EQUITY: JURNAL EKONOMI

Vol. 14 No (01): June 2026
p-ISSN: 1978-3795; e-ISSN: 2721-6721
Posted: 06 April 2026
Accepted: 07-May-2026
Published: 2026 – May -11

Does Fiscal Decentralization Impact Environmental Quality in Indonesia?

Indra Sulistyo[1], Priyagus[2] and Diana Lestari[3], *

[1,2,3] Faculty of Economics and Business, Universitas Mulawarman, Samarinda
* Correspondence: indrasulistyo@student.unmul.ac.id

Abstract: *Purpose: In realizing the need for environmental governance, this study examines the effect of fiscal decentralization on Environmental Quality Index (IKLH) through Green Budgeting as mediation and educational-level moderation as proxy social supervision. Design/Methodology/Approach: Using a balanced panel dataset of 34 Indonesian provinces for the period 2018 to 2024, the study employs Two-Stage Least Squares (TSLS) with Fixed Effects. This approach systematically identifies and accounts for endogeneity bias between fiscal capacity, budgetary allocations, and ecological outcomes. Key Findings: The first-stage estimation indicates that the Flypaper Effect and the Resource Curse are rigid; indeed, none of the central transfers (DAU, DAK, DBH) have an effect on encouraging Green Budgeting. As such, Local Own-Source Revenue (PAD) is established as the driver of ecological innovation. A crucial conditional moderation is highlighted in the second stage: Green Budgeting (GB) alone has no effect on, or improves, IKLH, but when combined with higher education, it acts effectively and, by any means, becomes an important driver of environmental quality. Originality/value: This research challenges the widely held notion that fiscal decentralization improves local environments. It lends empirical support to the argument that, in the absence of rigorous scrutiny from a well-informed citizenry (demand-side social control), government financial interventions (supply-side) will continue to spur inefficiencies. Practical/Policy implications: The reform of revenue-sharing schemes into Ecological Fiscal Transfers (EFT) should be treated as an emergency solution by the central government, whereas local governments must implement transparency in the execution of environmental budget to enforce community social control.*

Keywords: Green Budgeting, Environmental Quality Index (IKLH), Education Level.

JEL : Q5, Q51, I21

1. INTRODUCTION

The environmental crisis today is more severe than ever faced by the world. The emerging threats call for international institutional agreements, such as the Paris Agreement and the SDGs, to be complemented by an economic transformation for a green economy. Environmental degradation calls for urgent action that requires the reassessment of economic and financial policies adopted by sovereign states.

According to contemporary economic theory, the cause of this world crisis is market failure. Natural environmental assets, such as clean air, water, and forest cover, are believed to have public good properties because they are both non-excludable and non-rivalrous. Because of their public-good nature, the free market fails to properly price them, leading to negative externalities. Underpricing natural resources represents the greatest market failure in history, leading to resource depletion (Harris & Roach, 2017; Tietenberg & Lewis, 2012). And the Dasgupta Review (Dasgupta, 2024) shows that current human needs already outstrip nature's capacity, so government intervention is needed.

A potential solution to the stated problem is to use fiscal policy. Modern global institutions endorse fiscal policy as their main weapon against climate change. Emphasis should also be placed on the fact that the government must intervene to preserve environmental goods through fiscal policies (e.g., subsidies, public purchases of or investments in green goods, e.g., renewable resources, and ecological (tax-based) transfers, and that this intervention is obligatory. (Bhattacharya et al., 2023) recommend that climate change interventions depend heavily on the expansion of developing countries' economies without harming the environment.

However, using these fiscal instruments to address ecological issues is not straightforward. First, we have the missing middle of climate finance. Conventional wisdom holds that we can only achieve global ecological targets through powerful local action. Doughnut Economics (Raworth,

2017) asserts all subnational economic activity must occur in a safe & just space. Within this framework, local authorities must care for citizens' health and the local economy without exceeding ecological limits. It is advisable that regional budgets (APBDs) should be the main instruments for internalizing externalities in this case.

First, divergent interests make localizing international mandates an added challenge for the global south. Too often, local governments are more interested in rapid industrialization and building infrastructure than in environmental sustainability. So such practice creates a trade-off in which conservation can be treated as a luxury public good having less immediate or deferred economic benefits against social spending.

Characterized by a sophisticated framework of fiscal devolution, Indonesia empowers its 34 provinces and multiple municipalities to administer central transfers alongside independent revenues. As articulated by Boadway & Shah, 2009 within the context of fiscal federalism and multi-order governance, this localized approach aims to deliver public services including environmental conservation more efficiently by capitalizing on specific geographic and informational insights. Ironically, this decentralized strategy has yielded paradoxical results. While Transfers to Regions (TKD) and local environmental budgets consistently rise year-over-year, official data demonstrates that Indonesia's Environmental Quality Index (IKLH) has stagnated at 75.11 as of 2024. Thus, despite funneling hundreds of billions of Rupiah into provincial governments annually, meaningful ecological progress has failed to materialize, highlighting a profound disconnect between fiscal spending and environmental realities.

