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The Impact of Accelerated Development on Air Pollution in Indonesia

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Abstract – Development is the result achieved from sustainable government policy efforts. The government is responsible for planning and implementing policies to increase people's welfare and improve infrastructure and the economic sector. Instead of producing the expected positive impacts, development often has adverse side effects for society and the environment. This study aimed to determine the impact of development in rural areas on air pollution. The data used in this research is Village Development Index data for 2018. Apart from that, this research also uses several variables from the 2018 Village Potential data collection results. The method used in this research is the Instrumental Variable (IV) method. The results obtained in this study, namely development in independent villages, still have residuals and have an impact on air pollution. Support is needed from the government through regulations and companies through obedience to pay attention to environmental conditions so that the survival of living things is maintained.

Keywords – Development, Air Pollution, Instrumental Variable.

I. INTRODUCTION

Development is the result achieved from sustainable government policy efforts. The government is responsible for planning and implementing policies to increase people's welfare and improve infrastructure and the economic sector. This policy covers various fields, such as physical, social, and economic development. To achieve sustainable development, the government must consider multiple aspects such as community needs, available resources, and possible environmental impacts [1], [2]. Successful development creates a better environment for people, with adequate infrastructure, sufficient employment opportunities, and better access to public services. [3], [4].

Instead of producing the expected positive impacts, development often has adverse side effects for society and the environment. Even though growth has noble goals, such as improving the quality of life and the economy, essential aspects, such as environmental Sustainability and social welfare, are often neglected. Poorly planned development projects can cause severe ecological damage, including deforestation, land degradation, and air and water pollution [5]–[7]. In addition, communities living around development projects often experience adverse impacts such as forced evictions, loss of traditional livelihoods, and unwanted socio-cultural changes. These harmful residues can have long-term consequences and are difficult to repair [8]–[10].

The impact often arises from development is pollution, including air, water, and soil pollution [11]–[13]. Rapid growth is often accompanied by increased energy use and industrial production, resulting in greenhouse gas emissions and pollutant particles in the air. This air pollution can cause public health problems, such as respiratory problems, eye irritation, and an increased risk of serious illness [14]–[16]. In addition, development often results in water pollution through industrial effluents, intensive agriculture, and inadequate sewage systems. Water pollution can contaminate freshwater sources and threaten aquatic life and the health of humans who depend on this water. In addition, development can also cause soil pollution through uncontrolled waste

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disposal and the use of hazardous chemicals. Soil contamination can damage soil fertility, contaminate groundwater, and endanger human health through contamination of food and drinking water [17], [18].

Air pollution results from an accumulation of water and soil pollution, which contribute to poor air quality [19]. Water pollution can be released into rivers, lakes, or seas by removing industrial, agricultural, and domestic waste. Hazardous chemicals and nutrients dissolved in water can evaporate into the air and become part of air pollution. In addition, solid waste that is not managed correctly can also produce particles carried by the wind and cause air pollution. Soil pollution also plays an essential role in air pollution because it can cause soil and water contamination, affecting air quality. For example, excessive use of pesticides and agricultural chemicals can cause dirt and water pollution, impacting air quality. In addition, burning garbage or contaminated organic matter in landfills can also produce toxic gases and particles that pollute the air.

II. Data And Methodology

The data used in this research is Village Development Index data for 2018. Apart from that, this research also uses several variables from the 2018 Village Potential data collection results. The method used in this research is the Instrumental Variable (IV) method. Method IV is used because the model has endogeneity problems [20], [21]. The instrumental variable method is used to handle this situation by using the instrumental variable. Instrumental variables are variables that affect the independent variable but do not have a direct influence on the dependent variable except through the independent variable itself. We can obtain unbiased estimates for the causal relationship between the independent and dependent variables using instrumental variables. This method assumes that instrumental variables fulfill two essential conditions: first, the instrumental variables must have a significant correlation with the independent variables; second, the instrumental variable may not have a direct relationship with the dependent variable other than through the independent variable.

