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The Impact of Economic Variables and Energy Consumption on Deforestation in Indonesia

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Abstract

Indonesia occupies the third position as a country with the largest tropical forest in the world. In addition, Indonesia is also one of the countries with the largest deforestation rate in the world (Austin, 2019). The Center for International Forestry Research (2018) shows that the total tree cover loss o Indonesian forests in 2001-2018 was 36.7%. The impact of the high rate of deforestation in Indonesia is due to economic activity. In the demand side, the continued population growth has driven the demand for economic output tend to increase. Meanwhile, in the supply side, the increase in economic activity encourages industrialization and energy consumption, especially non- renewable energy because of its relative low cost. Both from the demand and supply side drive deforestation for infrastructure development. This study aims to analyze the effect of economic variables and energy consumption on deforestation in Indonesia. By using the Autoregressive-Distributed Lag (ARDL) methods and Error Correction Model (ECM), we use time series data from 1980-2017 sourced from the World Bank, OECD, IEA and CIFOR. We estimate that there is a statistically significant effect between economic variables and energy consumption on deforestation rates in Indonesia. The results of our research are expected to provide policy recommendations to the government in order to implement a sustainable economic development program with an environmental perspective.

Keywords: *Deforestation, Economic, Energy Consumption, Industrialization*

Introduction/Background

Forest area is land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems and trees in urban parks and gardens (World Bank). Forests cover 31 percent of the world's land surface, just over 4 billion hectares. Indonesia occupies the third position as a country with the largest tropical forest in the world. Indonesia has 10% of the world's tropical forests, 60% of Asia's tropical forests, and a significant proportion of the world's remaining virgin stands. These forests are home to vast numbers of animal and plant species and people. Thus their value is substantially greater than simply their ability to produce wood and associated forest products. In addition, Indonesia is also one of the countries with the largest deforestation rate in the world (Austin, 2019). Economic activity and energy consumption can cause deforestation in Indonesia. Deforestation can contribute to increase in global warming which is one variant of climate change. Global warming is believed to have negative impacts that endanger human life.

Development in the economic sector is a pillar towards a more prosperous society. Therefore, developing countries are trying to catch up with developed countries by implementing development. The fastest way for developing countries to do this is by utilizing existing natural resources to be exploited so as to spur economic growth, one of which is to utilize forest resources through deforestation. The Center for International Forestry Research (2018) shows that the total tree cover loss of Indonesian forests in 2001-2018 was 36.7%. Based on Global Forest Watch Research, Indonesia lost 26.8Mha of tree cover from 2001 to 2019, equivalent to a 17% decrease in tree cover since 2000, and 10.9Gt of CO_2 emissions. In Indonesia, 93% of tree cover loss from 2001 to 2019 occurred in areas where the dominant drivers of loss resulted in deforestation

Forest goods provide an important "hidden harvest" for rural populations, keeping many people out of extreme poverty. According to the Poverty and Environment Network (PEN), forests are an important aspect of rural livelihoods, with rural households living near forested areas deriving as much as 22 percent of their income from forest sources. At the national level, economic growth is measured by the increase in GDP. in Indonesia, Gross Domestic Product (GDP) has an increasing trend. At 2019, GDP at Current Market Prices is IDR 15.833.943,4 Billion. If there is an increase in GDP, it means that the aggregate national production capacity increases. Futhermore, the continued population growth has driven the demand for economic output to increase. The problem arises when people exploit forests to fulfill this matter because of the potential of forests in Indonesia, thus causing deforestation.

Economic activity is closely related to human behavior, while intensity is related to technological development. The increase in economic activity encourages industrialization. Thus, industrialization can cause increasing energy consumption. In 2018, primary energy consumption for Indonesia was 7.99 quadrillion btu. Primary energy consumption of Indonesia increased from 3.85 quadrillion btu in 1999 to 7.99 quadrillion btu in 2018 growing at an average annual rate of 3.98%. Currently, final energy consumption is still dominated by the use of fuel with a share of 50%. The largest sector that uses energy is the transportation sector (43%) followed by the industrial sector (35%), the household sector (14%) and the rest, the commercial sector, and others. Industrialization that relate with energy consumption can cause deforestation for infrastructure development.