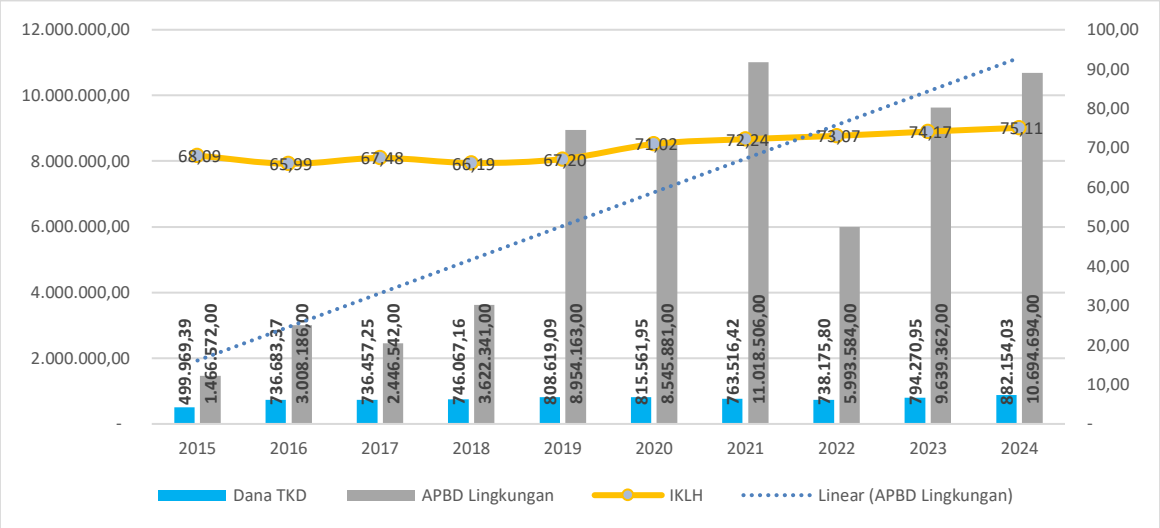

Figure 1. Trend of Transfers to Regions (TKD), Regional Environmental Budget, and Environmental Quality Index (IKLH) (2015-2024)

Source: KemenLHK and BPS (2025)

Much of the existing literature is divided on whether the effects of fiscal decentralization are harmful or beneficial to the environment, indicating further need for study of this empirical issue. While fiscal decentralization should improve the management of environmental resources, through drawing on locally available information, it more often facilitates a “race to the bottom.” In helping secure high GRDP growth, regional officials fully invest in business and big industry, leaving environmental concerns behind entirely. Consequently, environmental harm is a systemic byproduct of regional aspirations.

As noted in the Green Budgeting in OECD Countries 2024 report (OECD, 2024), the Green Budgeting literature holds that it is not possible to integrate environmental elements into local budgets without adequate fiscal autonomy. Various empirical studies have shown that municipalities without sufficient PAD do not allocate the budgetary resources needed to address environmental concerns (Fitriyani et al., 2022).

The flypaper effect explains the lack of local fiscal autonomy. Transfers away from central

administration (DAU, for example) are typically rigid. In Mazzucato (2021) concept of the Mission Economy, without a mission-oriented path forward, public money is raided to cover administrative burdens, salaries, and inefficiencies, leaving little to spend on innovative green initiatives.

Transfers, even if they are targeted, e.g., DAK toward environmental purposes, can only be established under considerable administrative barriers. Top-down transfers are not absorbed well due to rigid rules that ignore specificity, as stated in the Green Budget Tagging guidelines (OECD, 2024). As a result, the funds earmarked for environmental rehabilitation are not only wasted but also diverted to other, more important infrastructure projects.

Another thing to think about is the resource curse. In more recent literature on natural resource management globally (Aruga, 2022; Kanazawa, 2021) and locally in Indonesia (Hilmawan et al., 2016; Priyagus, 2018) abundant DBH from mining and oil industries has been shown to be counterproductive for environmental rehabilitation. As demonstrated by (Andriani et al., 2025) the abundance of mining as a key export commodity in Indonesia gives rise to a political economy in which revenues from environmental degradation are used to fund the same destructive processes.

Resource-rich states are locked in institutionally by the political economy. Local elites have a strong political incentive to sustain the extractive status quo, setting up major conflicts of interest. And therefore, the environmental budget allocation is merely administrative, prescribing cosmetic compliance rather than actually reducing the larger negative externality of large-scale mining and deforestation.

The environmental economics literature often draws on the theory of human capital to address bureaucratic inefficiency and rigidity. For this reason, according to the theory, a well-educated population matures into a key civil society that monitors expenditure and prevents leakages. Widening participation in education can improve people's ecological literacy, giving them a tool for social control over local authorities and thus enabling environmental policies to be realized.

But the theory's application to fast-growing countries creates a demographic quandary. Educational participation rates are higher in densely populated, industrially developed, and urbanized regions like the Java corridor of Indonesia. Thus, higher levels of education are commonly accompanied by a resource-consuming middle class, urbanization, and high consumption orientations that exacerbate environmental issues. Furthermore, the persistent issue of endogeneity severely complicates the empirical separation of financial drivers from ecological outcomes. This literature primarily relies on single-equation OLS methods and dismisses the possibility of reverse causality. In places where environmental degradation is extreme, the public is in arms demanding that the government substantially increase the budget for environmental protection. Ignorance of the two-way relationship without econometric separation (e.g., instrumental variable techniques) will lead to bias and false policy inferences.

While there has been significant investigation into this area, the lines between fiscal and social dynamics remain largely untested empirically. Earlier research often simplifies the relationship between budget allocation and environmental improvement by assuming a direct effect without friction, neglecting the endogeneity between fiscal capacity and ecological quality. Lastly, the potential moderating role of education in developing countries, where high levels of formal education tend to coincide with high-carbon lifestyles, remains empirically underexplored and theoretically unresolved.

The motivation for the current analysis is to advance the literature on environmental and public economics in both dimensions simultaneously. The study presents a simultaneous TSLS (Two-Stage Least Squares) Panel Regression method for analyzing fiscal independence. First, this study explores the responsiveness of decentralization instruments (DAU, DAK, DBH, and PAD) in facilitating Green Budgeting. Second, with instruments based on the influx of endogenous variables, it assesses the structural direct effect of Green Budgeting embedded within IKLH by including 'Education Level' as a moderating variable to empirically ascertain if formal community literacy is a condition for ecological output.

2. LITERATURE REVIEW

2.1 Fiscal Federalism and Market Failure Theory

The current literature on fiscal federalism suggests that decentralizing public goods provision can be achieved through fiscal means, as regional governments have better information about local needs and preferences than central authorities. This perspective informs the hypothesis in environmental governance (which seeks to understand sustainable development) that regional fiscal capacity variables, General Allocation Fund (DAU), Specific Allocation Fund (DAK), Revenue-Sharing Fund (DBH), and Local Own-Source Revenue (PAD), allow provinces to arrange adequate resource allocation for environmental preservation. The OECD (2024) notes that the success of Green Budgeting ultimately depends on sub-national governments' ability to integrate fiscal policies with locally determined ecological goals.