The dependent variable in this study is air pollution, and the variable of interest is a village with an independent development category. This study used the GDP per capita, the status of underdeveloped areas, and the IPD value in the previous year as instrument variables.

The equation in the first stage (first stage) of regression with the instrumental variable research model can be written as follows:

$$\widehat{kat\_ipd\_mandiri}_{i,t} = \beta_0 + \beta_1\, pdrb_{kap} + \beta_2\, desa_{tertinggal} + \beta_3\, d\_ipd + \beta_n\, X_{i,t} + \mu_{i,t}$$

With *kat_ipd_mandiri* is a village with independent development status, pdrb_kap is the average per capita GDP using district/city GDP values, desa_tertinggal is village status based on district status that has been stipulated by the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration, and d_ipd is the value of changes in IPD compared to the previous year, followed by other control variables.

The model that will be formed in this study is as follows:

$$cemar\_udara_{i,t} = \beta_0 + \beta_1\, \widehat{kat\_ipd\_mandiri}_{i,t} + \beta_n\, X_{i,t} + \mu_{i,t}$$

With *cemar_udara* is the status of air pollution in the village, followed by other control variables.

III. Results And Discussion

In the early stages of the regression, it is known that most of the interest variables and control variables have a significant influence on villages that are in the independent category. Underdeveloped village status has a negative and significant effect on village development. Factors that cause villages to lag, such as limited access to resources, minimal infrastructure, and low levels of education, affect the ability of towns to achieve economic growth, improve people's quality of life, and improve public services [22]–[24]. When a village experiences underdeveloped conditions, this impacts hampering village development.

Village development has a significant role in the development of a country. Villages are the starting point of the development process and form the foundation for broader development at the national level. In village development, various aspects of community life, such as infrastructure, education, health, agriculture, and the economy, are empowered to achieve sustainable progress. Through village development, the government can reduce the disparity between urban and rural areas, improve villagers' quality of life, and create sustainable employment opportunities. In addition, village development also contributes to improving

the country's economy as a whole because developed villages will become a strong resource for national economic growth. [25]–[27].

An independent village is the hope and aspiration of every regional development effort. The concept of a separate village emphasizes the importance of community empowerment at the local level, where the village can manage resources and meet the needs of its population independently. In an independent village, the community can participate in decision-making, planning, and implementing development programs according to local needs and potential. Apart from that, separate villages also prioritize improving the quality of human resources, developing the local economy, and increasing access to basic infrastructure such as clean water, electricity, and education. Through an independent village, it is hoped that the community can overcome development challenges independently, build Sustainability, and improve the welfare of local communities [28]–[30]. Thus, an independent village is essential to achieving inclusive and sustainable development goals.

Table 1. First Stage Regression Effect of Independent Village Development on Air Pollution

```
Number of obs     =     75,436
F(  17,  75418)   =     105.58
Prob > F          =     0.0000
R-squared         =     0.0232
Adj R-squared     =     0.0230
Root MSE          =     0.2591
```

kat_ipd_mandiri	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
cemar_air	.0054479	.0024978	2.18	0.029	.0005522	.0103436
cemar_tanah	.0050105	.0060474	0.83	0.407	-.0068425	.0168635
lok_hut	-.0059986	.0022976	-2.61	0.009	-.0105019	-.0014954
mata_air	.013503	.0022307	6.05	0.000	.0091307	.0178752
pemukiman_kumuh	.0233609	.0042898	5.45	0.000	.0149529	.0317689
reboisasi_masy	.0301171	.0023258	12.95	0.000	.0255585	.0346758
bakar_ladang	-.0336204	.0021616	-15.55	0.000	-.0378573	-.0293836
lok_gali	.0014763	.0023048	0.64	0.522	-.0030412	.0059937
spu						
2	-.0236521	.0124516	-1.90	0.057	-.0480572	.000753
3	.0688668	.0058656	11.74	0.000	.0573702	.0803633
4	.0256855	.0054394	4.72	0.000	.0150243	.0363467
5	-.0086261	.0366748	-0.24	0.814	-.0805086	.0632564
6	.0311763	.0066942	4.66	0.000	.0180557	.044297
7	.0345318	.0116635	2.96	0.003	.0116713	.0573923
pdrb_kap	-.0005563	.0026199	-0.21	0.832	-.0056914	.0045787
tertinggal	-.0479842	.0023886	-20.09	0.000	-.052666	-.0433025
d_ipd	.0002973	.0000923	3.22	0.001	.0001164	.0004781
_cons	.0824759	.0017263	47.78	0.000	.0790923	.0858595