Literature Review

Based on the empirical result of Khalid et al. (2014) by using time series data from 1980– 2013 with deforestation as an indicator (dependent variable) for environmental degradation, and four independent variables (economic growth, energy consumption, trade openness, and population) through The Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration and the VECM–Granger causality test. They confirmed the existence of cointegration among the variables both in long-run and short-run paths. The results suggest that a 1% increase in growth adds 2.782% deforestation in the short-run; if growth continues, the effect decreases to 0.035% in the long-run. Similarly, in the short-run, a 1% increase in energy consumption and population contribute 2.80% and 7.948%, respectively, and in the long run, 0.039% and 1.13%, respectively. In contrast, trade has little effect on deforestation in Pakistan. There was a unidirectional causality between income and energy consumption to deforestation and a bidirectional causal effect was detected between income and energy consumption. However, income and trade openness Granger causes energy consumption.

Syeda et al. (2013) investigate short-run or long-run the causal relationship between energy consumption (i.e., nuclear energy consumption, electricity power consumption and fossil fuels energy consumption) and economic growth; energy consumption and industrialization (i.e., industrial GDP, beverages and cigarettes); energy consumption and environmental degradation (i.e., carbon dioxide emissions, population density and water resources); and finally, energy consumption and resource depletion (i.e., mineral depletion, energy depletion, natural depletion and net forest depletion) in Pakistan over a period of 1975–2011. The method used is the Granger causality test to determine the strength of the relationship between variables. Results of the study show that there exists a unidirectional relationship of energy demand to manufacturing and services sectors of Pakistan at different frequencies. The most significant relationship among all variables of energy demand and industrialization would be from nuclear energy to industrial growth in the long run and electricity power consumption to industrial growth in the short-run. The results indicate almost insignificant direct relationship between resource depletion and energy demand.

Raheel et al. (2014) investigate the shortrun and long-run causality relationship among energy (electricity production from renewable sources), carbon dioxide emissions, natural resource depletion, Gross Domestic Product (GDP) and poverty in selected SAARC countries, namely, Bangladesh, India, Nepal, Pakistan and Sri Lanka, over a period of 1975-2010. This study used unit root test is performed for checking the stationarity of the variables and also employ Pedroni's (1999) FMOLS estimation procedure to obtain estimates of the cointegrating vector in the five long-run equations. The results provide evidence of the existence of a positive causal link and have a longrun existence of energy production, environmental degradation, poverty and income in SAARC region.

Thomas (2015) conducted a study on the national determinants of deforestation in sub-Saharan Africa. The independent variables all represent conditions before 2000, whereas the dependent variable represents processes occurring during the 2000–2005 period, so the equations do not exhibit simultaneity biases. The dependent variable used is the level of deforestation, while the independent variable used includes proportion of lands that are unsuitable for agriculture, carbon stock density in forests, proportion of the population living in urban areas, 2000, oil and gas receipts as% of exports, cereals imports per capita, and population growth 1990s (% per annum). This study used spatially lagged regression models that allow for deforestation in one spot during one period to create deforestation in adjacent spots in subsequent periods. Results of the study show that the most extensive clearing occurred in dry forest areas, so the countries with less dense forests and lots of arid lands unsuitable for agriculture experienced higher rates of deforestation. In this analysis the urban population can spur deforestation by increasing the demand for agricultural products.

Methodology

This study uses a quantitative approach to determine how the influence of the independent variables on the dependent variable. By using the diagnostic test and multiple regression of the Autoregressive-Distributed Lags (ARDL) method where data processing uses the Stata 13 software. The data used is a type of time series and is secondary data from official sources. The following is Indonesian data for 1985-2016, where the information sources for the variables are presented in the following table:

Table 1.