According to recent studies in environmental economics, the environment (clean air or protected forests) is considered a pure public good that is highly susceptible to free-rider and market failure problems(Harris & Roach, 2017; Tietenberg & Lewis, 2012). “When there are no profit incentives in the private sector to conserve natural capital, then it falls on regional governments to fill the void with corrective fiscal instruments (Dasgupta, 2024). Inspired by the work of (Raworth, 2017) it draws on Doughnut Economics and its emphasis on public budgets as vital tools to prevent economic activities spilling over into ecological excesses and to internalize negative externalities.

2.2 Regional Financial Dynamics Theory

Uniting different levels with fiscal policy is not so easy; there are often bureaucratic and structural oddities that prevent the effective application of decentralized fiscal policy. The Flypaper Effect refers to the asymmetric responsiveness of local governments to central government transfers versus their own-source revenues. Indeed, there is strong evidence that transfer funds (DAU, DAK) are used more for operational budgets than for investment expenditure. On the other hand, Local Own-Source Revenue (PAD) has greater discretionary flexibility and is better able to finance timber-independent, innovative budgets that can support environmental mitigation.

Additionally, it is often not the economic prosperity afforded by natural resources that contributes to success; the Resource Curse Theory further explains how areas abundant in natural resources tend to have worse ecological and developmental outcomes. Recent empirical studies show that regions dependent on extractive industries, as indicated by high Revenue-Sharing Fund (DBH) levels, often experience increased environmental degradation (Kanazawa, 2021). We argue that these anticipated flows, rather than enabling ecological restoration, are largely employed to reproduce extractive pursuits and reduce political incentives to finance mitigation.

2.3 Human Capital Theory

Recent human capital literature classifies education as a significant investment that affects cognitive structures and raises social consciousness of sustainability. Higher participation rates in education foster a civil society with stronger ecological literacy and as demonstrated in recent studies, apply political pressure and social oversight to ensure that Green Budgeting functions properly, thereby enabling the Environmental Quality Index to show measurable improvement (Cheng et al., 2023; Huang & Chen, 2022). But developing countries face a more complex relationship due to demographic context. Higher education is typically concentrated in metropolitan, industrialized, and urban regions where expansion of an energy-intensive middle class, increased urbanization, and heightened consumerism may be detrimental to environmental quality. Hence, formal education as a mechanism of ecological stewardship is conditionally complex and would benefit from empirical scrutiny.

3. METHOD

3.1 Research Design

The methodology employed in this study is explanatory and quantitative, following a panel design that combines cross-sectional and time-series data. This design enables substantial spatial heterogeneity across provinces to be captured alongside dynamic temporal variations and allows for strong causal identification of effects of fiscal interventions on ecological quality.

3.2 Data Types and Sources

The entire data used in this research are all secondary and systematically compiled through official publications of Indonesian government agencies. The data related to fiscal capacity indicators in the form of DAU, DAK, DBH, and PAD are obtained from the Directorate General of Fiscal Balance, Ministry of Finance (Kemenkeu), while Green Budgeting, which is actualized in this study for regional budget realization for environmental functions.

Provincial IKLH scores are obtained from the Ministry of Environment and Forestry (KLHK). The School Enrollment Rate for ages 19–23 was used as a moderating variable for human capital, sourced from the official databases of Statistics Indonesia (BPS). The selection of the School Enrollment Rate (APS) for ages 19-23 over Mean Years of Schooling (RLS) is deliberate and theoretically grounded. Recent advanced econometric literature confirms that school enrollment rates are robust, forward-looking indicators of human capital development (Lee & Lee, 2016; Solarin, 2024). In the context of environmental economics, (Kim & Go, 2020) demonstrated the explicit validity of enrollment rates in predicting environmental sustainability and policy compliance. While RLS represents a lagging historical stock of general education, the tertiary enrollment rate (ages 19-23) captures the active, dynamic formation of advanced human capital. This specific demographic represents the avant-garde of ecological literacy, civic engagement, and environmental activism in developing nations. Therefore, it serves as a far more precise proxy for the active *demand-side social control* needed to monitor complex policies like Green Budgeting than the general adult population's average schooling.

All monetary variables are transformed to their natural logarithms (Ln) to standardize measurement scales, minimize heteroscedasticity, and provide direct interpretations of regression coefficients as percentage elasticities. Zero values in the dataset occur where provinces have no grant budget distribution for a year; a raw data constant with a value of 1 is added before the transformation so that original zero values remain as zero after applying the natural logarithm (Ln(1) = 0). This method maintains data integrity, ensuring that no data or computational errors are missed during panel regression estimation (Gujarati & Porter, 2010)

3.3 Variable Operational Definition

This study employs an explanatory quantitative approach utilizing a panel dataset (pooled cross-section and time-series). The object of this research encompasses 34 provinces in Indonesia over a consecutive 7-year period (2018–2024), yielding a total of 238 balanced observation points.

To systematically address the research hypotheses, the variables utilized in the econometric modeling are operationally defined in Table 1 below:

Table 1. Variable Operation Definition

Variable Role	Variable Name	Symbol	Operational Definition & Measurement	Data Source
Dependent	Environmental Quality Index	Y_2	A composite ecological health score (scale 0-100) combining water, air, and land/forest cover quality metrics.	KLHK
Intervening	Green Budgeting	Ln_Y_1	The natural logarithm of the total realized Provincial Budget (APBD) specifically allocated for the 'Environmental Protection Function'.	Ministry of Finance
Independent	General Allocation Fund	Ln_X_1	The natural logarithm of the realized DAU distributed to the province.	
	Specific Allocation Fund	Ln_X_2	The natural logarithm of the realized DAK distributed to the province.	
	Revenue-Sharing Fund	Ln_X_3	The natural logarithm of the realized DBH derived from natural resources and taxes.	
	Local Own-Source Revenue	Ln_X_4	The natural logarithm of the realized PAD collected independently by the province.	
Moderating	Education Level	M_1	The School Enrollment Rate (APS) specifically for the 19-23 age demographic, measured as a percentage (%).	BPS

3.4 Conceptual Framework and Hypotheses

Using the tools of fiscal federalism, the flypaper effect, the resource curse, and human capital theory, this study develops a two-part conceptual framework to comprehensively chart out how decentralization is instantiated into ecological correspondences. Framed as a simultaneous-equation model, the two-stage sequential structure of the framework.

