



Quantifying progress: The correlation between illiteracy rates and the human development index

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ABSTRACT

Background: The elimination of illiteracy represents a key objective of Sustainable Development Goals (SDGs) 4, essential for fostering quality education and lifelong learning opportunities. Previous research indicated that illiteracy posed severe negative consequences for community well-being and societal progress. This study aimed to investigate the precise quantitative relationship between the provincial illiteracy rate and the Human Development Index (HDI) across Indonesia, thereby emphasizing the critical importance of achieving SDG 4. **Methods:** Researchers employed a quantitative descriptive design with a correlational approach. The study utilized 2024 cross-sectional data on the illiteracy percentage and HDI for all 38 Indonesian provinces, which was obtained from the Statistics Indonesia/*Badan Pusat Statistik (BPS)*. Following a test for normality, the non-parametric Spearman Rank correlation test was selected for the analysis, supplemented by visual examination via a scatter plot. **Findings:** The analysis revealed a strong, statistically significant inverse relationship between the provincial illiteracy rate and the HDI in Indonesia. The 2024 HDI data, spanning an interval of 1-100, showed an average of 73.5, with the maximum score (84.15) achieved by Special Capital Region of Jakarta and the minimum score (54.43) recorded by Highland Papua Province. Correspondingly, the illiteracy rates averaged 3.7%, with Highland Papua Province displaying the highest rate (29.63%) and Central Sulawesi province the lowest (0.25%). This inverse correlation confirmed the theory that low human capital, as measured by illiteracy, directly restricts developmental outcomes. **Conclusion:** The principal conclusion was that the eradication of illiteracy is crucial for significantly raising the HDI, directly supporting the successful realization of SDG 4, and enhancing overall public welfare. **Novelty/Originality of this article:** This research provided the most current (2024) and comprehensive correlation analysis using data from all 38 provinces in Indonesia, establishing a renewed empirical foundation that underscores the urgency of the SDG 4 target for regional development.

KEYWORDS: human development index (HDI); illiteracy; spearman rank correlation; sustainable development goals (SDGs).

1. Introduction

A better and more sustainable life is the hope of every individual. Every human being certainly does various things to achieve a better or higher quality of life. Strategies and cooperation between humans are needed to achieve this together. The Sustainable Development Goals (SDGs) are a global framework agreed upon by 193 UN member states to achieve sustainable development from 2015 to 2030. The main focus is to improve human welfare, economic prosperity, and environmental protection simultaneously. The Sustainable Development Goals (SDGs) cover 17 goals that depart from the previous agenda, namely Education for All and the Millennium Development Goals, by expanding the

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scope of education from primary to higher and adult education (Sareen & Mandal, 2024). Presidential Regulation of the Republic of Indonesia Number 111 (2022) explains sustainable development, whereby the Sustainable Development Goals (SDGs) are a global development agenda to end poverty, improve welfare, and protect the planet through the achievement of 17 goals by 2030. These interconnected global goals include: No Poverty, Zero Hunger, Good Health and Well-being, Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy, Decent Work and Economic Growth, Industry, Innovation, and Infrastructure, Reduced Inequalities, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action, Life Below Water, Life on Land, Peace, Justice, and Strong Institutions, and finally, Partnerships for the Goals. Achieving these objectives requires global collaboration, strategic planning, and dedicated action across all sectors.

To understand the distribution of literacy rates in 2024, it is critical to contextualize Indonesia's historical trajectory in educational equity. Historically, the Indonesian government has implemented aggressive intervention strategies to combat educational deficits. The foundational wave of literacy intervention was epitomized by the mass structural program known as Eradication of Illiteracy/"*Pemberantasan Buta Aksara*", initiated in the mid-20th century to build basic functional literacy across rural communities. Over the decades, this program evolved from basic phonetic training into more sophisticated frameworks, culminating in the contemporary National Literacy Movement/*Gerakan Literasi Nasional*. These systematic campaigns transformed literacy from a basic mechanics tool into a nationwide push for functional and digital competencies. Consequently, these historical efforts structurally reduced the national illiteracy baseline, shifting the core analytical focus in 2024 away from absolute nationwide ignorance toward mapping stubborn pockets of deep-seated regional disparities.

Implementing the Sustainable Development Goals (SDGs) within a governance framework can drive environmental progress and provide a foundation for evidence-based sustainable policies (Kateb et al., 2025). Each of the Sustainable Development Goals (SDGs) can be achieved with the right knowledge. Education is the key to becoming economically independent, thereby providing freedom for the future (Sriraman & English, 2010, p.63). The world's commitment to inclusive and equitable education initially ensured that everyone received a quality education. SDG 4 served as the primary global commitment intended to address inequality in access to education, curriculum adaptation, infrastructure, and the availability of educators. SDG 4 specifically addressed quality education. Ultimately, SDG 4 functioned as a global governance tool that aimed to improve education in a comprehensive and inclusive manner (Ydesen & Elfert, 2023). The implementation of SDG 4 is underpinned by various global initiatives, including the Transforming Education Summit (TES) and Global Initiatives (Wulff, 2024). Obtaining a proper education is certainly a gradual process, from basic education to further education. Basic education, such as reading, writing, and arithmetic, supports further education. One of the global and thematic indicators for SDG 4 is literacy and numeracy skills (Smith et al., 2024). Literacy skills are an important element in achieving SDG 4 and also support numeracy skills. Indicators related to literacy and numeracy for a certain age are differentiated between functional literacy or numeracy skills, literacy level or literacy adaptation, and literacy learning participation for those who cannot read and write (Smith et al., 2024).

