates that income inequality is positively associated with poverty [16], [17], while poverty is generally associated with lower human development [20]–[23]. Therefore, poverty is expected to transmit the effect of income inequality to HDI.

H8: The poverty rate mediates the effect of the Gini Ratio on HDI.

Adequate sanitation may influence human development indirectly by reducing household economic vulnerability. Poor sanitation increases exposure to disease, health expenditures, and productivity losses, whereas improved sanitation can reduce these burdens and contribute to lower poverty [18], [19]. Under the Capability Approach, lower poverty expands households' ability to access health care, education, and adequate living conditions. Accordingly, poverty is expected to provide a pathway through which greater sanitation access contributes to human development.

H9: The poverty rate mediates the effect of access to adequate sanitation on HDI.

Household internet access may also influence human development through poverty by expanding access to information, education, public services, employment, and income-generating activities. Greater connectivity can improve households' economic opportunities and potentially reduce poverty [28], [29]. A reduction in poverty may subsequently expand the capabilities

required to achieve better health, education, and living standards. Thus, poverty is expected to mediate the relationship between household internet access and HDI.

H10: The poverty rate mediates the effect of household internet access on HDI.

Based on these relationships, the research model positions the Gini Ratio, access to adequate sanitation, and household internet access as independent variables, poverty as the mediating variable, and HDI as the dependent variable. The model examines both the direct effects of the three structural variables and poverty on HDI and the indirect effects of the structural variables on HDI through poverty as the proposed socioeconomic pathway, thereby providing an integrated framework for assessing how conditions are linked to human development.

3. METHODS

This study employed a quantitative explanatory design to examine the direct and indirect relationships among income inequality, access to adequate sanitation, household internet access, poverty, and human development [31]. The units of analysis were Indonesian provinces observed from 2010 to 2025. Secondary data were obtained from official publications and statistical tables issued by Statistics Indonesia. A structured data compilation matrix was used to organize observations by province, year, and research variable.

The balanced panel dataset comprised 33 Indonesian provinces observed over 16 years, resulting in 528 province-year observations. The panel included only provinces with complete and comparable data throughout 2010–2025. North Kalimantan, South Papua, Central Papua, Highland Papua, and Southwest Papua were excluded because complete data were unavailable from the beginning of the study period. This restriction maintained a consistent observation period and comparability across provinces and over time.

The dependent variable was the Human Development Index (HDI), representing achievements in health, education, and a decent standard of living. The independent variables were the Gini Ratio, the percentage of households with access to adequate sanitation, and the percentage of households with internet access. The poverty rate, measured as the percentage of the population below the poverty line, was treated as the mediating variable. The Gini Ratio ranged from 0 to 1, while sanitation, internet access, and poverty were measured in percentages.

Data were analyzed using panel data regression with IBM SPSS Statistics. Descriptive statistics summarized the minimum, maximum, mean, and standard deviation of each variable. Panel estimation considered the Common Effect Model, Fixed Effect Model, and Random Effect Model. Model selection used the Chow, Hausman, and Lagrange Multiplier tests. Based on these procedures, the poverty model employed REM, whereas the HDI model employed FEM.

Two panel regression models were estimated. The first model examined the effects of the Gini Ratio, adequate sanitation access, and household internet access on poverty:

$$Z_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{3it} + \delta t + u_i + \epsilon_{it}$$

The second model examined the effects of the three independent variables and poverty on HDI:

$$Y_{it} = \beta_0 + \beta_4 X_{1it} + \beta_5 X_{2it} + \beta_6 X_{3it} + \beta_7 Z_{it} + \alpha_i + \delta t + \epsilon_{it}$$

Here, X_1 represents the Gini Ratio, X_2 access to adequate sanitation, X_3 household internet access, Z the poverty rate, and Y HDI. The subscripts i and t denote province and year, respectively; δt represents time effects, u_i the province-specific random component in Model 1, α_i province fixed effects in Model 2, and ϵ_{it} the idiosyncratic error term.

Serial correlation was assessed using the Wooldridge test, while cross-sectional dependence was examined using the Pesaran

CD test. The final specification of Model 1 employed REM with time effects and a first-order autoregressive [AR(1)] residual structure. Model 2 employed FEM with province and time effects and an AR(1) residual structure. Robust covariance estimation with provinces as the clustering unit was used in both models to obtain adjusted standard errors and statistical inference. Direct effects were evaluated at the 5% significance level.