In the first stage, the regional fiscal capacity, as independent exogenous variables that influence the allocation of the Regional Environmental Budget (Green Budgeting), are the General Allocation Fund (DAU), the Specific Allocation Fund (DAK), the Revenue-Sharing Funds (DBH), and Local Own-Source Revenue (PAD). The second stage evaluates the more immediate effects of instrumented Green Budgeting on the Environmental Quality Index (IKLH). This stage also includes Education Level as a moderating variable to explicitly assess whether formal human capital reinforces the effectiveness of environmental expenditures through demand-side social control.

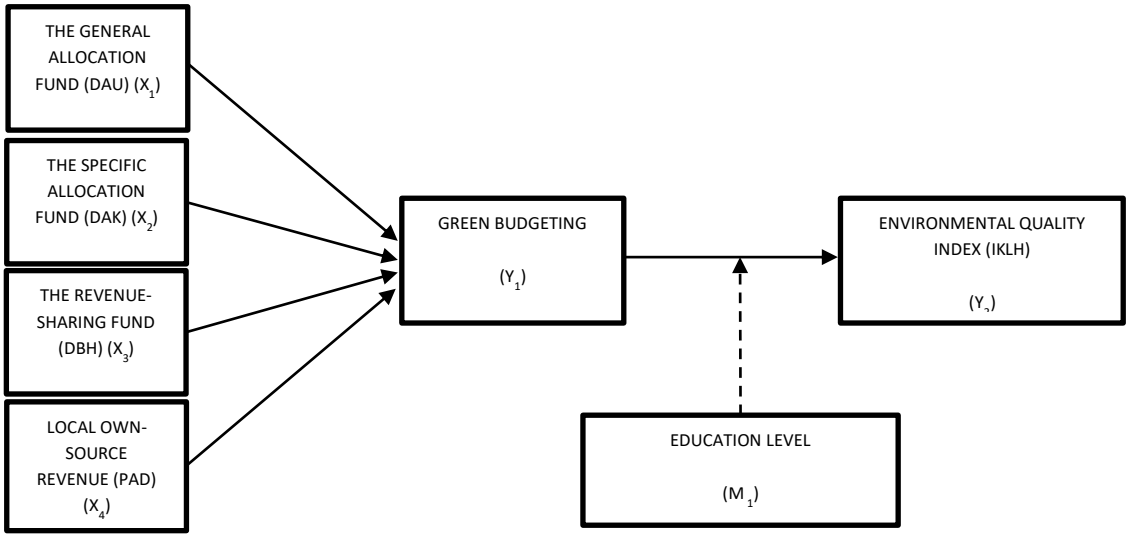

Figure 2: Conceptual Framework

Based on the theoretical linkages and the conceptual framework, the hypotheses proposed in this study are formulated as follows:

1. The General Allocation Fund (DAU) has a positive and significant effect on Green Budgeting (Regional Environmental Budget).
2. The Specific Allocation Fund (DAK) has a positive and significant effect on Green Budgeting (Regional Environmental Budget).
3. The Revenue-Sharing Fund (DBH) has a positive and significant effect on Green Budgeting (Regional Environmental Budget).
4. Local Own-Source Revenue (PAD) has a positive and significant effect on Green Budgeting (Regional Environmental Budget).
5. Green Budgeting, conditionally moderated by the Education Level, has a positive and significant effect on the Environmental Quality Index (IKLH).

3.5 Data Analysis Techniques

In examining the impact of fiscal capacity on IKLH through the mediation pathway of Green Budgeting and the moderating effect of education, the direct application of single-equation Ordinary Least Squares (OLS) regression risks yielding biased estimators. This is attributed to potential endogeneity bias, wherein the actual Green Budgeting (Y_1) in the field is influenced by unobserved factors that simultaneously affect the IKLH (Y_2).

3.6 Descriptive Statistics and Preliminary Tests

A preliminary phase of data analysis is performed before the primary regression models. To provide an overarching summary of the characteristics of our raw dataset, we use descriptive statistics to systematically report central tendencies (mean, median), dispersion (standard deviation), and the data's extremes (minimum and maximum).

Following the descriptive analysis, a systematic process is employed to determine which of the three competing models, Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM), provides the most robust estimation approach. This process consists of a few statistical diagnostic tests:

1. Chow Test: This test is employed to adjudicate between the CEM (which assumes all provinces share the same intercept) and the FEM (which captures unique provincial heterogeneities). If the probability of the Cross-section F is less than the 0.05 significance level, the null hypothesis is rejected, indicating that the FEM is superior to the CEM.
2. Breusch-Pagan Lagrange Multiplier (LM) Test: This test is utilized to compare the CEM against the REM. A significant p-value indicates that individual province variances are nonzero, favoring the REM over the simple pooled OLS (CEM).
3. Hausman Test: As the ultimate adjudicator between the FEM and REM, this test evaluates whether the unique errors are correlated with the regressors. If the p-value of the cross-sectional random statistic is less than 0.05, the REM is deemed inconsistent, and the FEM is conclusively selected as the most unbiased and appropriate model.

