Assessing Local Environmental Spending and Air Pollution Reduction in Indonesia: A Satellite Data Approach

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Presentation Outline

Indonesia's Environmental Challenge

Political & Environmental Concerns:

- Indonesia committed to **net-zero emissions by 2060** at COP26
- Currently among **top 10 global carbon emitters** (Union of Concerned Scientists, 2021)
- Decentralized governance requires local-level environmental action
- Limited progress in emission reduction at local level

Data & Research Gaps:

- **Paucity of air pollution data** at local level. This highlights the need for alternative data sources for evaluation
- Most studies use general budget instead of environmental-specific spending

Policy Context & Research Objective

- The Government of Indonesia mandates the local government to manage the environmental quality through **environmental funds** (Government Regulation No. 32 of 2009 concerning Environmental Economic Instruments and Presidential Regulation No. 77 of 2018 concerning the Management of Environmental Funds).
- This study focuses on **environmental spending of local governments**. The potential sources of environmental budget of local governments are:
  - Indonesia's national budget (APBN) through the Special Allocation Funds for Environmental Functions (DAK *Fungsi Lingkungan Hidup*) and General Allocation Funds (DAU)
  - Locally generated revenue

Research Objective

This study, thus, aims to evaluate the effect of local environmental spending on pollution level.

Literature Overview: Mixed Results (1/2)

Region/Country	Finding	Key Studies
World	Mixed results: insignificant relationship to positive impact on SO_2 emissions. Direct negative impact varies by income level.	Halkos & Paizanos (2013); Bernauer & Koubi (2013); Yilanci & Pata (2022)
Europe	Negative relationship - spending reduces SO_2, NO_2, and O_3. Attributed to carbon taxes and governance quality.	Lopez & Palacios (2010); López & Palacios (2014)
USA	No significant effect of central government spending. Budget composition at state level more important than total amount.	Islam & López (2013); Halkos & Paizanos (2017)

Literature Overview: Mixed Results (2/2)

Region/Country	Finding	Key Studies
China	Mixed results: negative impact on SO_2 but positive on chemical oxygen demand and soot. Spatial spillover effects between provinces.	Zhang et al. (2017); Huang (2018); Xiong et al. (2020)
Developing Asia	Context-dependent: large fiscal spending decreases pollution with shadow economy, increases with higher taxes.	Huynh (2020)
Indonesia	Limited evidence - positive relationship with Environmental Quality Index at provincial level. Uses general spending, not environmental-specific budgets.	Oktavilia et al. (2021)

Research Gaps

- Most studies use **general government spending**
- Limited focus on **local-level analysis**
- Lack of **comprehensive analysis on various pollution types**
- Few studies in **developing countries**
- Indonesia-specific evidence is **very limited**

Data Sources & Coverage

Dataset Overview:

- **474 cities/regencies** across Indonesia (2011-2019)
- **4,266 observations** total
- Excludes DKI Jakarta (outlier) and administratively divided regions

Air Pollution Data:

- **NASA Giovanni** satellite database
- Spatial resolution: 13.75 km $\times$ 13.75 km
- Monthly data aggregated annually
- Pollutants: NO_2, SO_2, $PM_{2.5}$, O_3, Black Carbon

Budget & Control Data:

- **Environmental budget**: Ministry of Finance
- **Economic data**: SIMREG (BAPPENAS)
- **Geographic data**: USGS + QGIS
- Population density, elevation, GDP, industry share

Summary Statistics

Variable	Mean	Std. Dev.	Min	Max	Obs
Air Pollution Growth:					
NO_2 Growth	-0.001	0.083	-0.231	0.187	3,724
SO_2 Growth	0.018	1.027	-6.431	6.043	3,359
$PM_{2.5}$ Growth	0.000	0.334	-1.797	1.341	3,318
O_3 Growth	0.001	0.025	-0.040	0.059	3,768
Black Carbon Growth	1.010	2.647	-2.105	8.906	3,700
Key Variables:					
Env. Budget Growth	0.093	0.745	-10.727	10.940	3,673
Population Density	999.8	2,296.3	0.85	16,208.7	4,266
Regional GDP (ln)	9.123	1.249	2.565	13.272	4,264

Key Observations:

- Large variation in environmental budget growth (-10.7% to +10.9%)
- Most pollutants show near-zero average growth
- Substantial heterogeneity across regions