Basic literacy skills are an important element in achieving quality education. The implementation of literacy requires a sustainable approach, not just a set of indicators (Ocampo Cantillo & Lazaro, 2024). Literacy is not limited to decoding and encoding text, but also includes critical thinking and the ability to challenge existing social practices and systems (Arenius & Lenz, 2024). SDG 4 highlights the literacy rate of people aged 15 years and older, but in Indonesia there are still people over the age of 15 who are illiterate, according to data from the Central Statistics Agency/*Badan Pusat Statistik (BPS)*. The research by Gedik & De la Garza (2025) examined illiterate individuals, consisting of those who cannot read at all and those who can read a few words per minute but are still unable to understand long texts. Those who are unable to understand more complex texts are

considered functionally illiterate. The conclusion of the study is that literacy has a significant influence on performance in semantic fluency tasks. Individuals who are able to read and have literacy skills tend to produce more words and demonstrate better retrieval abilities across various categories. Literacy not only increases vocabulary and world knowledge, but also strengthens semantic networks and efficiency in accessing verbal information. Therefore, literacy plays an important role in the development of language cognitive functions and influences semantic memory abilities, even beyond the influence of formal education and age.

In developing economies, this phenomenon is deeply intertwined with the "educational trap" theory. This economic framework posits that low initial human capital locks individuals and entire regions into low-productivity cycles, making development stagnant. Illiteracy acts as a structural anchor within this educational trap, specifically suppressing the non-income dimensions of the Human Development Index (HDI), such as health, longevity, and child survival rates. Illiterate populations experience acute deficits in health literacy; they encounter severe barriers in decoding medical instructions, understanding nutritional guidelines, and executing preventative healthcare protocols. Consequently, even if a region experiences artificial macroeconomic growth through natural resource extraction, the underlying human capital remains compromised, resulting in suppressed life expectancy and high public health vulnerabilities that drag down the aggregate regional HDI performance.

Reading ability affects the quality of education, and the quality of education can affect the Human Development Index (HDI). The human development index is a measure that shows the level of human development in a region. The Human Development Index (HDI) is an indicator that shows social and economic development in various countries (Al-Mahamid, 2025). The human development index was developed by the United Nations Development Programme (UNDP) to comprehensively measure a country's level of development (Wang et al., 2023). In measuring the development of a region, assessment indicators are certainly needed. The human development index can be calculated based on the dimensions of health, education, and income (Lian et al., 2023). These three dimensions are certainly influenced by each individual's literacy skills. Good financial literacy can help individuals make better financial decisions, reduce the risk of mistakes such as overindebtedness, and improve their personal financial outcomes (Pitthan & De Witte, 2025).

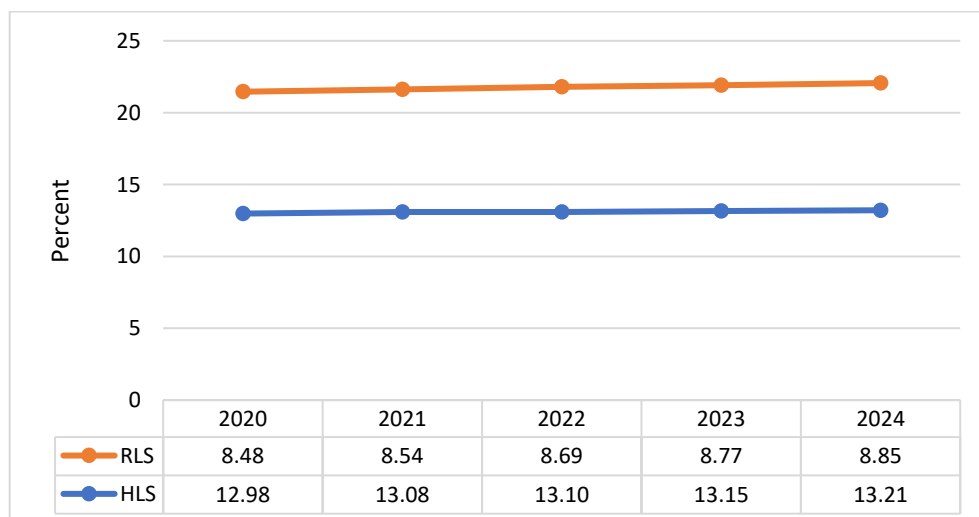


Fig 1. Expected years of schooling/*harapan lama sekolah* (HLS) and average years of schooling/*rata-rata lama sekolah* (RLS) in Indonesia, 2020–2024
(Badan Pusat Statistik, 2024)

The Human Development Index (HDI) provides an overview of the level of human development in a region, with higher values indicating better development (Cohen-Solal et

al., 2025). In Indonesia, the Human Development Index (HDI) is an indicator that measures quality of life by taking into account three basic dimensions, namely a long and healthy life, knowledge, and a decent life (Badan Pusat Statistik, 2024). Education indicators are certainly influenced by the literacy skills of the community. Education indicators are reviewed based on Expected Schooling Length/*Harapan Lama Sekolah (HLS)* and Average Schooling Length/*Rara-rata Lama Sekolah (RLS)*. During 2020–2024, Indonesia's human development index increased by an average of 0.75 percent per year. Human development index data in the field of education shows that the Expected Schooling Years of the population aged 7 years in 2024 will increase compared to the previous year. The Average Schooling Years of the population aged 25 years and above will also increase compared to the previous year.