Source of Data

Variables	SYMBOL	Unit	Sources
Forest Area	DEFOR	Percentage of land area	
Gross Domestic Product (GDP)	GDP	A billion dollars at purchasing power parities	
Trade oppenes	TO	Percent of GDP	World Bank
Foreign Direct Investment (FDI)	FDI	Billion USD	
Crude Palm Oil (CPO) Export	CPO	1000 metrik ton	
Gas onsumption	GAS	Kilo-watt hour (TWh)	US Energy Information
Oil consumption	OIL	1000 MT	
Coal Consumption	COAL	Thousand Short Tons	

Source: Processed

Where the hypothesis of the relationship between forest area decline, economy and energy consumption based on the Environmental Kuznet Curve (EKC) theory is formulated with the following model:

$$DEFOR_t = \beta_0 + \beta_1 GDP_t + \beta_2 (GDP_t)^2 + \beta_3 TO_t + \beta_4 FDI_t + \beta_5 CPO_t + \beta_6 OILt + \beta_7 COALt + \beta_8 GAS_t + \mu_t \quad (1)$$

This study uses the ARDL method to determine the dynamic relationship between variables. Distributed-Lag model involves the lag (past value) of the independent variable (X) in the model, meaning that the Y (dependent) variable is influenced by the independent variable and the lag

$$\Delta DEFOR_t = \alpha_0 + \sum_{i=2}^{p} \beta 1 \ \Delta DEFOR_{t-i} + \sum_{i=2}^{p} \beta 2 \ \Delta GDP_{t-i} + \sum_{i=2}^{p} \beta 3 (GDP_{t-i})^2 + \sum_{i=2}^{p} \beta 4 \Delta TO_{t-i} + \sum_{i=2}^{p} \beta 5 \ \Delta FDI_{t-i} + \sum_{i=2}^{p} \beta 6 \ \Delta CPO_{t-i} + \sum_{i=2}^{p} \beta 7 \ \Delta OILt\text{-}i + \sum_{i=2}^{p} \beta 8 . \Delta COAL_{t-i} + \sum_{i=2}^{p} \beta 9 \ \Delta GAS_{t-i} + \gamma_1 DEFOR_{t-i} + \gamma_2 GDP_{t-i} + \gamma_3 (GDP_{t-i})^2 + \gamma_4 TO_{t-i} + \gamma_5 FDI_{t-i} + \gamma_6 CPO_{t-i} + \gamma_7 OILt\text{-}i + \gamma_8 COALt\text{-}j + \gamma_9 GASt\text{-}j + \mu_t \quad (2)$$

of the independent variable itself. Meanwhile, the Autoregressive Model involves the dependent variable lag (Y) in the model (Gujarati, 2009). Where is the model as follows:

In the above model, γj represents the longterm relationship between variables. To determine the long-term relationship of the non-statistical variables in a model, it can be seen through linear combinations. If both variables contain the unit root element or are not stationary, the linear combination of the two variables may indicate otherwise. The error term in the time series regression equation is a linear combination (Gujarati, 2009). If the disturbance variable is not stationary at the level, the two variables are cointegrated.

Cointegration of time series variables in the long run even though these variables are not statistical at level I (0) indicates imbalance in the short term, so adjustments are needed to correct the short term with the Error Correction Model (ECM) with the following model:

$$\Delta DEFORt = \alpha 0 + \sum_{i=2}^{p} \beta 1 \ \Delta DEFOR_{t-i} + \sum_{i=2}^{p} \beta 2 \ \Delta GDP_{t-i} + \sum_{i=2}^{p} \beta 3 (GDPt-i_j)^2 + \sum_{i=2}^{p} \beta 4 \ \Delta TOt_{-i} + \sum_{i=2}^{p} \beta 5 \ \Delta FDI_{t-i} + \sum_{i=2}^{p} \beta 6 \ \Delta \ CPO_{t-i} + \sum_{i=2}^{p} \beta 7 \ \Delta OIL_{t-i} + \sum_{i=2}^{p} \beta 8 . \Delta \ COAL_{t-i} + \sum_{i=1}^{p} \beta 9 \ \Delta GAS_{t-i} + \gamma 1 \ ECT_{t-i} \quad (3)$$

A significant negative relationship ECT is expected to show an indicator of long-term causality, while a significant lag indicates shortterm causality. To determine the variable statistical use the Augmented Dickey Fuller test, while the robustness of the model estimation uses several diagnostic tests such as: i) Breusch-Godfrey LM to test autocorrelation ii) Breusch-Pagan test to test for heteroscedasticity iii) Skewness test to test for normality iv) Ramsey RESET for model specifications.

