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TÁC ĐỘNG CỦA NGÀNH NÔNG NGHIỆP: VIỆC LÀM, XUẤT KHẨU NGUYÊN LIỆU THÔ VÀ GIÁ TRỊ GIA TĂNG LÊN SỰ BỀN VỮNG MÔI TRƯỜNG Ở CHÂU Á GIAI ĐOẠN 1990 - 2022

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Tóm tắt

Chủ đề phát triển bền vững và môi trường từ lâu đã được nhiều tác giả quan tâm và nghiên cứu. Tuy nhiên, nghiên cứu cho trường hợp tác động của những hoạt động nông nghiệp lên môi trường ở các quốc gia Châu Á vẫn còn rải rác. Nghiên cứu của chúng tôi bổ sung vào khoảng trống nghiên cứu trước thông qua đo lường tác động tổng hợp của những hoạt động nông nghiệp bao gồm lao động, xuất khẩu nguyên liệu thô và giá trị gia tăng trong lĩnh vực nông nghiệp lên lượng khí thải CO2, N2O, CH4 và các khí thải nhà kính. Mối liên hệ này được kiểm soát bằng cách cân nhắc thêm ảnh hưởng của thị trường, tài nguyên thiên nhiên và yếu tố dân số từ đó khắc họa bức tranh tổng thể về sự bền vững môi trường. Nghiên cứu sử dụng phương pháp GLS để kiểm định dữ liệu bảng từ The World Development Indicators, đồng thời đánh giá mức độ ảnh hưởng của các biến độc lập lên sự bền vững môi trường ở các nước Châu Á, được phân loại theo mức thu nhập, từ 1990 đến 2022. Kết quả nghiên cứu cho thấy có sự khác biệt trong ảnh hưởng của một số nhân tố như giá trị gia tăng hoặc đất nông nghiệp giữa nước có thu nhập cao và thu nhập thấp. Tuy nhiên, đối với toàn bộ các nước, lao động và xuất khẩu nông nghiệp có tác động tích cực tới lượng khí nhà kính thải ra. Từ đó, bài viết đề xuất một số khuyến nghị liên quan tới việc điều chỉnh xuất khẩu, tỉ lệ lao động trong ngành nông nghiệp và sử dụng tài nguyên thiên nhiên hợp lý để thúc đẩy phát triển môi trường bền vững.

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Từ khóa: bền vững môi trường, lao động nông nghiệp, xuất khẩu nguyên liệu nông nghiệp thô, giá trị gia tăng trong nông nghiệp.

AGRICULTURE AND POLLUTION IN ASIA: EXAMINING THE IMPACTS OF AGRICULTURAL EMPLOYMENT, RAW MATERIALS EXPORT AND VALUE-ADDED ON ENVIRONMENT SUSTAINABILITY

Abstract

The topic of sustainable development and the environment has long captured the interest of many authors. However, research on the impact of agricultural activities on the environment in Asian countries remains insufficient. The study fills the gap in previous literature by investigating the synthesized impacts of agricultural activities including employment, raw materials exports and value-added on CO2, N2O, CH4, and greenhouse gas emissions. This connection is further moderated by considering the impacts of the market, natural resources, and population, thus providing a complete picture of environmental sustainability. In this study, the Generalized Least Squares (GLS) Method is employed to examine panel data collected from the World Development Indicators and evaluate the level of effects that independent variables had on the environmental sustainability of Asian countries, categorized by income levels, between 1990 and 2022. Results show that there are differences in the impacts of agricultural employment, exports, and value-added on high and low-income countries. However, for all countries in the dataset, agricultural employment and agricultural exports have positive impacts on the emissions of greenhouse gases. From these findings, the study provides some recommendations regarding the adjustment of agricultural exports, labor structure as well as the use of natural resources to promote environmental sustainability.