Following the presentation of the resilient and sustained growth in the national Human Development Index (HDI) over the five-year period from 2020 to 2024 in educational indicator, it is essential to delve into the underlying factors and correlations that drive this improvement. A key preliminary finding suggests that the observed rise in the HDI is consistently and inversely proportional to the decline in the percentage of illiteracy among the Indonesian population aged 15 years and above, a vital statistic that dropped by 0.14% between 2023 and 2024. Despite the fact that literacy skill rates have been removed from the list of direct calculation inputs, the conceptual link between the HDI and fundamental literacy skills remains profoundly relevant. As the cornerstone of educational attainment, proficiency in reading and writing directly contributes to the knowledge and skill components that ultimately determine a region's HDI performance. Thus, in order to validate whether the relationship between the provincial Human Development Index (HDI) and illiteracy figures in Indonesia is indeed direct or, more likely, inverse, a precise correlation analysis is indispensable. This crucial statistical procedure is carried out to explicitly determine if the two variables exhibit a positive, negative, or reciprocal association. Consequently, the central aim and focus of this study is to statistically analyze and quantify the precise nature of the relationship between the Human Development Index (HDI) and the illiteracy rates among all provinces in Indonesia.

2. Methods

The method used in this research was a quantitative descriptive method coupled with a correlational approach. Initially, the collected data underwent a basic descriptive statistical analysis. This involved detailing the datasets by calculating key measures such as the mean, the maximum value, the minimum value, and the overall data range. Once both sets of data had been thoroughly summarized and described, the researchers proceeded to execute a correlation test. Correlation test, as defined by Kuncoro (2018) is a statistical technique utilized for the purpose of identifying and quantifying the reciprocal relationship that exists between one variable and another. Correlation analysis attempts to determine the extent of the relationship, or the linear dependence, present between the two respective sets of data points (Jockers, 2014). The relationship between the two variables could also be initially observed visually by examining the position and pattern of the data points on a scatter plot; however, a statistical correlation test was subsequently performed to provide a rigorous, quantitative measure. The specific statistical analysis chosen for the correlation test was contingent upon the normality of the data. Assessing the data's normality was a crucial prerequisite, as it determined whether a parametric or a non-parametric analysis would be appropriate.

2.1 Data cleaning and validation process

Parametric methods, as stated by Triola (2014) typically require that several conditions be met, most importantly the stipulation that the sample data originated from a population that followed a normal distribution. Therefore, a normality test was conducted. The normality test serves as a formal procedure to ascertain whether the distribution of the

data within the collected sample could reasonably be considered to have originated from a specific population that followed a normal distribution (Budiwanto, 2017). The normality test used in this study was performed with a significance level of 0.05 which led to the formulation of the following hypothesis: H_0 is the data is normally distributed; H_1 is the data is not normally distributed.

When the statistical result, specifically the p-value, was found to be greater than the predetermined significance level (α) of 0.05 the null hypothesis (H_0) was not rejected. This outcome indicated that there was insufficient evidence to conclude that the data significantly deviated from a normal distribution, thus confirming the assumption that the data was normally distributed. Conversely, if the calculated p-value was less than or equal to 0.05 the null hypothesis (H_0) was rejected. The rejection of the null hypothesis in this context meant that the observed sample data was highly unlikely to have come from a population with a normal distribution, leading to the conclusion that the data was not normally distributed. For this particular research, the researchers chose to employ the Shapiro-Wilk test to perform the normality assessment. The Shapiro-Wilk test is specifically recommended for small to moderate sample sizes and operates based on the following established formula with W as Shapiro-Wilk test statistics; $x_{(i)}$ as the i data value after sorting from smallest to largest $\bar{x}$ as sample mean; x_s as weighting coefficient calculated based on the variance and covariance of the normal sample data; and n as sample size.

$$W = \frac{(\sum_{i=1}^n a_i x_{(i)})^2}{(\sum_{i=1}^n (x_i - \bar{x})^2)} \quad (\text{Eq. 1})$$

Following the determination of data normality, the next step that was undertaken was the correlation analysis, which served the primary purpose of quantitatively ascertaining the nature and strength of the relationship between the two variables under investigation. To guide this statistical test, a formal set of hypotheses was established. These hypotheses represented the opposing statements regarding the existence and direction of a relationship between the variables, and they were framed as follows, H_0 : $\rho = 0$ as there is no relationship between the two variables); H_1 : $\rho \neq 0$ as there is a relationship between the two variables).

If the data were to be determined as normally distributed, then it would be permissible and appropriate to proceed with a parametric analysis. Parametric correlation techniques, such as the well-established Pearson Product Moment correlation, were identified as suitable options under this condition. To ensure the mathematical validity and representation of the normality test, a rigorous data cleaning and validation protocol was executed in R Studio. The primary structural challenge involved reconciling secondary data across the newly established administrative boundaries in Indonesia, which expanded the regional landscape to 38 provinces. Specifically, the datasets for the newly formed provinces in the Papua region—Highland Papua, Central Papua, South Papua, and Southwest Papua—were extracted and cross-referenced with parent-province legacy databases from the Central Statistics Agency/*Badan Pusat Statistik (BPS)* to avoid statistical overlap or data gaps. Outliers and incomplete entries were validated using interquartile range (IQR) scanning. This data validation process ensured that the 2024 cross-sectional dataset maintained absolute structural completeness across all 38 provinces, rendering the subsequently applied Shapiro-Wilk normality assessment completely representative of the actual regional administrative topography.