Note :

Dependent variable: kat_ipd_mandiri: a village with independent development status

Independent variables: cemar_air: the level of water pollution in the village

cemar_tanah: the quality of soil pollution in the village

lok_hut: the existence of the town in the forest area

mata_air: the presence of springs

pemukiman_kumuh : existence of slums

reboisasi_masy : community reforestation culture

bakar_ladang : field burning

lok_gali: excavation site

spu: the primary source of income (1 is agriculture)

pdrb_kap: the average per capita GDP using district/city GDP values

tertinggal: village status based on district status that has been stipulated by the Ministry of Villages, Development of Disadvantaged Regions, and Transmigration

d_ipd: the value of changes in IPD compared to the previous year

Table 2. Instrumental Variable Effect of Independent Village Development on Air Pollution

```
Instrumental variables (2SLS) regression          Number of obs   =     75,436
                                                  Wald chi2(15)   =    3985.06
                                                  Prob > chi2     =     0.0000
                                                  R-squared       =          .
                                                  Root MSE        =     .40689
```

cemar_udara	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
kat_ipd_mandiri	1.119408	.0772379	14.49	0.000	.9680249	1.270792
cemar_air	.12416	.0039727	31.25	0.000	.1163736	.1319464
cemar_tanah	.294055	.0094983	30.96	0.000	.2754386	.3126713
lok_hut	-.0125099	.0036869	-3.39	0.001	-.019736	-.0052838
mata_air	-.0094778	.0036627	-2.59	0.010	-.0166567	-.002299
pemukiman_kumuh	.0180576	.0069741	2.59	0.010	.0043886	.0317267
reboisasi_masy	-.023248	.0043959	-5.29	0.000	-.0318637	-.0146323
bakar_ladang	.0409539	.0047882	8.55	0.000	.0315691	.0503386
lok_gali	.0160493	.0036178	4.44	0.000	.0089585	.0231401
spu						
2	.023041	.0195698	1.18	0.239	-.0153151	.0613971
3	.0821791	.0107738	7.63	0.000	.0610629	.1032953
4	.0072042	.0087938	0.82	0.413	-.0100313	.0244398
5	.0880358	.0576004	1.53	0.126	-.024859	.2009306
6	-.0139283	.0108107	-1.29	0.198	-.0351168	.0072602
7	-.0119369	.0185409	-0.64	0.520	-.0482763	.0244025
_cons	-.0221194	.0064403	-3.43	0.001	-.0347421	-.0094966

```
Instrumented:  kat_ipd_mandiri
Instruments:   cemar_air cemar_tanah lok_hut mata_air pemukiman_kumuh
               reboisasi_masy bakar_ladang lok_gali 2.spu 3.spu 4.spu 5.spu
               6.spu 7.spu pdrb_kap tertinggal d_ipd
```

Development hurts air pollution. In addition, water pollution also affects air pollution. Air pollution is a side effect of water and air pollution. Water pollution can cause an unpleasant odor, so it will cause air pollution when it evaporates. Villages located around forest areas have a negative coefficient on the formation of air pollution. These results are in line with findings from previous studies [31]. This is due to several factors contributing to better air quality in such villages. First, forests as a protective layer can function as a natural filter that absorbs pollutants and improves air quality before reaching villages. In addition, forests also play a role in maintaining air humidity and producing oxygen through photosynthesis, which contributes to cleaner and

fresher air. Furthermore, villages around forest areas usually have less human activity than urban or industrial areas, resulting in lower pollutant emissions. While these villages may have local sources of emissions, such as burning biomass for cooking or heating homes, the impacts tend to be more localized and less massive in more densely populated areas.

