Environmental Sustainability in Agricultural Economic Development in Indonesia

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Abstract

This study analyzes AEG factors in Indonesia by evaluating the effect of OILC, ELC, GASC, CO2 emissions, and AGExp using time series data. This research takes a period of 35 years, namely from 1985-2020 by modeling the "auto regressive distributed lag" (ARDL) time series to estimate long-term and short-term relationships. This study uses secondary data from world bank, unstats.un.org, and ourworldindata.org. This research contributes as a complement to the study of literature related to agriculture economics, energy, and environmental sustainability within the scope of green economics. Practically, the findings of this study will be very useful for policymakers in Indonesia regarding agriculture economics, energy, and environmental sustainability. We found that In the long term CO2, GDP, AGExp, HAH, OILC, and GASC have a significant effect on AEG in Indonesia. However, ELC and PLA have no significant effect on AEG in Indonesia in the long term. The results of the short-term effect GDP, HAH, OILC, and GASC have a significant effect on AEG in Indonesia. Based on the ARDL results, it can be concluded that modern agricultural activities in Indonesia if not carried out carefully in the long term can degrade the environment, although in the short term it is not yet significant from the use of chemical fertilizers and pesticides, air pollution from burning fuel oil for diesel engines, and so on.

Keywords : Agriculture Economics, Environmental Sustainability, Energy, Indonesia
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Introduction

The agricultural sector provides food security and provides job opportunities that absorb a large amount of labor. Indonesia, with a large population, certainly requires a large number of jobs. The agricultural sector is one sector that is able to absorb a lot of labor (Widarni & Drean, 2021). The agricultural industry in Indonesia is supported by state-owned enterprises that work in synergy with the people in the agricultural sector. State policies related to the agricultural sector have an impact on the growth of the agricultural sector and have an impact on national food security (Drean & Prabowo, 2021). Investments with large capital in the agricultural sector are increasingly massive in Indonesia with the establishment of various companies engaged in the agricultural sector both from within the country and foreign investment entering Indonesia which is engaged in the agricultural sector (Sasongko et al,2021). Modernization of the agricultural sector in Indonesia is influenced by the need for economic growth and economic motives in the agricultural sector which are closely related to technological developments. Technology in agriculture that is developing in Indonesia includes various aspects, both agricultural machinery and technology for producing superior seeds (Widarni et al,2020).

Agricultural modernization in Indonesia has an impact on the energy sector and energy consumption in the agricultural sector and agricultural exports (AGExp). Previous studies that have looked at energy and environmental sustainability indicated by CO2 gas and Agriculture economics Growth (AEG) such as research by Xiong, Yang, Huo, & Zhao, (2016) and Luo, Long, Wu, & Zhang, (2017). CO2 in AEG is still ambiguous and further research needs to be done to explain the effect of CO2 on AEG in Indonesia And previous studies that examined the causal relationship between economic growth, agricultural exports (AGExp), and Agriculture economics Growth such as Gilbert, Linyong, and Divine (2013), Ijirshar (2015), Verter and Bečvářová (2016). However, these studies are not sufficient to explain empirically how Indonesia's AGExp affects Indonesia's AEG, so further empirical research is needed. Another factor that tends to have an important relationship with AEG is carbon emissions (CO2) from agricultural production. This research contributes as a complement to the study of literature related to agriculture economics, energy, and environmental sustainability within the scope of green economics. This study analyzes AEG factors in Indonesia by evaluating the effect of OILC, ELC, GASC, CO2 emissions, and AGExp using time series data. short between variables. Practically, the findings of this study will be very useful for policymakers in Indonesia regarding agriculture economics, energy, and environmental sustainability.

Literature Review

Indonesia as a country that contributes oxygen to the world is threatened by the problem of agricultural practices that pollute the environment. Agricultural practices that are not environmentally friendly in Indonesia cause various problems (Istriningsih et al, 2021). Balamurugan et al (2020) Modern agriculture require a variety of supporting infrastructures such as irrigation and electricity. Manogaran et al (2021) explained that agricultural infrastructure has an impact on agricultural performance when infrastructure is bad, agricultural performance will deteriorate and vice versa. Many previous studies have investigated the performance of agriculture, energy, and economic growth such as research conducted by Tang & Tan (2015) which concluded that energy has an important role in the performance of the agricultural sector in promoting economic growth. However, previous studies have not studied the relationship between energy to the agricultural sector and economic growth in Indonesia. Gao et al. (2020) explain that electrical energy is very important in the modern agricultural sector. Chandio et al (2019) study in Pakistan found that ELC has a causal relationship with Pakistan AEG both in the long and short term. Asghar (2008) examines the relationship between energy and economic growth in five South Asian countries and finds that ELC and economic growth are significantly related. Previous studies indicated that ELC is a strong predictor of agricultural economic growth (AEG). However, it has not clearly explained the relationship between ELC and AEG, especially in Indonesia.