2.2 Correlation test

As noted in the statistical literature by Gunawan (2017), the utilization of Pearson Product Moment correlation explicitly requires the foundational assumption of normality to ensure the validity and reliability of the statistical inference drawn. Should this critical precondition of normality be successfully met by the collected data, the relationship

between the two main variables would be quantified using the Pearson Product Moment correlation formula, which is formally expressed as follows. The variables under examination, denoted as X and Y, represented the two key factors whose relationship was being statistically investigated in the study.

$$r = \frac{n(\sum XY) - (\sum X)(\sum Y)}{\sqrt{\{n \sum X^2 - (\sum X)^2\} \{n \sum Y^2 - (\sum Y)^2\}}} \quad (\text{Eq. 2})$$

The strength and direction of the linear relationship, specifically calculated by the Pearson Product Moment correlation, are conventionally symbolized by the letter r . This coefficient exists within a defined and critical interval, ranging from -1 to +1. The interpretation of the calculated r value is standardized, according to Riduwan (2015) an r value of -1 signifies a perfectly negative correlation, meaning the variables move in completely opposite directions. Conversely, an r value of 0 (zero) indicates that no linear correlation exists between the two variables. Finally, an r value of +1 denotes a perfectly positive correlation, which is also interpreted as an extremely strong correlation, where the variables increase or decrease together in perfect alignment. Following the computation of the Pearson r value, the next procedural step required a t -test to determine the statistical significance of the correlation. The result of the calculated t value would then be rigorously compared against the critical table t table to definitively ascertain which formulated hypothesis should be accepted or rejected. Importantly, the methodology also provided a necessary contingency, if the earlier normality test failed to meet the parametric assumption, and the data was thus confirmed to be not normally distributed, the appropriate analytical technique would shift to the Spearman Rank Correlation. The formula for the Spearman Rank Correlation coefficient was then specified with d_i as the difference in rank between two variables for observation i ; and n as number of data points (observation pairs).

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \quad (\text{Eq. 3})$$

Specifically, a computed negative value for the correlation coefficient (ρ) is the statistical indicator that the two variables possess an inverse connotation, meaning that as one variable increases, the other tends to decrease. Conversely, a positive value for the correlation coefficient (ρ) definitively indicates that the two variables are positively correlated, signifying that they tend to increase or decrease in tandem. If the computed value of $\rho = 0$ it suggests that there is no significant linear correlation existing between the variables. The entirety of the data utilized for this investigation is classified as cross-sectional data, specifically obtained from the year 2024. This data was strategically acquired from a recent, official publication issued by the Central Statistics Agency/*Badan Pusat Statistik (BPS)* of Indonesia. In terms of data acquisition methodology, the sampling approach employed was non-probability sampling, specifically utilizing the purposive sampling technique. This particular data set comprehensively describes the relationship between the human development index and the illiteracy rates across all provinces in Indonesia during the most recent period for which official figures are available. All subsequent data analysis and statistical computations, including the generation of the scatter plot and the determination of the correlation coefficient were meticulously performed using the advanced capabilities of the R Studio application.

3. Results and Discussion

A comprehensive examination of the Indonesian national statistics reveals significant variations in key socio-economic indicators across the archipelago's 38 provinces. Specifically, the latest 2024 Human Development Index (HDI) data for Indonesia, which is measured on a standardized interval scale ranging from 1 to 100, presented a national

average HDI of 73.5. At the upper extreme of this distribution, the province of DKI Jakarta achieved the maximal HDI score of 84.15, illustrating its position as the region with the most robust human capital development. Conversely, the newly formed province of Highland Papua (Papua Pegunungan) registered the minimal value of 54.43, highlighting a substantial disparity in human development outcomes across the country. As noted by Al-Maadid et al. (2025) an elevated HDI score is generally interpreted as a direct reflection of a region's increased institutional capacity to effectively formulate and implement policies, thereby achieving superior performance and defined human development goals. In parallel, an analysis of the 2024 illiteracy rate data for all Indonesian provinces, expressed as a precise percentage of the population, shows its own set of wide fluctuations. The nationwide average illiteracy rate stood at 3.7%. Unsurprisingly, the province of Highland Papua (Papua Pegunungan) also recorded the highest illiteracy percentage at a staggering 29.63%, which stands in sharp contrast to the province of Central Sulawesi, which achieved the lowest recorded rate of merely 0.25%.

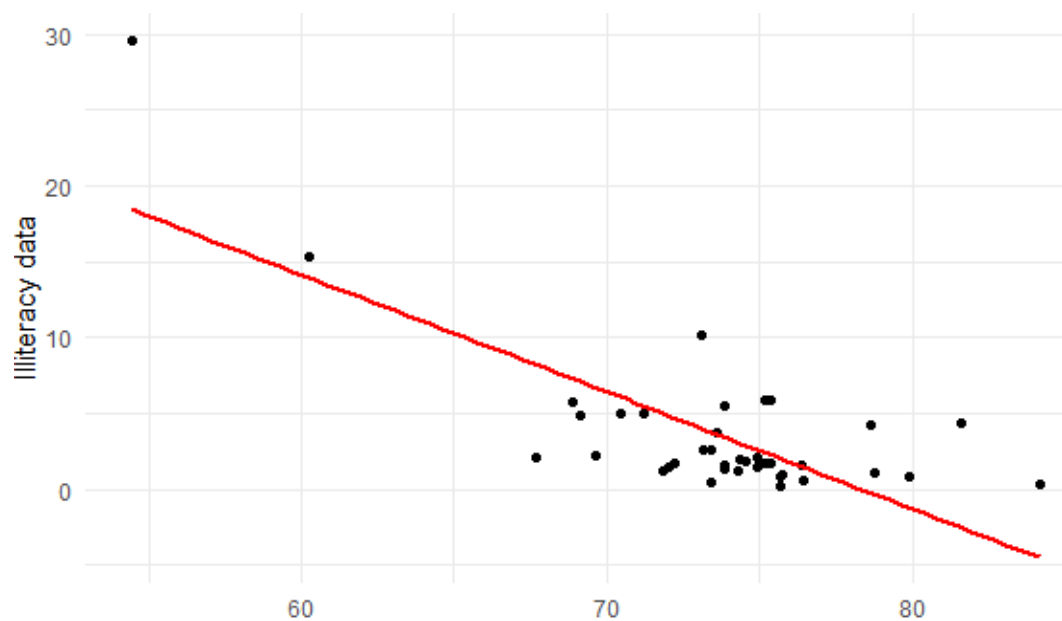


Fig. 2. Scatter plot of illiteracy data and human development index (HDI)