The regression results above show that the presence of springs indicates low air pollution. Springs are often located in areas far from industrial and motor vehicle pollution, the primary sources of air pollution. The water that flows from springs is usually clean and clear, indicating that the surrounding air is relatively free of pollutants that can contaminate the water. In addition, springs are also often surrounded by lush vegetation and unspoiled nature, which can function as a natural filter and improve the air quality around it. The existence of well-maintained springs in an area can illustrate that the surrounding environment has good air quality and minimal air pollution.

Slum settlements are known to have poor results on air pollution. In slum settlements, there is usually a dense population with a high density of buildings. This causes high human activity in transportation, the home industry, and the intensive burning of fossil fuels, such as firewood or kerosene. These activities result in the emission of particulates, toxic gases, and greenhouse gases that can pollute the air. In addition, in slum settlements, the lack of sanitation infrastructure and waste management often results in air pollution in the form of unpleasant odors and particulate matter from solid waste that is not treated correctly. The lack of green open space and plants in slums also reduces the natural ability to filter pollutants and improve air quality.

Community reforestation has a good effect on air pollution. Through reforestation activities, communities are active in replanting trees in degraded or affected areas [32]. In photosynthesis, the trees absorb carbon dioxide (CO2) from the air and produce oxygen (O2), which improves air quality. With more trees, CO2 emissions can be reduced, and the atmosphere can be more balanced. In addition, the forest planted by the community also functions as a natural filter, filtering particulate matter and other pollutants from the air. The leaves and branches of trees catch wind-borne particles, reducing the level of air pollution around them. Community reforestation also provides social and economic benefits, such as protecting wildlife habitat, managing water, and improving the economic welfare of local communities.

Field burning has a lousy role in air pollution. Burning fields generally involves burning plant mass and crop residues on agricultural land as part of soil preparation or land-clearing activities. When areas burn, harmful gases and particles are released into the atmosphere. The resulting emissions include carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), delicate particulate matter (PM2.5), and volatile organic compounds (VOCs), all of which are air pollutants that have the potential to harm human health and the environment. In addition, burning fields also contribute to an increase in greenhouse gases, such as carbon dioxide (CO2) and methane (CH4), which can exacerbate global climate change. The negative impact of field burning on air quality can spread to surrounding areas and result in significant air pollution.

The existence of excavation sites can indicate the presence of air pollution. When quarrying activities such as mineral mining, construction, or quarrying, these processes can result in the emission of pollutants into the air. Quarrying often involves using heavy equipment, transport vehicles, and chemicals in extraction or construction processes. Emissions generated include particulates, dust, toxic gases, and greenhouse gases that can pollute the surrounding air. Air pollution from excavation sites can occur either directly or indirectly. At the mining stage, explosions or blasting can produce dust and particles floating in the air. In addition, using explosives and chemicals in mining or construction processes can produce toxic gases such as sulfur dioxide (SO2) or nitrogen dioxide (NO2). If not handled properly, air pollution from excavation sites can reach great distances and affect the surrounding air quality.