OILC and GASC are important indicators in agriculture because farmers need gas and oil for tractors and fireplaces. Energy consumption in modern agriculture cannot be avoided. In addition to energy, farmers also need fertilizers and pesticides which are generally in the form of pesticides and chemical fertilizers (Ghimire, et al., 2021). OILC and GASC are important indicators in understanding energy and economic development in the agricultural sector (Chandio et al., 2019). Previous studies have investigated the importance of the energy sector in economic growth, especially in the agricultural sector such as the research of Chandio et al. (2019), Qureshi et al.(2016). However, previous studies were less clear in explaining the role of energy consumption with ELC, OILC, and GASC indicators on AEG, especially in Indonesia. Therefore, the current study aims to investigate the role of ELC, OILC, and GASC on Indonesian AEG using ARDL modeling. The same thing was also found by Verter and Bečvářová (2016) in Nigeria. Research by Sertoglu, Ugural, and Bekun (2017) also found similar things in different countries. Han, Zhong, Guo, Xi, and Liu (2018) also found that agricultural activities that are less environmentally friendly can increase AEG and economic growth but degrade the environment.

Research Method

This research takes a period of 35 years, namely from 1985-2020 by modeling the "auto regressive distributed lag" (ARDL) time series to estimate long-term and short-term relationships. This study uses secondary data from world bank, unstats.un.org, and ourworldindata.org. This study uses the independent variables OILC, GASC, ELC, CO2 emissions, AGExp, and other control variables arable land (PLA), GDP, and land under cereal crop (HAH). To evaluate the long-term and short-term relationship of OILC, GASC, ELC, CO2 emissions, AGExp, PLA, GDP, and HAH with Indonesia's AEG, the following multivariate regression model was used:

$$AEG_t = \beta_0 + \beta_1 CO2_t + \beta_2 GDP_t + \beta_3 AGExp_t + \beta_4 PLA_t + \beta_5 HAH_t + \beta_6 OILC_t + \beta_7 ELC_t + \beta_8 GASC_t + e_t$$

In time series data, this equation converts into Log form as follow:

$$LnAEG_t = \beta_0 + \beta_1 LnCO2_t + \beta_2 LnGDP_t + \beta_3 LnAGExp_t + \beta_4 LnPLA_t + \beta_5 LnHAH_t + \beta_6 LnOILC_t + \beta_7 LnELC_t + \beta_8 LnGASC_t + e_t$$

Description :
$LnAEG$ indicates the natural logarithm of AEG,
LnCO2 indicates the natural logarithm of CO2, $LnGDP$ indicates the natural logarithm of GDP,
$LnAGExp$ indicates the natural logarithm of AGExp,
$LnPLA$ indicates the natural logarithm of PLA,
LnHAH indicates the natural logarithm of HAH,
$LnOILC$ indicates the natural logarithm of OILC,
$LnELC$ indicates the natural logarithm of ELC,
$LnGASC$ indicates the natural logarithm of GASC, and
et indicates the error term

Based on the Dickey-Fuller zero theory, the PP test is taken and the formula is $\rho=1$ in $\Delta yt = (\rho - 1)yt-1 + ut$, in which Δ – different operators for the first time. The following equation "unit root test" carried out in this study: $\Delta Y_1 = \alpha_0 + \beta_0 T + \beta_1 Y_{t-1} + \sum_{i-1}^{q} \alpha_1 \Delta Y_{t-1} + e_t$

Description :
Y indicates the variable being examined for unit root,

T indicates the "linear trend", $\Delta Yt{-}1$ indicates the "lag difference",
$\alpha 0$ is the "constant term", and
"t" indicates the "time trend".
The null and alternative hypotheses of "unit root test" can be represented in following way:
$H_0 : \alpha = 0$
$H_1 : \alpha \neq 0$