The mediating role of poverty was examined by estimating the indirect effect as the product of the coefficient linking each independent variable to poverty and the coefficient linking poverty to HDI. Statistical significance was assessed using 5,000 bootstrap replications with provinces as the resampling units. Province was sampled with replacement while all annual observations for that province were retained, thereby preserving the within-province temporal structure. Mediation was evaluated using 95% bias-corrected and accelerated (BCa) confidence intervals. An indirect effect was considered significant when its confidence interval did not include zero.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Table 1 summarizes the descriptive statistics for the study variables. The Gini Ratio averaged 0.357, with values ranging from 0.214 to 0.459, indicating relatively limited variation in income inequality across provinces and years. Access to adequate sanitation averaged 69.41%, ranging from 16.12% to 98.20%, which reflects substantial disparities in basic sanitation coverage. Household internet access showed even wider variation, with an average of 57.34% and values between 7.18% and 99.16%.

The poverty rate averaged 11.22%, while the Human Development Index (HDI) averaged 71.09. Overall, these descriptive patterns indicate considerable differences across Indonesian provinces in basic infrastructure, digital connectivity, poverty conditions, and human development outcomes throughout the 2010–2025 study period. The wide ranges in sanitation and internet access illustrate persistent unevenness in essential services and connectivity.

Table 1. Descriptive Statistics

Variable	N	Min	Max	Mean	Std. Dev.
Gini Ratio	528	0.214	0.459	0.357	0.042
Access to Adequate Sanitation (%)	528	16.12	98.2	69.41	17.07
Household Internet Access (%)	528	7.18	99.16	57.34	26.97
Poverty Rate (%)	528	3.42	36.8	11.22	6.01
Human Development Index	528	55.55	85.05	71.09	4.58

Source: Processed secondary data (2026)

4.2. Panel Diagnostics and Regression Results

Table 2 summarizes the final panel regression estimates for the poverty and HDI models. Model 1 was estimated using REM with time effects

and an AR(1) residual structure, whereas Model 2 employed FEM with province and time effects and AR(1). Robust standard errors clustered by province were used in both models to support statistical inference.

Table 2. Panel Regression Results

Variables	Poverty Rate - Model 1	HDI - Model 2
Gini Ratio	3.692** (1.805)	-1.330 (2.515)
Access to Adequate Sanitation	-0.030** (0.014)	-0.013 (0.012)
Household Internet Access	-0.011 (0.016)	0.075 (0.040)
Poverty Rate	-	-0.070 (0.144)

Variables	Poverty Rate - Model 1	HDI - Model 2
Constant	14.952*** (1.892)	73.371*** (2.201)
Estimator	REM	FEM
Province effects	Random	Fixed
Time effects	Yes	Yes
AR(1)	Yes	Yes
Observations	528	528
R ²	0.142	0.957
Wald test p-value	0.068	0.001

Note: Robust standard errors are reported in parentheses. *** $p < 0.01$; ** $p < 0.05$. Model 1 uses REM with time effects and an AR(1) residual structure. Model 2 uses FEM with province and time effects and an AR(1) residual structure.

Source: Processed secondary data (2026)

Model 1 shows that the Gini Ratio has a positive and significant coefficient of 3.692 ($p = 0.041$), supporting H1. Since the Gini Ratio ranges from zero to one, a 0.10-point increase in the index corresponds to an estimated increase of approximately 0.369 percentage points in the poverty rate, holding the other variables and time effects constant. This relationship suggests that greater income inequality is associated with higher poverty because the benefits of economic activity and opportunities are distributed unevenly across population groups. Low-income households may consequently face more limited access to productive resources, decent employment, and opportunities for upward economic mobility. This pattern is consistent with the structural poverty perspective, which views unequal access to resources and economic opportunities as structural conditions that can sustain poverty [16], [17], [24]–[27].

Access to adequate sanitation has a negative and significant coefficient of -0.030 ($p = 0.029$), supporting H2. A one-percentage-point increase in the proportion of households with adequate sanitation is associated with a 0.030-percentage-point decrease in the poverty rate, other factors being constant. Adequate sanitation can reduce exposure to environmentally related diseases, health expenditures, and productivity losses that disproportionately burden economically vulnerable households. Better sanitation may therefore improve

household economic resilience by reducing avoidable health-related costs and preserving time available for productive activities. The result indicates that access to basic sanitation is not merely an environmental or health condition but also forms part of the structural conditions associated with poverty reduction [18], [19].