3.7 Panel Data Regression Modeling

To address endogeneity effectively, this study employs the Two-Stage Least Squares (2SLS) Instrumental-Variable panel regression approach. The 2SLS approach purifies the endogenous Green Budgeting variable by using strictly exogenous instruments (the fiscal capacity indicators). The conceptual modeling is mathematically specified as a system of simultaneous equations:

First-Stage Equation (Instrumental Projection) This stage aims to model the structure of regional fiscal capacity on Green Budgeting allocation, effectively projecting the endogenous variable onto the space of the exogenous instruments.

$$\boldsymbol{Ln\_Y_{1it}=\beta_0+\beta_1 Ln\_X_{1it}+\beta_2\, Ln\_X_{2it}+\beta_3\, Ln\_X_{3it}+\beta_4\, Ln\_X_{4it}+\alpha i+\delta t+\epsilon it}$$

Description:

Ln_Y_{1it}	= Logarithmic value of the actual Green Budgeting
β_0	= Constant
$\beta_{1...4}$	= Regression coefficients
Ln_X_{1it}	= General Allocation Fund (DAU)
Ln_X_{2it}	= Specific Allocation Fund (DAK)
Ln_X_{3it}	= Revenue-Sharing Fund (DBH)
Ln_X_{4it}	= Local Own-Source Revenue (PAD)
αi	= Individual (province) fixed effects
δt	= Time-specific fixed effects
ϵit	= Error term

Second-Stage Equation (Structural Model) In the structural stage, the IKLH outcome is estimated. Using the TSLS estimator, the endogenous variable (Ln_Y_{1it}) is evaluated along with the moderating interaction term involving the Education Level variable (M_{1it}).

$$\boldsymbol{Y_{2it}=\gamma_0+\gamma_1\, Ln\_Y_{1it}+\gamma_2 M_1 it+\gamma_3(Ln\_Y_{1it}\times M_{1it})+\mu i+\tau t+\mu_{it}}$$

Description:

Y_2it	= Environmental Quality Index (IKLH)
$\gamma 0$	= Constant

$\gamma_{1...4}$ = Regression coefficients
Ln_Y_{1it} = Green Budgeting (Instrumented via 2SLS)
M_{1it} = Education Level (School Enrollment Rate)
$Ln\_Y_{1it} X M_{1it}$ = Moderation interaction variable
μ_i = Individual (province) fixed effects
τ_t = Time-specific fixed effects
ν_{it} = Error term

4. RESULTS AND DISCUSSION

4.1 Result

4.2.1 Descriptive Statistical Analysis Results

Before implementing the primary regression models, an initial data analysis phase was conducted. Descriptive statistics systematically examined the central tendencies, dispersion, and extreme values within the raw dataset. For clarity and ease of interpretation, monetary variables representing regional fiscal capacity (X1-X4) are reported in billions of Indonesian Rupiah (IDR), while the environmental budget (Y1) is reported in millions of IDR.

A Variance Inflation Factor (VIF) diagnostic was also performed to assess multicollinearity among the independent and moderating variables. As shown in Table 2, all VIF values are below the critical threshold of 10.0, ranging from 1.09 to 3.76. These results confirm the absence of severe multicollinearity, indicating that the exogenous variables are suitable for use as instruments in subsequent Two-Stage Least Squares (2SLS) estimations.

Table 2. Descriptive Statistics and Multicollinearity Diagnostic (VIF)

Variable	Unit of Measurement	Obs.	Mean	Median	Min.	Max.	Std. Dev.	VIF*
Environmental Quality Index (Y_2)	Index (0–100)	238	71.06	72.24	39.06	84.22	7.63	-
Green Budgeting (Y_1)	Million IDR	238	244,464.50	51,035.50	0.00	7,462,670.00	913,417.50	-
General Allocation Fund (X_1)	Billion IDR	238	1,630.00	1,460.00	0.00	4,460.00	781.00	1.13
Specific Allocation Fund (X_2)	Billion IDR	238	1,520.00	969.00	77.60	10,900.00	1,700.00	2.28
Revenue-Sharing Fund (X_3)	Billion IDR	238	1,370.00	493.00	13.20	21,000.00	2,950.00	2.15
Local Own-Source Revenue (X_4)	Billion IDR	238	5,240.00	2,240.00	301.00	50,700.00	8,670.00	3.76
Education Level (M_1)	Percentage (%)	238	29.99	28.92	18.45	56.81	7.03	1.0

Source: Output of EViews 13 based on processed raw data (2026).
*VIF is calculated based on the natural logarithm transformation of the respective independent variables to accurately assess multicollinearity prior to the regressions

4.2.2 Selection of The Most Appropriate Panel Estimation Model

Before executing the 2SLS regression, a systematic sequence of diagnostic tests was conducted to select the most appropriate panel estimation model. First, the Chow Test produced a highly significant Cross-section F-statistic of 17.809 (p-value = 0.0000 < 0.05), indicating that the Fixed Effect Model (FEM) is superior to the Common Effect Model (CEM).

Table 3. Chow Test Result

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	17.809030	(33,201)	0.0000
Cross-section Chi-square	325.364700	33	0.0000

Cross-section fixed effects test equation:
Dependent Variable: Y2
Method: Panel Least Squares
Date: 03/25/26 Time: 22:26
Sample: 2018 2024
Periods included: 7
Cross-sections included: 34
Total panel (balanced) observations: 238

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	80.39741	12.82631	6.268164	0.0000
LN_Y1	-1.322421	1.156978	-1.142996	0.2542
M1	0.006124	0.400658	0.015285	0.9878
INTERAKSI	0.014153	0.036035	0.392743	0.6949

R-squared	0.078976	Mean dependent var	71.06105
Adjusted R-squared	0.067168	S.D. dependent var	7.634491
S.E. of regression	7.373638	Akaike info criterion	6.850363
Sum squared resid	12722.71	Schwarz criterion	6.908721
Log likelihood	-811.1933	Hannan-Quinn criter.	6.873883
F-statistic	6.688333	Durbin-Watson stat	0.307334
Prob(F-statistic)	0.000238		

Source: Output of EViews 13 based on processed raw data (2026).