Descriptively, a stark and immediately evident inverse comparison emerges when examining the relationship between these two indicators, particularly noticeable in the pronounced phenomenon occurring within the province of Highland Papua. This province simultaneously exhibits the lowest recorded HDI value and the highest illiteracy rate, strongly suggesting an inverse relationship, areas with a high illiteracy rate tend to concurrently demonstrate a low HDI. To move beyond mere description and formally confirm the existence, direction, and strength of this hypothesized relationship, a rigorous correlation analysis is absolutely necessary. One effective preliminary method for visually assessing the joint distribution of these two variables and identifying any obvious patterns is through the construction and examination of a scatter plot. The nature of the potential correlation between the two variables, the HDI and the illiteracy rate can be initially inferred from the overall trend and positional arrangement of the data points on the scatter plot, which will then be validated by the subsequent statistical correlation analysis. Utilizing the R Studio application as the computational environment, the resulting scatter plot illustrating the correlation between these two crucial datasets can be visually presented as Figure 2.

The visual evidence presented by the scatter plot clearly and unequivocally indicates a negative or inverse relationship existing between provincial illiteracy rates and the Human Development Index (HDI) scores. This inverse association is precisely illustrated by the red regression line, which is observed to slope distinctly downward, moving from the top-left quadrant toward the bottom-right. This geometrical orientation means that as the value

measured on the X-axis (representing the HDI) increases, there is a corresponding tendency for the value on the Y-axis (representing the illiteracy rate) to decrease, and the reverse is also consistently true. While the overall negative trend is quite pronounced and statistically clear, closer inspection of the plot reveals that not all data points (or plots) are perfectly aligned with the regression line; in fact, several are scattered quite far from the line of best fit. This dispersion indicates that the relationship between these two variables is not perfectly linear or deterministic. This imperfect correlation strongly suggests that while illiteracy is a significant factor, other variables besides the illiteracy rate are certainly influencing the final Human Development Index (HDI) outcome in the Indonesian provinces. The presence of several distinct data points that lie far outside the main cluster confirms the existence of outliers within the dataset, which may require further investigation. In order to select the most appropriate statistical test for deeper analysis, the next logical step in the methodology was to perform a normality analysis on both the illiteracy and Human Development Index (HDI) data. The specific results pertaining to the data normality assessment are detailed as follows.

Table 1. Normality test result

Data	W	p-value
Illiteracy	1.808e-09	1.808e-09
Human Development Index (HDI)	0.85727	0.0001946

The p-values calculated for both the illiteracy rate and the Human Development Index (HDI) datasets were found to be smaller than the established significance level of 0.05. This outcome necessitated the conclusion that the data were not normally distributed. Consequently, the appropriate statistical method for conducting the correlation analysis had to be a nonparametric technique, specifically the Spearman Rank Correlation test. This result was perfectly consistent with the initial scatter plot visualization, which clearly showed the presence of numerous outlier data points significantly removed from the regression line which are known to be a common cause of non-normally distributed data. After executing the Spearman Rank Correlation analysis using the R Studio application, a definitive correlation coefficient $\rho = -0.5134603$. This calculated ρ value was negative, unequivocally indicating a negative or inverse correlation between the two variables. This statistically significant negative result required the rejection of the null hypothesis, thereby proving that the two variables were correlated. This confirmed that the two variables were not directly proportional; rather, one variable had to be lowered to maximize the other. The results of this analysis vividly showed how dangerous the effects of illiteracy were in an area, which, if high, would lower the Human Development Index (HDI).

The statistically significant inverse relationship ($\rho = -0.5134603$) demonstrated that lower illiteracy correlates with higher HDI is consistent and deeply rooted in, established literature. The detrimental influence of illiteracy extended far beyond its quantifiable effect on the Human Development Index (HDI) score, deeply affecting the practical lives and cognitive functioning of various communities. Research conducted by Valiyaveetil et al. (2021) demonstrated that individuals who were illiterate or possessed poor educational backgrounds often did not fully comprehend the intended purpose of various tasks assigned to them and consequently could not perform tests effectively. This situation inevitably complicated their daily lives and inhibited their participation in structured activities. Fundamentally, illiteracy defined as the inability to adequately read and write, was consistently associated with either low levels of formal schooling or a complete lack of formal education. Furthermore, the study by Balduino et al. (2020) highlighted that illiteracy could significantly compromise neuropsychological assessment results and the accuracy of cognitive interpretations, particularly within elderly populations who had no history of formal education. Specifically concerning language and knowledge acquisition, individuals who were unable to read tended to possess a more limited breadth of world knowledge and experienced marked difficulties in rapidly accessing verbal information. As reported by Gedik & De la Garza (2025) this deficit subsequently impacted their

performance across various cognitive domains, including semantic fluency tasks and general language skills. Reinforcing this critical social barrier, the research by Ayalew & Walea Wanke (2024) also explicitly stated that illiteracy was considered a major barrier to effective social communication and necessary societal change, thereby hindering broader development efforts.

Beyond the general negative linear trend, a granular analysis of Figure 1 and Figure 2 reveals critical socio-economic nuances. The tracking of Expected Years of Schooling (HLS) and Mean Years of Schooling (RLS) from 2020 to 2024 illustrates a resilient but disrupted progression. The visible slowdown and minor fluctuations within the 2020–2022 window directly mirror the structural shock of the post-pandemic educational landscape, where school closures and economic hardships caused localized dropouts.