Breusch-Godfrey LM to test autocorrelation

H0: No serial correlation

H1: There is serial correlation

Reject the null hypothesis if p-value <α (1%, 5%, or 10%

Breusch-Pagan test to test for heteroscedasticity

H0: Homoscedasticity

H1: Heteroscedasticity

Reject the null hypothesis if the p-value <α (1%, 5%, or 10%)

Skewness test to test for normality

H0: residual normally distributed

H1: residual not normally distributed

Reject the null hypothesis if the p-value <α (1%, 5%, or 10%)

Ramsey Reset for model specifications.

Ho: The model used is correct

H1: The model used is not quite right (misspecifications) Reject the null hypothesis if the p-value

Result and Discussion

The validity of the estimation model when all variables are statistically at the level or first difference. The following table is the variable statistical level, where at the level of the variables are not statistical, except for the TO variable which is already statistical at the level, while the other variables are statistical at level I (1) and for the stationary area at the second difference level I (2) through ADF test, this condition shows that ARDL is a feasible approach to estimate the model.

Table 2.

ADF Result

Variables	*ADF*		
	At level	*First Difference*	*Second Difference*
DEFOR	*-0.973*	*-1.256*	*-5.282*
	[0.9477]	*[0.6489]*	*[0.000]**
GDP	*0.650*	*-2.978*	
	[0.9970]	*[0.0370]**	
(GDP)2	*11.822*	*-2.978*	
	[1.000]	*[0.0370]**	
TO	*-2.905*		
	*[0.034] **		
FDI	*-1.366*	*-5.944*	
	[0.911]	*[0.000]**	
CPO	*-1.755*	*-8.546*	
	[0.7262]	*[0.000]**	
OIL	*-2.416*	*-4.978*	
	[0.3711]	*[0.000]**	
COAL	*0.367*	*-3.677*	
	{0.9965]	*[0.0044]**	
GAS	*-1.200*	*-5.524*	
	[0.9150]	*[0.000]**	
E	*[0.000] **		

***: level signifikan 5%*

p-value are within the parenthess

Then the ADF from the error term at the first level shows a significant number, this indicates that the two variables are co-integrated so that a long-term relationship occurs in that variable. Then, the conclusion of the diagnostic test is shown in the summary below, using a significant level of 5% and the p-value are within the parenthess.

Table 3.

Classical Assumptions Test

Asumptions	**Test**	**P-value (alpha 5%)**	Conclusion
Normality	Skewness Test	0.3204	Normal Distributed
Autocorrelation	Breusch-Godfrey LM test	0.3074	There is no autocorrelation
Heteroscedasticity	Breusch-Pagan Test	0.3141	There is no heteroscedasticity
Model Specification	Ramsey RESET Test	0.0785	Model is correct
DW Test 1.794 > R-square 0.9983			There is no spurious regression

From the conclusion of the diagnostic test above, it shows that there is nothing significant at the 5% level, there is no heteroscedasticity, autocorrelation, normally distributed and does not contain misspecifications. The results also show that the Durbin-Watson test value is greater than R-squared which indicates the absence of spurious regression. This indicates that this study is robust. The next is the long-term estimation result of this study, where the results show the following

Figure 1.

Result

Source	SS	df	MS
Model	1232.28372	8	154.035465
Residual	4.47710552	23	.194656762
Total	1236.76083	31	39.8955105

Number of obs =	32
F(8, 23) =	791.32
Prob > F =	0.0000
R-squared =	0.9964
Adj R-squared =	0.9951
Root MSE =	.4412

From the above conclusion, it shows with a significance level of 5% that simultaneously the estimated variable is significant, then the R- squared

Source	SS	df	MS
Model	.608879415	10	.060887942
Residual	.2068957	18	.011494206
Total	.815775115	28	.029134826