Result and Discussion

To evaluate the normality of the data AEG, OILC, GASC, ELC, CO2 emissions, AGExp, PLA, GDP, and HAH are presented in table 2. The standard deviation of each variable also reveals that there is not too much variation which proves that the data for each variable is adequate. To check the normality of the data, skewness is also considered, which ranges from -1 to +1 for normal data and each variable meets its normality. The normality of the time series data has also been confirmed by the kurtosis statistic, which ranges from 1-3 for normal data for each variable having a kurtosis statistic >1 and less than 3 which confirms that the data for each variable is normal. To assess the stationarity of the variables, the ADF and PP unit root tests are used which are presented in table 3. All variables are stationary at the first difference. In the F-test, FPE, SIC, LR, AIC, and HQ were used which are presented in Table 4. To find out whether there is a correlation between multiple time series, it is said to be cointegrated using the boundary test presented in table 5. To evaluate the existence of a long-term relationship, the Johansen and Juselius cointegration approach is presented in table 6. After meeting all conditions for ARDL modeling, long-term and short-term estimates were calculated along with significance and t-statistics to test the effect of each independent variable on the dependent variable with p-value <0.05 considered a significant effect. Table 7 shows the results of the ARDL estimation. The long-term estimation results show that CO2 emissions have a significant positive long-term effect on AEG of 12.8% with p <0.05 and t-statistics are higher than t-tabulations. GDP shows a significant positive long-term effect on AEG with an effect of 14.3%. The effect of AGExp on AEG is significant and positive by 11.7% in the long term. However, the long-term effect of PLA on AEG was not significant with p-value > 0.05.

HAH has a significant positive long-term effect of 13.8%. OILC has a long-term negative effect of 12.7%. The effect of ELC on AEG was not significant. However, GASC has a significant positive effect of 13.1%. So it can be concluded that CO2, GDP, AGExp, HAH, OILC, and GASC are the long-term drivers of AEG. The short-term estimation results show that CO2 emissions have no significant effect on AEG with a p value of > 0.05 and the t-statistic is smaller than the t-tabulation. So it can be concluded that environmental degradation is not related in the short term to AEG. GDP has a significant positive effect on AEG by 17.3%. However, AGExp has no significant effect on AEG in the short term. The short-term effect of PLA on AEG is also not significant. HAH has a significant positive effect of 18.7% on AEG in the short term. OILC also has a significant negative effect on AEG by 19.6% in the short term. The short-term effect of ELC on AEG was also not significant. However, GASC has a significant positive effect on AEG in the short term by 12.2%. Based on the ARDL estimation results, it can be concluded that GDP, HAH, OILC, and GASC are significant short-term predictors of AEG.

Conclusion

In the long term CO2, GDP, AGExp, HAH, OILC, and GASC have a significant effect on AEG in Indonesia. However, ELC and PLA have no significant effect on AEG in Indonesia in the long term. The results of the short-term effect GDP, HAH, OILC, and GASC have a significant effect on AEG in Indonesia. Based on the ARDL results, it can be concluded that modern agricultural activities in Indonesia if not carried out carefully in the long term can degrade the environment, although in the short term it is not yet significant from the use of chemical fertilizers and pesticides, air pollution from burning fuel oil for diesel engines, and so on. This is an important concern for all parties both in Indonesia and outside Indonesia in an effort to improve food security and environmental sustainability considering that Indonesia is one of the countries that contribute significantly to the world's oxygen so Indonesia's natural preservation needs to be maintained.

References

Asghar, Z. (2008). Energy-GDP relationship: a causal analysis for the five countries of South Asia. Applied Econometrics and International Development, 8(1), 167-180

Balamurugan, S., et al. (2020). Call for Special Issue Papers: Big Data Analytics for Agricultural Disaster Management. Big Data, 8(6), 544–545.

Chandio, A. A., Jiang, Y., & Rehman, A. (2019). Energy consumption and agricultural economic growth in Pakistan: is there a nexus?. International Journal of Energy Sector Management,13(3),597-609.

Drean,B.,Prabowo,B.H. (2021).Education, work participation and income in Agriculture Industri In Indonesia.Splash Magz,1(2),80-85. http://doi.org/10.54204/splashmagzvol1no1pp80to85

Gao, J., Wang, H., & Shen, H. (2020). Smartly Handling Renewable Energy Instability in Supporting A Cloud Datacenter. IEEE International Parallel and Distributed Processing Symposium (IPDPS). 769-778.http://doi.org/10.1109/IPDPS47924.2020.00084

Ghimire.A, Feiting Lin & Peifen Zhuang. (2021). The Impacts of Agricultural Trade on Economic Growth and Environmental Pollution: Evidence from Bangladesh Using ARDL in the Presence of Structural Breaks. Sustainability, 13(15), 1-15.