Furthermore, the data points in Figure 2 exhibit a "scattered" nature that reveals critical regional outliers. For instance, certain provinces function as high-literacy, low-HDI outliers. This phenomenon is typically driven by structural economic bottlenecks where high basic literacy rates fail to translate into regional prosperity due to limited industrial diversification or low regional per capita income. Conversely, low-literacy, high-HDI outliers represent regions heavily anchored by massive resource-based investments (such as mining or capital-intensive infrastructure) that artificially inflate the province's economic dimension while leaving fundamental educational indicators lagging. The most severe disparity is visualized by Highland Papua, an extreme outlier where high geographical isolation, historical infrastructure deficits, and logistical challenges create an intense educational barrier, pushing the illiteracy rate to 29.63% and keeping the HDI at a national low of 54.43. To further examine how these spatial disparities operate across the archipelago, the 38 provinces were divided into two main regional clusters: Western Indonesia (comprising Sumatra, Java, Bali, and Kalimantan) and Eastern Indonesia (comprising Sulawesi, Nusa Tenggara, Maluku, and Papua). The regional analytical breakdown is summarized in Table 2.

Table 2. Summary of spearman correlation coefficients by region cluster

Region Cluster	Number of Provinces (N)	Spearman Coefficient (ρ)	p-value	Significance
Western Indonesia	22	-0.5255	0.0251	Significant
Eastern Indonesia	16	-0.4782	0.0345	Significant

Table 2 presents the empirical summary of the Spearman rank correlation analysis, which examines the socio-economic relationship between the Human Development Index (HDI/IPM) and Illiteracy Rates (BA) across thirty-eight provinces, categorized into two distinct macro-regional clusters: Western Indonesia (N = 22) and Eastern Indonesia (N = 16). For the Western Indonesia region, which encompasses a sample size of 22 provinces, the Spearman rank correlation yields a coefficient (ρ) of -0.5255. This numerical value denotes a moderate-to-strong negative monotonic relationship between the two investigated variables. Statistically, the negative sign implies an inverse proportionality, as a province's human development capacity enhances, its corresponding illiteracy rate systematically diminishes. The probability value associated with this cluster is documented at 0.0251. Because this p-value falls below the conventional statistical significance threshold (0.05), the null hypothesis is successfully rejected. Consequently, the findings confirm that the inverse relationship between human development and illiteracy in Western Indonesia is statistically significant and cannot be attributed to random sampling variation.

In regards to the Eastern Indonesia cluster, which constitutes a smaller cohort of 16 provinces, the analysis demonstrates a Spearman correlation coefficient (ρ) of -0.4782. Similar to the western counterpart, this value establishes a moderate negative correlation, reinforcing the geographical universality of the inverse relationship between institutional human development and the eradication of illiteracy. The calculated p-value for this regional cluster is 0.0345, which strictly satisfies the criteria for statistical significance under the standard alpha level (0.05). This empirical data confirms that both regional clusters operate

within established significance parameters ($p < 0.05$), validating that the structural mechanisms driving down illiteracy rates through human development frameworks are robust and operational within Eastern Indonesia. The empirical data confirms that the structural mechanisms driving down illiteracy rates through human development frameworks are robust and operational within Eastern Indonesia.

When comparing the two macro-regions, a subtle yet distinct variance in the magnitude of the correlation coefficients becomes apparent. The Western Indonesia cluster exhibits a slightly higher absolute correlation value relative to Eastern Indonesia. This divergence suggests that the structural socio-economic dynamics in the western provinces facilitate a marginally more consistent and tightly integrated translation of human development advancements into the reduction of illiteracy. Conversely, the slightly lower coefficient observed in Eastern Indonesia indicates a higher degree of internal variance among its 16 provinces, implying that while the overarching negative trend remains intact and statistically valid, the trajectory of illiteracy mitigation across individual eastern provinces is subject to minor regional fluctuations.

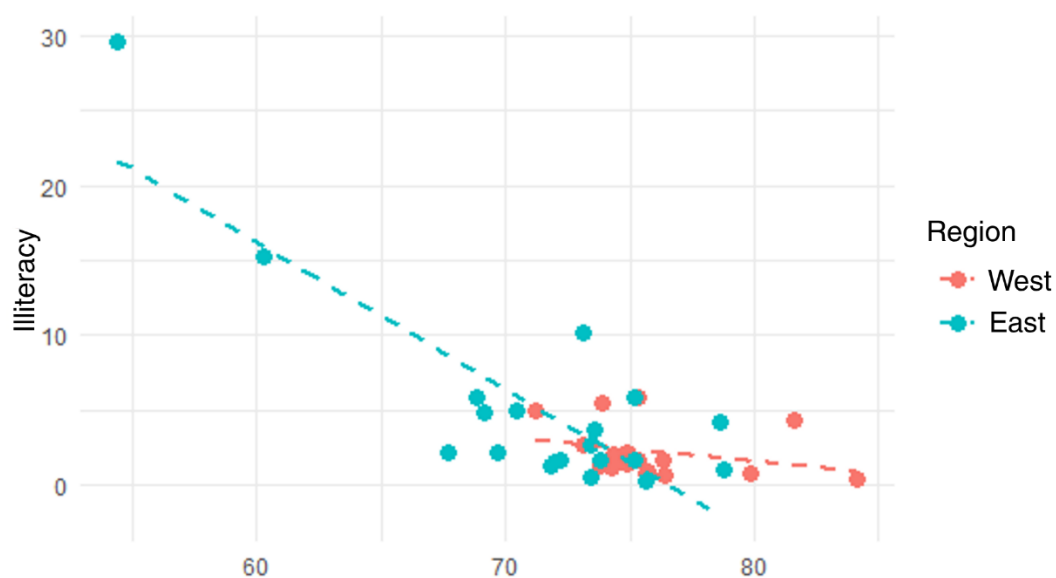


Fig. 3. Scatter plot of illiteracy data and human development index (HDI) for every region