Keywords: agricultural employment, agricultural raw materials exports, value-added, environmental sustainability

1. Introduction

Sustainable development is the goal of various countries in the world that strive to attain economic growth and meet present demands without depleting resources for coming generations. An important aspect of fostering sustainable growth is to promote environmental sustainability. However, a primary obstacle to achieving this goal is environmental pollution because it perpetuates several ecological issues (Usman et al. 2022) such as water scarcity, global warming, and climate change. Therefore, the topic of environmental sustainability attracts much attention from both governments and scholars. A great amount of the current literature focuses on discovering what significantly drives environmental degradation to suggest proper solutions and has identified multiple factors. For example, in BRICs, developed and developing countries, environmental degradation mainly results from total natural resources rent and economic growth (Muhammad et al. 2021). In this regard, multiple studies investigated the negative impacts of agricultural activities on the environment. Those findings suggested that outdated agricultural practices generated a substantial amount of greenhouse gas emissions (Frank et al., 2017; Zurek et al., 2020; Pata, 2021). Agriculture requires the use of water, genetic materials, and land, likely causing environmental degradation. Likewise, the IPCC disclosed that from 2007 to 2016, the use of land and agriculture was responsible for almost 23% of GHG emissions. There is a need to consider crucial factors that should extend beyond direct inputs like land, water, and soil (Saidmamatov et al., 2023, Raihan et al., 2022), especially employment and export, which significantly influence the environmental sustainability of agriculture.

Furthermore, it is important to study the connection between agricultural factors and the environmental quality of Asia because this region has many economies that are the major exporters in the world (Rehman et al., 2021) such as China, Japan, South Korea or Hong Kong (Akram, 2024). Teng and McConville (2016) agreed that agriculture is a driving force behind inclusive, social growth in Asia; a significant source of export revenue; a guarantee of food supply for Asian people; and a direct and indirect source of employment through value-adding, agriculture-related enterprises. However, Asia is also the most critical part of climate change, as it is one of the most heavily polluted regions in the world (Asian Development Bank, 2017). Over the last decade, this region has been the largest emitter of GHG in the world (Le et al., 2020) Many of the major emitters of agricultural greenhouse gas (GHG), such as India, the People's Republic of China (PRC), Indonesia, and Japan lie in the Asian region (Panda & Yamano, 2023). Therefore, analyzing the impacts of agricultural factors such as exports, value-adding activities or employment on the environment in Asia may lead to new insights and solutions to promote sustainable development in Asian countries.

Despite the awareness of agriculture's damaging influence, there has not been a concrete result on how factors in the agriculture sector can impact on environment and sustainability. Previous studies have found vastly different results on the link between economic sectors and short-run pollution instead of environmental sustainability in general. *Furthermore*, the majority of studies did not analyze sufficiently the difference between countries with different stages of development, relating to agriculture. Differences in terms of resource availability, technological foundation, and efficiency of government bodies can affect the validity of the ultimate result and its applicability in policy-making for the agricultural sector. *Thirdly*, there has been limited research addressing the systematic synthesis of the impact levels of agricultural activities, such as the export of agricultural raw materials and value-added employment, on the environment. While previous studies acknowledge causes such as trade liberalization, foreign investment, and fossil fuel usage (Ridzuan et al.2020, Eyuboglu et al., 2020), there is a gap in linking these factors to employment, production, and international trade in the context of agriculture.

This study contributes to the literature a comprehensive understanding of agriculture's environmental impact. It examines the combined influence of agricultural activities on long-term environment quality, including raw material exports, value-added production, and employment, on environmental quality indicators including CO2, N2O, CH4 and greenhouse gas emissions. *Furthermore*, it employs a panel data approach that incorporates income levels (low, lower-middle, upper-middle, and high) in Asian countries spanning 1990-2022. *Thirdly*, the study incorporates an EKC analysis to understand the intricate relationship between income and environmental pollution within the agricultural sector for each income group. *Fourth*, by analyzing the combined effects of agricultural activities, accounting for development stages, this regional focus significantly provides policymakers with crucial information for promoting sustainable agriculture in Asia. The authors propose effective strategies that promote sustainable agricultural practices across varying development stages, ultimately fostering a more sustainable future.