Gilbert, N. A., Linyong, S. G., & Divine, G. M. (2013). Impact of agricultural export on economic growth in Cameroon: Case of banana, coffee and cocoa, International Journal of Business and Management Review,1(1),44-71

Han, H., Zhong, Z., Guo, Y., Xi, F., & Liu, S. (2018). Coupling and decoupling effects of agricultural carbon emissions in China and their driving factors. Environmental Science and Pollution Research, 25 (25), 25280-25293

Ijirshar, V. U. (2015). The empirical analysis of agricultural exports and economic growth in Nigeria, Journal of Development and agricultural economics,7(3),113-122.

Istriningsih., Dewi,Y.A., Yulianti,A., Hanifah,V.W., Jamal,E., Dadang., Sarwani,M., Mardiharini,M., Anugrah,I.S., Darwis,V., Suib,E., Herteddy,D., Sutriadi,M.T., Kurnia,A., Harsanti,E.S.(2021).Farmers' knowledge and practice regarding good agricultural practices (GAP) on safe pesticide usage in Indonesia. Heliyon,8(1),1-10.https://doi.org/10.1016/j.heliyon.2021.e08708

Luo, Y., Long, X., Wu, C., & Zhang, J. (2017). Decoupling CO2 emissions from economic growth in agricultural sector across 30 Chinese provinces from 1997 to 2014, Journal of Cleaner Production,159(1),220-228.

Manogaran, G., Alazab, M., Muhammad, K., & Albuquerque, V. H. (2021). Smart Sensing based Functional Control for Reducing Uncertainties in Agricultural Farm Data Analysis. IEEE Sensors Journal, 21(16),17469-17478.http://doi.org/10.1109/JSEN.2021.3054561

Qureshi, M. I., Awan, U., Arshad, Z., Rasli, A. M., Zaman, K., & Khan, F. (2016). Dynamic linkages among energy consumption, air pollution, greenhouse gas emissions and agricultural production in Pakistan: sustainable agriculture key to policy success. Natural Hazards,84(1), 367- 381.

Sasongko,B., Widarni,E.L, Bawono,S.(2021).Transaction Cost for Salt Farmers in Pesanggrahan Village, Kwanyar District, Bangkalan Regency.Studies of Applied Economics.39(12),1-12.https://doi.org/10.25115/eea.v39i12.6007

Sertoglu, K., Ugural, S., & Bekun, F. V. (2017). The contribution of agricultural sector on economic growth of Nigeria. International Journal of Economics and Financial Issues, 7(1), 547-552

Tang, C. F., & Tan, B. W. (2015). The impact of energy consumption, income and foreign direct investment on carbon dioxide emissions in Vietnam. Energy, 79(3), 447-454.

Verter,N., Becvarova,V.(2016).The impact of agricultural exports on economic growth in Nigeria,Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,64(2),691-700

Widarni,E.L., Drean,B. (2021). Human Capital in Agribusiness and Agriculture: Human Capital Studies in Agribusiness and Agriculture in Asia, Europe, Australia, Africa and America. Malang : Janega Press

Widarni,E.L., Sasongko,B., Bawono,S., Murniati,M.(2020).SALT BUSINESS GROWTH IN INDONESIA CASE: 4 DISTRICTS IN INDONESIA.Journal of Indonesian Applied Economics,8(1),37-40.

Xiong, C., Yang, D., Huo, J., & Zhao, Y. (2016). The Relationship between Agricultural Carbon Emissions and Agricultural Economic Growth and Policy Recommendations of a Low-carbon Agriculture Economy, Polish Journal of Environmental Studies,25(5). 2187–2195.https://doi.org/10.15244/pjoes/63038

Attachment

Table 1. Variable Description

Variable	Measurement	Source
AEG	Agriculture value added into GDP measured as percentage of GDP	World Bank
CO2	Metric tons of CO2 equivalent per capita	World Bank
PLA	Percentage of land area	World Bank
HAH	harvested area in Hectares	World Bank
GDP	Gross Domestic Product in current USD	World Bank
AGExp	Agriculture Export	World Bank
ELC	Electricity Consumption measured is Gwh	unstats.un.org
OILC	Oil consumption in ton	ourworldindata.org
GASC	Gas Consumption	ourworldindata.org