Chow Test Result (corrected using White period (cross-section cluster))

Dependent Variable: Y2
Method: Panel Two-Stage Least Squares
Date: 04/26/26 Time: 20:45
Sample: 2018 2024
Periods included: 7
Cross-sections included: 34
Total panel (balanced) observations: 238
White period (cross-section cluster) standard errors & covariance (d.f. corrected)
WARNING: estimated coefficient covariance matrix is of reduced rank
Standard error and t-statistic probabilities adjusted for clustering
Instrument specification: C M1 LN_X1 LN_X2 LN_X3 LN_X4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	63.42904385232724	10.75613164956411	5.897012598846139	1.3063173757893 07e-06
LN_Y1	1.149842765938459	0.739962111 8050048	1.553921136764184	0.1297424200496046
M1	-2.425497374976389	0.648671134 4617731	-3.739178832 10406	0.0007008377257123118
INTERAKSI	0.004949963382266 15	0.001055300122539638	4.690574061863832	4.5775151 19689348e-05

Effects Specification			
Cross-section fixed (dummy variables)			
R-squared	0.90639092 65789832	Mean dependent var	71.061050 42016808
Adjusted R-squared	0.88962512 2384174	S.D. dependent var	7.6344908 6650158
S.E. of regression	2.53638512 4109964	Sum squared resid	1293.0831 4905907
F-statistic	23.4464709 4218748	Durbin-Watson stat	1.6756810 94862633
Prob(F-statistic)	3.97312197 7475486e-54	Second-Stage SSR	2656.7944 45694032
Instrument rank	39	Prob(J-statistic)	0.6784987 20048913

Subsequently, the Breusch-Pagan Lagrange Multiplier (LM) Test yielded a significant cross-section test statistic of 126.049 (p-value = 0.0000 < 0.05), confirming the presence of panel effects.

Table 4. Breusch-Pagan Lagrange Multiplier (LM) Test Result

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	126.0492 (0.0000)	30.99631 (0.0000)	157.0455 (0.0000)
Honda	11.22716 (0.0000)	5.567433 (0.0000)	11.87557 (0.0000)
King-Wu	11.22716 (0.0000)	5.567433 (0.0000)	9.524949 (0.0000)
Standardized Honda	11.93273 (0.0000)	6.562478 (0.0000)	8.645083 (0.0000)
Standardized King-Wu	11.93273 (0.0000)	6.562478 (0.0000)	7.259176 (0.0000)
Gourieroux, et al.	--	--	157.0455 (0.0000)

Source: Output of EViews 13 based on processed raw data (2026).

Finally, to adjudicate between FEM and the Random Effect Model (REM), the Hausman Test

was conducted, yielding a Chi-Square statistic of 19.492 (p-value = 0.0002 < 0.05). This strongly rejects the random-effects assumption.

Table 5. Hausman Test Result

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	19.492127	3	0.0002

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
LN_Y1	0.050267	0.120499	0.000365	0.0002
M1	-2.135955	-1.852317	0.006942	0.0007
INTERAKSI	0.004637	0.004275	0.000000	0.0000

Cross-section random effects test equation:
Dependent Variable: Y2
Method: Panel Least Squares
Date: 03/26/26 Time: 07:06
Sample: 2018 2024
Periods included: 7
Cross-sections included: 34
Total panel (balanced) observations: 238

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	70.70689	2.215374	31.91645	0.0000
LN_Y1	0.050267	0.058623	0.857455	0.3922
M1	-2.135955	0.101617	-21.01963	0.0000
INTERAKSI	0.004637	0.000129	35.97707	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.968449	Mean dependent var	71.06105
Adjusted R-squared	0.962798	S.D. dependent var	7.634491
S.E. of regression	1.472523	Akaike info criterion	3.753791
Sum squared resid	435.8334	Schwarz criterion	4.293598
Log likelihood	-409.7011	Hannan-Quinn criter.	3.971343
F-statistic	171.3793	Durbin-Watson stat	0.933955
Prob(F-statistic)	0.000000		

Source: Output of EViews 13 based on processed raw data (2026).

Consequently, these diagnostic tests unequivocally mandate the utilization of the Fixed Effect Model (FEM) for the subsequent estimations. Furthermore, it is critical to acknowledge that the

preliminary test equation exhibited a Durbin-Watson statistic of 0.307334, strongly indicating severe positive autocorrelation. To systematically resolve this violation of standard econometric assumptions, the final Fixed Effect TSLS estimation was executed utilizing White period (cross-section cluster) robust standard errors. Following this methodological adjustment, the Durbin-Watson statistic significantly improved to 1.675681, approaching the ideal threshold of 2.0. Consequently, the t-statistics and probability values reported in the final structural model are completely robust against serial correlation biases, ensuring highly valid statistical inferences.

4.2.3 TSLS Model Estimation Results

The empirical findings from the simultaneous Two-Stage Least Squares (2SLS) panel data regression utilizing the previously selected Fixed Effect Model (FEM) are summarized in Table 6 below.

Table 6. TSLS Model Estimation Results

Variable	Coefficient	t-Statistic	Prob.
First-Stage Estimation (Determinants of Ln_Y_1)			
Ln_DAU (Ln_X_1)	0.011286	0.213751	0.8310
Ln_DAK (Ln_X_2)	-0.412530	-1.437885	0.1520
Ln_DBH (Ln_X_3)	-0.206667	-0.587340	0.5576
Ln_PAD (Ln_X_4)	1.912447	2.406440	0.0170*
Second-Stage Estimation (Structural Model of Y_2)			
Constant (C)	63.42904	5.897012	0.0000*
Ln_Green Budgeting (Ln_Y_1)	1.149843	1.553921	0.1297
Education Level (M_1)	-2.425497	-3.739178	0.0007*
Interaction (Ln_Y_1 x M_1)	0.004950	4.690574	0.0000*
Model Diagnostics			
Obs	238	F-statistic	23.44647
R2 (Second-Stage)	0.906391	Prob(F-statistic)	0.0000*
R2 adjusted	0.889625	Instrument rank	39
First-Stage F-statistic	25.43	Prob(J-statistic)	0.6784

Source: Processed Data from EViews 13 (2026).

* Indicates significance at the 5% level.

Furthermore, to robustly validate the Instrumental Variable (IV) approach and satisfy the mandatory econometric standards for 2SLS estimation, two critical diagnostic tests were executed. First, the First-Stage F-statistic is recorded at 25.43. This value substantially exceeds the conventional critical threshold of 10.0, decisively rejecting the weak instrument null hypothesis. It empirically confirms that the selected fiscal capacity variables strongly correlate with the endogenous Green Budgeting allocation. Second, the overidentification restriction is evaluated using the Hansen J-statistic. The test yields a probability value (Prob. J-statistic) of 0.6784. Since this p-value is strictly greater than the 0.05 significance level, the null hypothesis of instrument exogeneity cannot be rejected. This result fundamentally guarantees that the instruments are completely valid, strictly exogenous, and appropriately excluded from the second-stage structural equation, addressing any concerns regarding the credibility of the TSLS estimates.