Empirical Strategy

Growth Rate Definition:

$$PollutionGrowth_{it} = \ln(Pollution_{it}) - \ln(Pollution_{it-1})$$

Fixed Effects Model:

$$\begin{aligned} PollutionGrowth_{it} = \alpha + \beta \cdot EnvBudgetGrowth_{it} \\ + X'_{it}\gamma + Z'_{it}\delta + \omega_i + \phi_t + \epsilon_{it} \end{aligned} \tag{1}$$

Where:

- X_{it}: Regional characteristics (population density, elevation)
- Z_{it}: Economic characteristics (GDP, government spending, industry share)
- ω_i: City/regency fixed effects
- ϕ_t: Year fixed effects

Main Results

	(1) Bivariate		(2) + Regional		(3) + Economic	
	SO_2	NO_2	SO_2	NO_2	SO_2	NO_2
Env. Budget	0.130	**-0.010****	0.132	**-0.018***	0.107	**-0.016***
	(0.270)	(0.004)	(0.028)	(0.010)	(0.300)	(0.011)
Pop. Density			-0.184*	0.039**	-0.202*	0.039**
Elevation			0.100**	-0.004**	0.090*	-0.004***
ln(Regional GDP)					2.600	0.003
ln(Total Gov. Spend.)					0.130	-0.007
Share of Industry					1.001	-0.004
Fixed Effects			Year + City/Regency: Yes			
N	3,314	3,673	3,195	3,545	3,194	3,544
Adj. R^2	0.048	0.829	0.048	0.834	0.048	0.834

Key Findings:

- Environmental budget **significantly reduces NO_2 pollution**
- **No significant effect on SO_2 pollution**
- Results consistent across specifications

Effect Magnitude & Economic Interpretation

Main Finding

A **10% increase** in environmental budget spending is associated with a **0.16% reduction** in NO_2 pollution growth

Economic Interpretation:

- **Inelastic relationship** - spending increases do not translate proportionately to pollution reduction
- Suggests **inefficiencies** in current environmental spending
- NO_2 reduction likely due to programs targeting **fuel combustion sources** (vehicles, power plants)
- SO_2 unaffected suggests programs do not address **industrial pollution sources**

Heterogeneity Analysis: Income Levels

	Q1 (Poorest)		Q2		Q3		Q4 (Richest)	
	SO_2	NO_2	SO_2	NO_2	SO_2	NO_2	SO_2	NO_2
Env. Budget Growth	**-0.961*** (0.574)	**-0.036*** (0.019)	0.127 (0.086)	**-0.047*** (0.027)	0.397 (0.559)	0.014 (0.018)	-0.194 (0.599)	-0.008 (0.017)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	807	883	796	914	842	908	749	839

Key Insights:

- Environmental spending **more effective in poorer regions**
- Effect becomes **insignificant in wealthier areas**
- Suggests **diminishing returns** with economic development

Temporal Dynamics & Other Pollutants

Lagged Effects:

- **No significant lagged effects** found
- Environmental spending only affects pollution in **current year**
- Suggests **short-term focus** rather than sustainable programs

Policy Concern:

- Programs may focus on **budget absorption** rather than long-term environmental improvement

Other Pollutants:

Pollutant	Effect
NO_2	**-0.016***
SO_2	0.107
O_3	**-0.005****
$PM_{2.5}$	0.019
Black Carbon	**+0.160****

Mixed Results:

- **Effective** for NO_2 and O_3
- **No effect** on SO_2 and $PM_{2.5}$
- **Increases** Black Carbon

Conclusion

Key Findings:

- Environmental spending significantly reduces NO_2 pollution but shows no significant effect on SO_2 levels
- Budget effectiveness is inelastic - 10% budget increase yields only 0.016% NO_2 reduction
- Environmental programs show short-term impact only with no lasting effects in subsequent years
- Effects are stronger in economically disadvantaged areas compared to wealthier regions

Policy Implications

- Current programs primarily target vehicle and power plant emissions (NO_2 sources)
- Need for programs addressing industrial pollution sources (SO_2 emissions)
- Efficiency improvements required for optimal budget utilization
- Taking advantage of satellite data for evaluation
- Focus on sustainable, long-term environmental strategies rather than short-term measures

Limitations

- Natural phenomena (e.g. forest fires, volcanic eruptions) and other possible factors that may influence pollution levels not controlled
- Cannot isolate specific environmental programs within environmental spending within local governments

Thank You!

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