The relationship between the Human Development Index (HDI) and Illiteracy Rates is visually delineated in the scatter plot below, which was generated using R programming software. The graphical representation employs a dual-categorical color scheme to differentiate between Western and Eastern Indonesian provinces, providing a clear comparative overview of regional socio-economic trends. Both regional clusters exhibit a downward-sloping regression line, visually confirming the negative monotonic relationship identified through the Spearman rank correlation analysis. This trend indicates that higher levels of human development are consistently associated with a reduction in illiteracy across both macro-regions.

In Western Indonesia (indicated in red), the data points are densely clustered within the higher HDI spectrum (approximately 70 to 85), coinciding with relatively low and stable illiteracy rates. Conversely, the Eastern Indonesia cluster (indicated in teal) displays a more pronounced slope, capturing a wider range of developmental stages. Notably, the steeper gradient in the eastern region highlights a dramatic decline in illiteracy as provinces transition from low to moderate HDI levels. While both regions demonstrate statistical significance, the visual dispersion in the eastern cluster suggests a higher degree of intra-regional variance compared to the more homogenized performance observed in the western provinces. This graphical output serves to validate the empirical findings, illustrating that

while the impact of human development is universal, the rate of transformation varies according to regional structural characteristics.

The repercussions of illiteracy extended beyond the affected individuals, casting a wide shadow over the broader society and surrounding environment. As noted by Arenius & Lenz (2024) illiteracy actively hindered citizens ability to access vital information, effectively communicate with various stakeholders, and successfully navigate complex bureaucratic and legal processes. This inability, therefore, had a major impact on the potential for achieving crucial societal development targets as well as on individual progression. It was recognized that illiteracy did not merely involve the inability to read simple sentences, rather it encompassed the crucial competence to understand a variety of texts and contexts, a skill that was fundamentally important for effective social and economic functioning (Pritchett & Sandefur, 2020). Another significant social consequence was observed in the utilization of essential social services, such as healthcare. Krause (2024) detailed how adequate literacy skills influenced an individual's capacity to properly understand complex health information and actively participate in both social and health networks. Furthermore, research by Pynnönen et al. (2022) discussed that the impact of illiteracy was overwhelmingly negative, especially for children originating from disadvantaged socioeconomic backgrounds. This lack of access to quality education and the absence of an environment that actively supported literacy development caused significant delays in these children's mastery of reading and writing skills. This delay then translated into a severe, long-term impact on their overall ability to learn and access necessary information throughout the remainder of their lives.

The imperative to achieve the elimination of illiteracy, a foundational target embedded within Sustainable Development Goal 4 (SDG 4), could not be taken lightly due to the magnitude of the required global effort. SDG 4 focused specifically on ensuring the provision of inclusive and equitable quality education and actively promoting lifelong learning opportunities for all people worldwide. Crucially, the success of any comprehensive education reform was highly dependent not only on favorable external conditions but also on the internal capacity of the respective governments to implement change (Oketch, 2024). Furthermore, the framework of SDG 4 also explicitly emphasized quality, gender equality, and the sustainability of educational systems as core priorities (Anthony & Yadav, 2025). Ultimately, achieving SDG 4 demanded major shifts in the collective way of thinking and acting across the global education community. Morris et al. (2023) argued that reaching SDG 4 was not merely a matter of calculating numbers and compiling data, but fundamentally required understanding and changing the underlying philosophical, historical, and epistemological foundations of existing education systems. This deep-seated change was necessary to ensure that these ambitious goals were truly achieved in an authentic and fully inclusive manner. The attainment of SDG 4 could be significantly supported by leveraging the power of SDG 17 (Partnerships for the Goals). Both SDG 4 and SDG 17 collectively focused on expanding access to quality and equitable education alongside establishing robust global partnerships necessary to realize these goals. However, as cautioned by Menashy & Zakharia (2023) these partnerships had to support education efforts, particularly in emergencies and challenging contexts, while also directly confronting critical systemic issues like power dynamics, colonial hierarchies, racism, and market influences within the global humanitarian architecture.

Education, as a fundamental component of the global sustainable development agenda, consistently emphasized the crucial importance of quality, inclusion, and sustainability for achieving overall human development. The critical role of literacy is not limited to cognitive skills but also extends to vital aspects of community resilience and social functioning (Antoninis, 2023). For instance, research affirms that literacy and education play a significant role in reducing vulnerability to various risks, including disasters and climate change (Guha & Hazra, 2024). By enabling individuals to understand complex information and warnings, literacy directly improves social capacity and strengthens community communication networks, which are essential elements of a robust and developed society, ultimately supporting a higher Human Development Index (HDI). Despite this recognized

importance, the task of improving literacy as a key target of SDG 4, faces significant implementation hurdles, including insufficient funding and a lack of firm political commitment (Klees, 2024). These obstacles negatively affect all other SDG targets, demanding concerted political and financial effort.