4.2 Discussion

4.2.1 Effect of General Allocation Fund (DAU) on Green Budgeting

The first-stage estimation demonstrates that the General Allocation Fund (DAU) has an insignificant impact on the formulation of regional Green Budgeting (p-value = 0.8310 > 0.05). This result contradicts the ideal assumptions of unconditional block grants and supports the existence of the Flypaper Effect anomaly. Within the framework of multiorder governance (Boadway & Shah, 2009), intergovernmental transfers often fail to stimulate the provision of specific local public goods when administrative rigidities persist. Mazzucato, (2021) critiques that, without a mission-oriented approach, government funds such as the DAU in the Indonesian fiscal system are largely absorbed by routine expenditures and bureaucratic inertia. As a result, the substantial fiscal capacity provided

by the DAU offers little discretionary space for long-term ecological investments.

4.2.2 Effect of Specific Allocation Fund (DAK) on Green Budgeting

In addition, the Specific Allocation Fund (DAK) does not have a significant statistical effect on Green Budgeting (p-value = 0.1520 > 0.05). Though DAK is intended to be a targeted grant addressing certain national priorities, its rigid bureaucratic framework and technical standards often clash with heterogeneous local conditions (Boadway & Shah, 2009). This closely corresponds with the (OECD, 2021) bottlenecks in administration, including Green Budget Tagging and compliance complexities. (Bhattacharya et al., 2023) further observe that conditional grants create overlapping jurisdictions and inflexible compliance metrics, undermining climate action in developing countries. This can partly be due to such conditionality, which is difficult for the local government, leading to relatively low absorption of environmental DAK or its diversion to physical infrastructure projects with political economy preferences and short-term interests in ecology.

4.2.3 Effect of Revenue-Sharing Fund (DBH) on Green Budgeting

The empirical results exhibit that the Revenue-Sharing Fund (DBH) does not have a significant effect on Green Budgeting (p-value = 0.5576 > 0.05). This finding provides evidence for the Resource Curse at Indonesia's subnational governance levels. Consistent with current environmental economics frameworks (Aruga, 2022), extractive industry-dependent regions garner wealth from persistent activity, creating large externalities (Hilmawan et al., 2016; Priyagus, 2018). Recent studies have emphasized the mining sector's contribution to Indonesia's export commodities (Andriani et al., 2025), indicating that extractive regimes are common political economies in these geographies. Such a dynamic creates institutional lock-in, distorts the pricing of natural capital and biodiversity, as noted in The Dasgupta Review, and lowers political will to prioritize environmental mitigation in budgets (Dasgupta, 2024).

4.2.4 Effect of Local Own-Source Revenue (PAD) on Green Budgeting

Unlike central transfers, the Local Own-Source Revenue (PAD) emerged as the sole positive and statistically significant determinant of Green Budgeting (p-value = 0.0170 < 0.05). These results are consistent with the tenets of fiscal federalism (Boadway & Shah, 2009), which claim that regional governments' provision of local public goods is maximized when they hold fiscal powers. Therefore, building an independent revenue base (PAD) that provides fiscal space for long-term ecological policies is again confirmed by the latest OECD, (2024) assessment of subnational green budgeting. This outcome is in accordance with Ecological Fiscal Transfer (EFT) frameworks (Fitriyani et al., 2022), which highlight that only when local fiscal independence is not conditional on central government conditions can we generate regional commitment to address area-specific environmental externalities.

4.2.5 Effect of Green Budgeting on Environmental Quality Index moderated by Education Level

An important finding from the second-stage estimation on conditional moderation supports recent treatments in environmental and natural resource economics (Harris & Roach, 2017; Tietenberg & Lewis, 2012). The Green Budgeting variable (Ln_Y_1) alone is not statistically significant (p-value = 0.1297 > 0.05), which aligns with Mazzucato, (2021)'s assertion that society must guide budgetary spending to avoid bureaucratization and value destruction in the environmental budgeting sector. Compared to this, the independent effect of Education Level (M_1) is negative and significant (-2.425, p-value = 0.0007). The reason for this outcome is the demographic problem of sustaining a safe operating space for mankind, illustrated in the framework Doughnut Economics (Raworth, 2017), because places that report higher shares of education shall correspond to large urban agglomerations with ecological footprints and high consumption rates that lead to the violation of environmental limits.

The interaction variable ($Ln\_Y_1 \times M_1$) is highly significant and has a positive value (+0.0049, p-value = 0.0000 < 0.05). This means that only parts of the world with both sufficient Green Budgeting and a well-educated populace see marked increases in the Environmental Quality Index. Educated people play an important role in demand-side social control, where ecological literacy enables close monitoring of budget execution (Bhattacharya et al., 2023) minimizing bureaucratic inefficiencies and further strengthening collaboration to achieve local economic prosperity and climate objectives.

5. CONCLUSION AND SUGGESTION

5.1 Conclusion

Based on the empirical analysis using the Two-Stage Least Squares (2SLS) panel data regression across 34 Indonesian provinces, several key conclusions can be drawn regarding the dynamics of fiscal decentralization and environmental governance:

1. Determinants of Green Budgeting: Regional environmental budgets (Green Budgeting) are mainly influenced by regional fiscal independence, as reflected in Local Own-Source Revenue (PAD). Unlike combined transfers, neither DBH, DAU, nor DAK has a significant impact. The implication is that the transfer process remains rigid, highlighting the presence of both the Resource Curse and the Flypaper Effect, since almost all money transfers are absorbed at the ordinary bureaucratic spending level rather than trickling down to curb ecological innovation.
2. Moderating Role of Human Capital: The findings indicate successful conditional moderation. The Environmental Quality Index (IKLH) showed no variation when a Green Budgeting approach alone was used, whereas Education Level correlated negatively with IKLH due to its location in a high-consumptive urbanized area. In contrast, the interaction of Green Budgeting and Education Level has a significantly positive effect on IKLH. This implies that government-led financial interventions work only when paired with oversight by an enlightened civil society