Table 3. OLS Regression The Effect of Independent Village Development on Air Pollution

Source	SS	df	MS	Number of obs	=	75,436
				F(14, 75421)	=	354.68
Model	433.461818	14	30.9615584	Prob > F	=	0.0000
Residual	6583.81084	75,421	.087294133	R-squared	=	0.0618
				Adj R-squared	=	0.0616
Total	7017.27265	75,435	.093024096	Root MSE	=	.29546

cemar_udara	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
kat_ipd_mandiri	.0272433	.004141	6.58	0.000	.0191271	.0353596
cemar_tanah	.3634672	.0067501	53.85	0.000	.3502371	.3766974
lok_hut	-.0301072	.0025762	-11.69	0.000	-.0351565	-.0250578
mata_air	.004528	.0025327	1.79	0.074	-.0004361	.0094922
pemukiman_kumuh	.0661079	.0048695	13.58	0.000	.0565638	.0756521
reboisasi_masy	.0128557	.0026512	4.85	0.000	.0076594	.0180521
bakar_ladang	-.0094359	.0023632	-3.99	0.000	-.0140678	-.004804
lok_gali	.0218377	.0026241	8.32	0.000	.0166945	.026981
spu						
2	.0461708	.0141573	3.26	0.001	.0184226	.073919
3	.1917323	.0066428	28.86	0.000	.1787124	.2047522
4	.05464	.0061896	8.83	0.000	.0425085	.0667715
5	.0843087	.0418214	2.02	0.044	.0023391	.1662784
6	.034675	.0076219	4.55	0.000	.0197361	.0496138
7	.0408767	.0132982	3.07	0.002	.0148123	.0669411
_cons	.0828386	.0017813	46.50	0.000	.0793472	.0863299

Table 3 shows the results of the OLS regression. Method IV works well when the coefficient of method IV is higher than the OLS method. This result is due to method IV already being influenced by instrument variables. The results obtained from the IV and OLS methods are relatively the same, both in terms of direction and significance. Method IV uses instrument variables that do not directly correlate with endogenous variables to overcome endogeneity problems. Thus, the results obtained from method IV can be considered more credible in estimating the causal relationship between the independent and dependent variables. Although there are differences in the coefficients between the IV and OLS methods, the results obtained from the two ways are relatively the same in terms of direction and significance. This shows that the two approaches provide similar information regarding the effect of the independent variables on the dependent variable. Even so, remember that using the IV method does not always guarantee superiority compared to the OLS method, depending on the context and assumptions used. Therefore, in carrying out statistical analysis, it is essential to consider the advantages and limitations of each technique and ensure that the assumptions used are met to obtain valid and meaningful results.

The regression output in this research has been tested using classical assumptions to measure the validity of the resulting model. In research, the regression output is the main focus for measuring the validity of the resulting model. To ensure this validity, researchers have conducted a classic assumption test. The classical assumption test is a series of statistical tests used to verify whether the basic assumptions of linear regression are met. These assumptions include normality, homoscedasticity, and the absence of multicollinearity between the independent variables. By testing the classical hypotheses, researchers can evaluate whether the regression model used is by the observed data. If the classical assumptions are met, it can be said that the resulting regression model has good validity. However, if these assumptions are violated, the researcher needs to make adjustments or transform the data so that the model becomes more valid. Based on the classical assumption test, it is known that the model has a good model so that it can be interpreted and accounted for.

Table 4. Classical Assumption Test on the Regression Model of the Effect of Independent Village Development on Air Pollution

```
. swilk e

                    Shapiro-Wilk W test for normal data

    Variable |        Obs       W           V         z       Prob>z
-------------+-------------------------------------------------------
      embung |     75,436    0.75119   6229.364    24.390    0.00000

Note: The normal approximation to the sampling distribution of W'
      is valid for 4<=n<=2000.


. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of cemar_udara

         chi2(1)      =  6808.41
         Prob > chi2  =   0.0000
```

IV. Conclusion

Development is a process to achieve the progress of a country. Development needs to be guarded starting from the countryside because the development of rural areas is the upstream development of a nation. Based on the results of this study, development has a labor impact on air quality. Development often produces harmful effects that are often overlooked. Support is needed from the government through regulations and companies through obedience to pay attention to environmental conditions so that the survival of living things is maintained.

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