The data clearly established that the illiteracy rate had a significant negative effect on the Human Development Index (HDI), which served as the primary composite measure of human development progress (Moscona-Nissan et al., 2023). These negative effects of illiteracy not only resulted in a lower Human Development Index (HDI) score but also fundamentally made it difficult for individuals to navigate and successfully lead their lives. Crucially, the statistical evidence derived from the correlation analysis proved this inverse relationship, the higher the illiteracy rate recorded in a specific province, the lower the corresponding Human Development Index (HDI) value was found to be, and conversely, the lower the illiteracy rate in an area, the higher the Human Development Index (HDI) value became. While reading ability, which constituted the very basis of education, showed a clear and vital relationship with the Human Development Index (HDI), it was understood that the HDI was not influenced solely by educational factors. There were other critical indicators that also exerted substantial influence on the overall index score. Mburamatatare et al. (2025) specifically highlighted that other components having a significant impact on the Human Development Index (HDI) included per capita income and health expenditure. Therefore, the effort to reduce the illiteracy rate in each province was confirmed as a strategy to immediately boost the HDI. Nevertheless, this study underscored the necessity of implementing parallel policy improvements across other sectors, the goal of maximizing the HDI required that factors beyond education namely public health and overall community welfare were also significantly improved.

4. Conclusions

The robust statistical findings unequivocally confirmed that illiteracy rates maintained a significant negative or inverse relationship with the Human Development Index (HDI) across Indonesia's provinces. This relationship demonstrated a clear and compelling pattern, the higher percentage of illiteracy recorded within a province, the lower resultant Human Development Index (HDI) value tended to be. Conversely, provinces that successfully achieved lower illiteracy rates consistently exhibited higher corresponding HDI values. The preliminary visual evidence from the scatter plot, which showed a distinct downward-sloping regression line and a clear presence of non-normal data with outliers, was subsequently validated by the non-parametric Spearman Rank Correlation test. This conclusive finding underscored the profound detrimental influence of illiteracy, which extended beyond merely lowering the HDI score to fundamentally complicating individuals' lives, hindering cognitive function, impeding access to essential social services, and ultimately serving as a major barrier to effective social communication and broader societal development.

This research strongly suggested that Indonesia still needed to prioritize and intensify efforts to substantially reduce illiteracy rates, particularly in regions that currently exhibited high concentrations of illiteracy, such as Highland Papua. Such dedicated action was paramount not only for the fundamental purpose of improving the overall quality of life and human capital of the populace but also to meet the explicit global commitment encapsulated in the Sustainable Development Goals (SDGs) framework, specifically SDG 4 (Quality Education), which targeted the eradication of illiteracy. However, maximizing the HDI required a comprehensive and multi-sectoral approach. While reducing illiteracy was a highly effective strategy to immediately boost the HDI, the analysis also confirmed that the HDI was influenced by other critical components, notably per capita income and health expenditure. Therefore, policy improvements across these parallel sectors as public health and overall community welfare were necessary to maximize human development outcomes.

Ultimately, the successful eradication or substantial reduction of illiteracy rates across Indonesia represented a fundamental and necessary step towards achieving the ambitious national vision of Golden Indonesia 2030 (Indonesia Emas 2030). This goal was dependent on maximizing the country's demographic dividend through an educated and skilled citizenry. Addressing the identified implementation hurdles, such as insufficient funding and a lack of firm political commitment, was essential for realizing both the national development vision and the core targets of SDG 4. This study provided compelling statistical proof of the high cost of illiteracy and offered clear guidance for prioritizing resource allocation in favor of comprehensive literacy programs to drive inclusive human progress.

The limitations of this research is in the use of a cross-sectional design and the Spearman correlation method. Correlation alone cannot establish a definitive cause-and-effect relationship (causality) between the illiteracy rate and the HDI. Furthermore, this research exclusively utilized provincial-level aggregated data, meaning the findings may not fully reflect the heterogeneity present at the district, city or individual level. Based on these limitations, future research is recommended to employ approaches capable of exploring causality. Future research could utilize panel data (longitudinal data) to specifically analyze how changes in illiteracy rates over time affect changes in the HDI. Additionally, multi-level regression analysis or quantile regression could be employed to test this model using more detailed data levels, such as district/city data, or to identify whether the influence of illiteracy on HDI varies between provinces with high versus low HDI levels. Qualitative research is also encouraged to explore the effective policy mechanisms for addressing illiteracy and boosting the HDI in specific regions.

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Author Contribution

The author confirms sole responsibility for the following: study conception and design, data acquisition, analysis and interpretation of results, drafting the manuscript, and final approval of the version to be published.

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Ethical Review Board Statement

Ethical review and approval were waived for this study due to the exclusive use of publicly available and aggregated secondary data from the Central Statistics Agency/*Badan Pusat Statistik (BPS)*, which did not involve human subjects or identifiable private information.

Informed Consent Statement

Not available.

Data Availability Statement

All empirical datasets examined throughout this investigation are readily publicly accessible to the wider academic community and general public. These foundational statistics were systematically acquired from the central, official repository of the Indonesian government's statistical body, the Central Statistics Agency/*Badan Pusat Statistik (BPS)*. More precisely, the vital indicators necessary for measuring socio-economic development, namely the Human Development Index (HDI), were carefully extracted from the extensive archives of official PDF publications released by the agency. In parallel, the supporting demographic figures, particularly the provincial-level literacy rates, were methodically secured by downloading the precise information contained within the dynamic and publicly facing statistical tables hosted on the BPS's secure online platform. Consequently, this study exclusively leverages existing, published information, affirming the fact that no new primary data was created or generated specifically for the execution of this particular research project.

Conflicts of Interest

The author declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the author used DeepL and Gemini to assist in refining the manuscript's language, specifically for correcting grammatical errors, improving clarity, and enhancing the overall flow and academic tone of the text. After using these tools, the author meticulously reviewed, edited, and verified the generated content as needed, and ultimately took full and sole responsibility for the entire content and accuracy of the publication.

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