2. Literature Review and Theoretical Framework

2.1. The impact of agriculture on the environment

2.1.1. The relationship between agricultural employment and environment

Sandrey et al. (2011) applied two different computer models and found that the liberalization relationship and agricultural employment have positive effects in South Africa. Related to both the economy and environment, Erdiaw-Kwasie et al. (2024) claimed that the production and consumption of municipal waste negatively affects agricultural employment.

In terms of the environmental impact, Jiang et al. (2022) examined the effect of agricultural employment on the ecological footprint as the proxy of the environment with data from 96 countries. They concluded that agricultural employment is a factor that positively affects the overall quality of the environment in the long run but negatively in the short run. However, Jiaduo et al. (2023) conducted a study for BRICS Nations and had a different result. Particularly, employment in the agricultural sector is shown to have a positive impact on load capacity factor both in short run and long run.

2.1.2. The relationship between agricultural raw materials export and environment

Some studies suggest that agricultural raw material exports harm environmental quality, while more authors agree that such exports lead to a reduction in CO2 emissions, influenced by factors such as export diversification and quality.

On the one hand, Ul Haq et al. (2021) concluded that agricultural exports have a negative impact on ecological footprints in Pakistan. The negative association between agricultural exports and ecological footprints in both the long and short run aligns with the findings of a study by Balogh and Jámbor (2020), which revealed that the effect of agricultural exports on environmental degradation is negative. However, Ghimire et al. (2021)'s findings that agricultural trade openness has a positive impact on environmental pollution. Looking at the different impacts depending on levels of national income, the study of Saghaian et al. (2022) highlighted the environmental consequences of export-oriented policies in many developing nations where agricultural exports play a crucial role.

2.1.3. The relationship between agricultural value-added and environment

The existing literature highlights the significance of agriculture value-added in influencing environmental degradation (Usman et al., 2022; Raihan & Tuspekova, 2022). Some previous studies reached the consensus that AVA plays a role in mitigating environmental degradation in the scale of G7 nations and Turkey. Results of Baş et al. (2021) indicated that AVA and export value-added contribute positively to environmental sustainability. Similarly, this resembled findings from Wang et al. (2020)'s that the influence of AVA on CO2 emission reduction becomes gradually evident over time through the application of technology and management. However, Raihan & Tuspekova, (2022)'s estimates indicate that agricultural value-added contributes to environmental degradation by elevating CO2 emissions in Brazil. The contribution can be attributed to the extensive use of fossil fuels for irrigation, fertilizers, and pesticides to enhance agricultural productivity. Qiao et al. (2019) also indicated even though agriculture does not directly affect CO_2 emissions in developed G20 economies, which can indirectly influence emissions through its impact on GDP in the short term.

2.2. Theoretical Framework

2.2.1. Empirical setting on Environmental Kuznets Curve (EKC) hypothesis

Analyzing the environmental impact of trade is a highly intricate task that demands careful examination. Previous research from Liobikienė and Butkus (2019), Agboola and Bekun (2019) and Sharma et al. (2021), who are among those who break down the environmental effects of the global supply chain into three distinct categories based on their attributes: scale, composition, and technique.

The EKC hypothesis posits a negative relationship between per capita income and environmental degradation. This theory, proposed by Grossman and Krueger (1991), suggests that as economies develop, they initially prioritize economic growth over environmental quality, leading to increased degradation. Developed economies, having passed through these stages, reach the post-industrialization stage, where environmental quality is prioritized. Figure 1 illustrates the conceptualization of the EKC hypothesis.