Household internet access has a negative coefficient of -0.011 , but the effect is statistically insignificant ($p = 0.484$); therefore, H3 is not supported. The negative coefficient alone cannot be interpreted as evidence that expanding internet access reduces poverty. Internet connectivity may broaden access to information, employment opportunities, public services, education, and digital economic activities, but these potential benefits depend on whether households are able to convert connectivity into productive economic use. Network quality, affordability, device ownership, digital skills, educational capacity, access to capital, and the availability of income-generating opportunities may determine whether internet access produces measurable improvements in household welfare. Thus, increasing connectivity without complementary capabilities may be insufficient to reduce provincial poverty rates [28]–[30].

For human development, the Gini Ratio has a negative coefficient of -1.330 but is statistically insignificant ($p = 0.597$); therefore, H4 is not supported. Although the direction is consistent with

the proposition that greater inequality may restrict access to education, health services, and economic opportunities, the estimation does not provide evidence that changes in income inequality independently affect HDI. The fixed-effects specification identifies changes within each province over time while controlling for time-invariant provincial characteristics, common time effects, sanitation, internet access, and poverty. HDI is a composite outcome reflecting health, education, and living standards, whose development may also depend on the quality of public services, fiscal capacity, educational and health infrastructure, and other province-specific conditions. Consequently, changes in income distribution may not translate immediately into measurable changes in human development [4]–[7].

Access to adequate sanitation also has no significant direct effect on HDI, with a coefficient of -0.013 ($p = 0.289$), and H5 is therefore not supported. Because the coefficient is statistically insignificant, its negative sign should not be interpreted as evidence that improved sanitation reduces human development. The result instead indicates that changes in sanitation coverage within provinces were not independently associated with changes in HDI after province and time effects and the other explanatory variables were controlled. Sanitation remains an important basic service because it can improve health conditions, reduce exposure to disease, and support productivity [8]–[11]. However, improvements in coverage may require sufficient service quality, sustained use, complementary health interventions, and time before their benefits are reflected in the broader dimensions incorporated into HDI.

Household internet access has a positive coefficient of 0.075 , but its p -

value of 0.058 remains above the 5% significance threshold; accordingly, H6 is not supported. The positive direction cannot therefore be treated as statistical evidence that greater household connectivity improves HDI. Internet access may expand opportunities to obtain information, education, health services, public services, and economic opportunities, but access alone does not ensure that these opportunities are converted into improved human capabilities. The development effect of connectivity may depend on network quality, affordability, device availability, digital skills, educational capacity, and the extent to which internet use supports productive activities [12]–[15]. The result therefore points to the importance of distinguishing digital access from the effective use of digital resources for human development.

Finally, the poverty rate has a negative coefficient of -0.070 but is statistically insignificant ($p = 0.626$), leading to the rejection of H7. Although the coefficient follows the expected direction, the estimate does not establish that changes in provincial poverty rates independently affect HDI within the study period. The fixed-effects model controls for persistent differences across provinces and common changes over time; thus, the coefficient reflects the association between changes in poverty and changes in HDI within the same province rather than simple differences between high- and low-poverty provinces. Poverty can theoretically restrict access to education, health care, nutrition, and adequate living standards [20]–[23], but these effects may operate alongside public expenditure, social protection, education and health provision, and other structural conditions that are not represented by the poverty rate alone.

Table 3. Mediation Test Results

Hypothesis	Mediation Result	Decision
H8	Gini Ratio–HDI via Poverty Indirect effect = -0.2600	Not supported

Hypothesis	Mediation Result	Decision
	Boot. SE = 0.5922 95% BCa CI = [-2.0468, 0.5073]	
H9	Sanitation–HDI via Poverty Indirect effect = 0.0021 Boot. SE = 0.0048 95% BCa CI = [-0.0041, 0.0167]	Not supported
H10	Internet Access–HDI via Poverty Indirect effect = 0.0008 Boot. SE = 0.0023 95% BCa CI = [-0.0035, 0.0054]	Not supported

Note: Indirect effects were evaluated using 5,000 bootstrap replications with provinces as the resampling units. BCa = bias-corrected and accelerated confidence interval. An indirect effect is statistically significant when the 95% confidence interval does not include zero.

Source: Processed secondary data (2026)

The mediation results are reported in Table 3. The indirect effect of the Gini Ratio on HDI through poverty is -0.2600 , with a 95% BCa confidence interval ranging from -2.0468 to 0.5073 . Because the interval includes zero, H8 is not supported. The first stage of the proposed mechanism is evident, as the Gini Ratio significantly increases poverty, but poverty does not significantly affect HDI in the subsequent equation. Thus, the empirical evidence does not support poverty as the mechanism through which income inequality is transmitted to human development. The theoretically expected pathway is therefore incomplete: inequality is associated with higher poverty, but changes in poverty do not translate into statistically detectable changes in HDI after province and time effects are controlled.