5.2 Suggestions

To translate these empirical findings into actionable policies, the following recommendations are proposed for policymakers and future researchers:

1. For the Central Government (Ministry of Finance and Bappenas): The earmarking mechanisms for central transfers, especially DBH transfers, must be urgently reformed. Regional governments must also pay the cost of restoration if they are dependent on the extractive sector as a The Resource Curse is addressed through government fiscal schemes in terms of cash, such as an "Ecological Fiscal Transfer" (EFT) scheme that obliges regional governments to allocate a certain percentage of their DBH for only environmental purposes.
2. For Regional Governments and the Education Sector: Provincial governments must expand their Local Own-Source Revenue (PAD) base to ensure Green Budgeting has sustainable funding. At the same time, the education sector as well as local governments should create public transparency platforms. Open access to data on environmental budget execution will ensure the community plays its own social oversight role..
3. For Future Research: Future studies should seek out alternative proxy variables for demand-side oversight than School Enrollment Rates, such as the number of active environmental NGOs in a province or public environmental grievance data. It would also suggest to use spatial econometrics to reflect the spillover effects of environmental quality between adjacent provinces.

ACKNOWLEDGMENTS

The author would like to express their deepest gratitude to Prof. Dr. H. Priyagus, S.E., M.Si., and Dr. Diana Lestari, S.E., M.Si., for their invaluable guidance, insightful feedback, and continuous support throughout the development of this research. Special thanks are also extended to the Master of Economics Program at Universitas Mulawarman for facilitating this study. Furthermore, the author highly appreciates the Ministry of Finance, the Ministry of Environment and Forestry, and Statistics Indonesia (BPS) for providing the essential data for this study, as well as to all colleagues, family, and other parties who have contributed directly or indirectly to the completion of this paper.

REFERENCE

Andriani, E., Emo, M., & Baehera, S. (2025). *Analisis Komoditas Ekspor, 2020-2024, Sektor Pertanian, Kehutanan, dan Perikanan; Sektor Industri Pengolahan; dan Sektor Pertambangan dan Lainnya*. *15*, 107. ISSN 2085-6008

Aruga, K. (2022). *Environmental and Natural Resource Economics*. Springer International Publishing.

https://doi.org/10.1007/978-3-030-95077-4

Bhattacharya, A., Kharas, H., & McArthur, J. W. (2023). *Keys To Climate Action How Developing Countries Could Drive Global Success and Local Prosperity*. ISBN 9781785363450.

Boadway, R. W. ., & Shah, Anwar. (2009). *Fiscal federalism : principles and practices of multiorder governance*. Cambridge University Press. https://doi.org/10.1017/CBO9780511537301

Cheng, Y., Ma, B., & Sun, Y. (2023). Does central ecological transfer payment enhance local environmental performance? Quasi-experimental evidence from China. *Ecological Economics*, *212*, 107920. https://doi.org/10.1016/j.ecolecon.2023.107920

Dasgupta, P. (2024). *The Economics of Biodiversity*. Cambridge University Press. https://doi.org/10.1017/9781009494359

Fitriyani, R., Gusmansyah, & Guevarrato, G. (2022). *Buku Panduan Transfer Fiskal Berbasis Ekologi (EFT) TAPE dan TAKE Forum Indonesia untuk Transparansi Anggaran The Asia Foundation*. Forum Indonesia untuk Transparansi Anggaran. www.seknasfitra.org. ISBN 978-623-93402-1-6.

Gujarati, D. N. ., & Porter, D. C. . (2010). *Basic econometrics*. McGraw-Hill. ISBN 9780071276252

Harris, J. M., & Roach, B. (2017). *Environmental and Natural Resource Economics* (4th Edition). Routledge. https://doi.org/10.4324/9781315620190

Hilmawan, R., Yudaruddin, R., & Sri Wahyuni, Y. (2016). Coal Mining Operations And Its Impact On Sectoral And Regional Area: Evidence Of East Kalimantan, Indonesia. *Journal of Indonesian Applied Economics*, *6*(1), 22–43. https://doi.org/10.21776/ub.jiae.2016.006.01.2

Huang, Y., & Chen, C. (2022). The spatial spillover and threshold effect of green finance on environmental quality: evidence from China. *Environmental Science and Pollution Research*, *29*(12), 17487–17498. https://doi.org/10.1007/s11356-021-16892-x

Kanazawa, Mark. (2021). *Natural resources and the environment economics, law, politics, and institutions Mark Kanazawa*. Routledge. ISBN 9780429022654.

Kim, D., & Go, S. (2020). Human Capital and Environmental Sustainability. *Sustainability*, *12*(11), 4736. https://doi.org/10.3390/su12114736

Lee, J.-W., & Lee, H. (2016). Human capital in the long run. *Journal of Development Economics*, *122*, 147–169. https://doi.org/10.1016/j.jdeveco.2016.05.006

Mazzucato, Mariana. (2021). *Mission economy : a moonshot guide to changing capitalism*. Allen Lane, an imprint of Penguin Books. ISBN 9780241419731.

OECD. (2021). *Green Budget Tagging*. OECD Publishing. https://doi.org/10.1787/fe7bfcc4-en

OECD. (2024). *Green Budgeting in OECD Countries 2024*. Organization for Economic Cooperation & Development. ISBN 9789264859593.

Priyagus. (2018). Impact of Foreign Investment and Natural Resources Sharing Funds Against Environmental Degradation in Indonesia. *KnE Social Sciences*, *3*(10), 347. https://doi.org/10.18502/kss.v3i10.3140

Raworth, Kate. (2017). *Doughnut economics : seven ways to think like a 21st century economist*. Chelsea Green Publishing. ISBN 9781603586740.

Solarin, S. A. (2024). Human capital development convergence in OECD countries since 1870: Using school enrolment rates as indicators of human capital development. *International Journal of Educational Research*, *127*, 102389. https://doi.org/10.1016/j.ijer.2024.102389

Tietenberg, T. H. ., & Lewis, Lynne. (2012). *Environmental & natural resource economics* (9th ed). Pearson Education. ISBN 9780131392571.