Number of obs =	29
F(10, 18) =	5.30
Prob > F =	0.0011
R-squared =	0.7464
Adj R-squared =	0.6055
Root MSE =	.10721

d2defor	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
d2deforl	.0041461	.1384857	0.03	0.976	-.2868016	.2950939
d2gdp	-.0013011	.0006768	-1.92	0.071	-.002723	.0001208
d2gdp_l	.0017734	.0007856	2.26	0.037	.0001229	.0034239
d2gdp2	0	(omitted)				
d2to	-.0134821	.0026346	-5.12	0.000	-.0190172	-.0079471
d2fdi	.0336755	.0072304	4.66	0.000	.018485	.0488661
d2cpo	.0000399	.000012	3.33	0.004	.0000147	.0000651
d2oil	-.0021327	.000621	-3.43	0.003	-.0034373	-.000828
d2coal	-1.11e-06	.0000123	-0.09	0.930	-.000027	.0000248
d2gas	-.0038563	.0014302	-2.70	0.015	-.006861	-.0008515
ect	-.3237389	.0970677	-3.34	0.004	-.5276707	-.1198072
_cons	.0138048	.0216878	0.64	0.532	-.0317597	.0593692

value of 0.9964 means that 99.64% of the variation of the independent variables is able to explain the dependent variable, while 0.36% is explained by other variables outside the model.

Figure 2.

Long-Term Estimation Results

defor	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gdp	-.0099063	.0019724	-5.02	0.000	-.0139866	-.0058261
gdp2	1.82e-06	4.06e-07	4.48	0.000	9.80e-07	2.66e-06
to	-.0488081	.0106273	-4.59	0.000	-.0707923	-.0268239
fdi	.1286074	.0198584	6.48	0.000	.0875271	.1696877
cpo	.000118	.0000856	1.38	0.181	-.0000591	.0002951
oil	-.0070095	.0014934	-4.69	0.000	-.0100988	-.0039202
coal	-.0000365	.0000276	-1.32	0.198	-.0000936	.0000205
gas	-.0151761	.0058998	-2.57	0.017	-.0273807	-.0029714
_cons	82.36299	.7738663	106.43	0.000	80.76212	83.96385

Sources: processed

Alpha 5% p-value are within the parenthess

Figure 4.2 shows that at a significance level of 5% of GDP (0.000 <0.05), trade openness (0.000<0.05), has a significant negative effect on forest area. Meanwhile, FDI (0.000 <0.05) significantly increases forest area in the long term. Then for the variable energy consumption of oil (0.000 <0.05) and gas consumption (0.017 <0.05) have a significant effect on deforestation in Indonesia in the long run, indicated by the negative coefficient value on forest area.

Figure 4.2 also indicates that the EKC hypothesis in the form of a U-shaped curve occurs in Indonesia in the long run, this is shown by the significantly negative value of the coefficient (GDP) 2, which indicates that the greater the economic growth, the reduced contribution of the economy to forest deforestation due to concentration more towards the environment as well as environmental-based program improvements established.

Figure 4.3 Short-Term Estimation Results

Next, the short-term estimation results are presented through the conclusions in Figure 4.3. At the 10% significance level, GDP (0.071 <0.10) has a negative effect on forest area in the short term. Whereas at the level of 5% of GDP in the previous year it positively affected forest area.

Then, at the level of 5% CPO exports (0.004 <0.05) and FDI (0.000 <0.05) have a positive effect on forest area in the short term. And for the variable energy consumption of oil (0.003<0.05) and gas consumption (0.015 <0.05) have a negative effect on forest area. This picture shows that ECT value is significantly has negative coefficient, which means that the ECM is valid. And if there is shocks is a particular period, it need 32.37% adjustment to reach back the equilibrium.

Conclusion

Based on research, at a significance level of 5% of GDP and trade openness has a significant negative effect on forest area. Meanwhile, FDI significantly increases forest area in the long term. Then for the variable energy consumption of oil and gas consumption have a significant effect on deforestation in Indonesia in the long run, indicated by the negative coefficient value on forest area. The EKC hypothesis in the form of a U-shaped curve occurs in Indonesia in the long run, this is shown by the significantly negative value of the coefficient (GDP) 2, which indicates that the greater the economic growth, the reduced contribution of the economy to forest deforestation due to concentration more towards the environment as well as environmental-based program improvements established.

The provision of an adequate and affordable energy source is imperative to support sustainable growth and development. Therefore,

The government needs to collaborate, among others, in securing adequate energy supply, developing renewable energy, increasing access to modern energy and energy efficiency. One way to achieve the energy mix target is by creating regulations and permits in order to increase investment in the energy sector.

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