The indirect effect of access to adequate sanitation on HDI through poverty is 0.0021 , with a 95% BCa confidence interval of -0.0041 to 0.0167 ; therefore, H9 is not supported. Sanitation significantly reduces poverty in Model 1, but poverty does not significantly affect HDI in Model 2. The positive sign of the indirect effect results mathematically from multiplying two negative coefficients and should not be interpreted as evidence of a positive mediation effect because the confidence interval includes zero. This finding

indicates that the poverty reduction associated with improved sanitation has not been shown to constitute the pathway through which sanitation influences HDI. Sanitation may generate more immediate benefits through health and environmental conditions, while changes in the broader health, education, and living-standard components of HDI may require additional complementary conditions or longer adjustment periods.

Household internet access also shows no significant indirect effect on HDI through poverty. The estimated indirect effect is 0.0008 , with a 95% BCa confidence interval between -0.0035 and 0.0054 , leading to the rejection of H10. Unlike the previous two pathways, internet access does not significantly affect poverty, and poverty itself does not significantly affect HDI. Consequently, the proposed mediation chain is not empirically established. Although the indirect coefficient is positive because both component coefficients are negative, its direction has no substantive statistical meaning in the absence of a significant bootstrap effect. These results indicate that internet access alone does not produce a measurable poverty-mediated improvement in human development; its contribution may depend on productive use, digital skills, affordability, service quality, and complementary economic opportunities.

Taken together, the mediation analysis provides no evidence of either full or partial mediation by poverty. Although the Gini Ratio and access to adequate sanitation significantly affect poverty, the second stage linking poverty to HDI is not statistically supported. For household internet access, neither stage of the indirect pathway is significant. Hence, the results suggest that structural conditions associated with provincial poverty do not automatically translate into changes in human development through poverty within the study period. This distinction is important because it indicates that poverty reduction and human development, although conceptually related, may respond to different combinations of economic, social, institutional, health, and educational conditions.

From a policy perspective, the significant relationship between inequality and poverty supports policies that improve economic opportunities for lower-income groups through productive employment, skills development, targeted social protection, and more equitable access to education, health services, business capital, and markets. The negative effect of adequate sanitation on poverty also supports continued expansion of sanitation infrastructure, particularly in provinces with low coverage and high poverty, accompanied by access to clean water, facility maintenance, improved settlement conditions, and sustained hygienic practices. Although household internet access is not statistically significant in either model, digital access remains a supporting infrastructure whose potential benefits may depend on network quality, affordability, device availability, digital literacy, and productive use. Because poverty does not mediate the three relationships with HDI, policies aimed at improving human development should simultaneously address education, health, and living standards rather than assuming that

poverty reduction alone will automatically raise HDI.

5. CONCLUSION

This study examined the direct effects of the Gini Ratio, access to adequate sanitation, and household internet access on poverty and human development, as well as the mediating role of poverty, using a balanced panel of 33 Indonesian provinces from 2010 to 2025. Greater income inequality is associated with higher provincial poverty, whereas broader access to adequate sanitation is associated with lower poverty. Household internet access does not show a clear relationship with poverty. For human development, the evidence does not establish independent relationships between HDI and the Gini Ratio, adequate sanitation, household internet access, or poverty after provincial and temporal differences are accounted for. The bootstrap analysis provides no evidence that poverty mediates the effects of the Gini Ratio, sanitation, or internet access on HDI. These findings suggest that inequality and sanitation are more directly related to provincial poverty conditions, whereas changes in human development do not appear to operate through the proposed poverty-mediated pathways.

The findings support policies that reduce inequality by expanding productive employment, skills, targeted social protection, and equitable access to education, health services, capital, and markets, while continuing to improve adequate sanitation as part of poverty reduction. Digital policy should extend beyond internet coverage by addressing network quality, affordability, device access, digital literacy, and productive use. Improving HDI also requires interventions that directly strengthen health, education, and decent living standards rather than assuming that poverty reduction alone will generate improvements in human development. This study is limited to 33 provinces with complete observations throughout 2010–2025 and therefore does not separately represent newly established

provinces. It also focuses on a limited set of structural variables and does not incorporate factors such as economic growth, unemployment, government expenditure, education and health service quality, labor productivity, or regional fiscal capacity.

Future research could incorporate these factors and broader provincial coverage to examine more fully the mechanisms underlying poverty and human development in Indonesia.

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