Table 2. Descriptive Statistics

	AEG	CO2	PLA	HAH	GDP	AGExp	ELC	OILC	GASC
Mean	25.6	14.4	2.4	17.3	28.2	0.02	7.2	7.1	4.3
Median	25.5	14.2	2.3	17.1	28.1	0.02	7.1	7.0	4.2
Maximum	26.2	15.1	2.5	18.2	29.3	0.04	7.5	7.8	4.6
Minimum	24.3	13.2	2.1	16.5	27.3	0.01	6.9	6.8	3.9
Std. Dev	0.3	0.4	0.3	0.5	0.7	0.01	0.9	0.8	0.7
Skewness	0.01	0.02	0.01	0.03	0.02	0.04	0.01	0.03	0.02
Kurtosis	1.3	1.4	1.6	1.2	1.5	1.4	1.3	1.3	1.5
Jarque-Bera	2.01	2.34	2.39	2.15	3.01	2.14	2.27	2.32	2.51

Table 3. Unit Root Test

	ADF Unit Root Test		PP Unit Root Test	
Variable	At Level	First Difference	At Level	First Difference
AEG	-0.4312	-3.1241	-0.2112	-3.0111
CO2	-0.4518	-2.7598	-0.3621	-2.5123
PLA	-0.6278	-3.1221	-0.4168	-3.0111
HAH	-1.1892	-2.2213	-1.0212	-2.0603
GDP	-1.2173	-3.5167	-1.0103	-3.2236
AGExp	-0.3132	-4.1125	-0.2042	-3.9315
ELC	-1.2145	-2.6651	-0.8935	-2.2342
OILC	-0.6732	-3.1441	-0.3522	-2.9331
GASC	-1.1162	-4.0129	-0.8122	-3.7018

Table 4. Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SIC	HQ
0	471.228	112.512	2.17e-24	27.2231	27.1152	27.8945

1	839.727	501.223	9.77e-24	43.1123	42.8867	43.1165
2	956.112	98.772	3.12e-24	44.5152	43.0129	44.6745

Table 5. Bond Test

Statistic	95%LB	95%UB	90%LB	90%UB	Conclucion
F = 14.0123	2.02	3.11	1.97	2.72	Cointegration
W = 22.1121	8.11	11.02	6.97	9.32	Cointegration

Table 6. Johansen cointegration test

Hypothesized	Trace Statistic			Maximum Eigenvalue Statistic		
No. of CE(s)	Test Statistic	5% CV	Prob	Test Statistic	5% CV	Prob
None *	371.2341	189.2213	0.0000	151.1232	123.1121	0.0000
At most 1 *	256.1176	139.1121	0.0000	126.2143	110.2412	0.0002
At most 2 *	191.3321	102.2216	0.0000	112.2141	101.3305	0.0007
At most 3 *	130.2845	89.5541	0.0000	89.1413	70.4452	0.0012
At most 4 *	53.7781	42.0031	0.0021	42.6670	32.8712	0.0019
At most 5 *	30.6651	25.3319	0.0312	20.5342	18.2207	0.0201
At most 6	16.7812	20.9956	0.0567	8.6703	13.4413	0.0452
At most 7	6.3381	15.2291	0.0788	4.1125	8.1173	0.0673
At most 8	0.0216	3.2167	0.1214	0.0181	2.1253	0.0808

Table 7. ARDL Estimation

Regressor	Dependent Variable AEG			
Long Run Estimation	Coef.	SE	t-Ratio	Prob
CO2	0.1281	0.0657	2.2675	0.0002
PLA	0.1121	0.0512	2.5374	0.1817
HAH	0.1382	0.0727	2.1187	0.0006
GDP	0.1432	0.0827	1.7786	0.0008
AGExp	0.1171	0.0923	1.8965	0.0012
ELC	-0.1341	-0.0903	-2.1134	0.0782
OILC	-0.1273	-0.0879	-2.6743	0.0021
GASC	0.1312	0.0778	1.7854	0.0018
Short Run Estimation	Coef.	SE	t-Ratio	Prob
CO2	0.1372	0.0547	2.1565	0.0891
PLA	0.1712	0.0407	2.4514	0.1726
HAH	0.1871	0.0616	2.2267	0.0008
GDP	0.1733	0.0714	1.6651	0.0007
AGExp	0.1264	0.0892	1.7853	0.0922
ELC	-0.1252	-0.0889	-2.1221	0.0661
OILC	-0.1961	-0.0901	-2.5217	0.0021
GASC	0.1224	0.0867	1.6732	0.0027