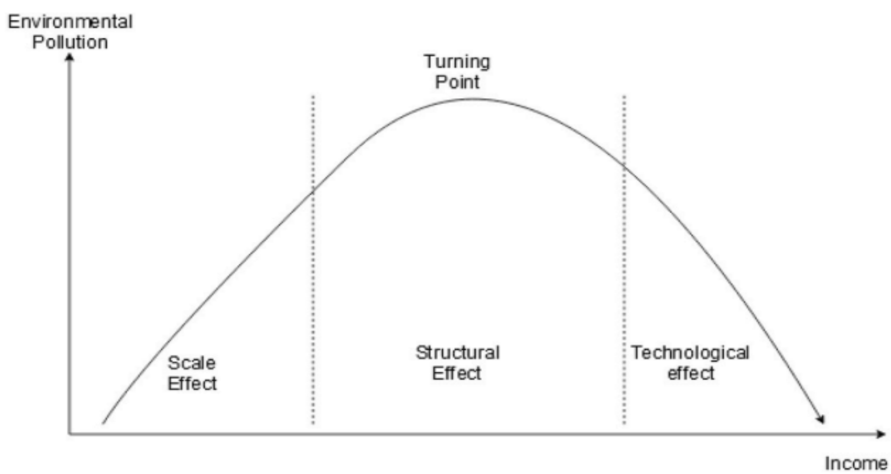

Figure 1: Environmental Kuznets curve conceptualization.

Source: Sharma et al (2021)

(1) The scale effect is prominent in developing economies, resembling a pre-industrialization stage, where the focus is on economic growth at the expense of environmental quality. This stage is marked by low environmental awareness, and economic activities, mainly in the primary sector such as mining and agriculture, contribute to pollution and environmental depletion. The scale effect commonly refers to the change in the scale of the economies, which can be demonstrated through the varying values of FDI, the scope of urbanization, or national GDP (Ali et al., 2015). As more resources and investments are poured into production procedures and commercial activities, the environment will suffer from increasing burdens.

(2) In industrialized economies, the composite stage marks both economic growth and heightened environmental awareness. This phase prompts a shift toward cleaner, sustainable technologies, including renewables. As economies advance and environmental consciousness grows, this transition becomes

more pronounced, especially in developing nations after a certain development threshold is crossed (Shahbaz et al., 2017). Progress often necessitates sector restructuring to prioritize more beneficial goods and services. Countries aim to maximize trade benefits by producing what aligns with their comparative advantages, as per the factor endowment theory (Khan et al., 2022).

(3) Finally, in the technique stage, observed in emerging economies, a decline in degradation occurs as cleaner technologies like renewable energy are adopted. The technique effect is defined by the production techniques, most commonly illustrated by the levels of technological innovation. This includes sustainable energy usage and technical upgrades. Economic growth drives increased investment in R&D for low-carbon technologies and the upgrade of outdated facilities. Industries, as they develop, can transition from fossil fuels to renewable energy sources in production, enhancing efficiency. Overall, this effect brings about positive changes in manufacturing facilities and lessens emissions while increasing efficiency at the same time (Liobikienė & Butkus, 2019).

2.2.2. Hypothesis development

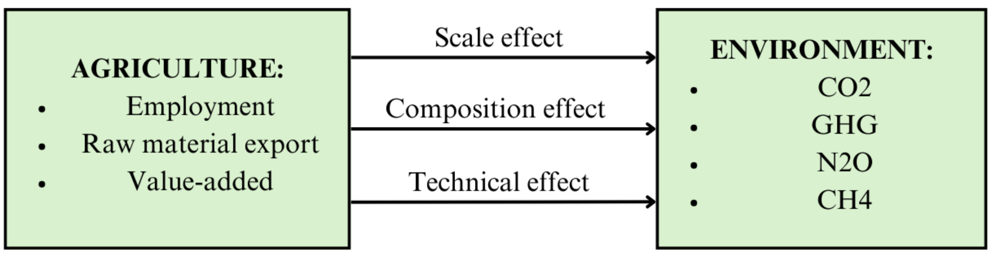

Figure 2: Theoretical framework

Source: Synthesized by the authors (2024)

The study examines the impact of the agricultural sector on the environment by grouping countries by income and applying the EKC hypothesis and three effects: scale, composition and technique. This approach has previously been taken by Saghaian et al. (2022) where the authors consider the magnitude of these separate effects of trade and economic measures. Agboola and Bekun (2019) also studied the contribution of agricultural value added to CO_2 emissions to classify the current stages (pre-industrial, industrial and post-industrial) of researched economies and give recommendations for their agricultural sector and trade. Based on the theories and frameworks reviewed, the authors propose the following hypotheses:

H1: Agricultural employment has a (positive) impact on the environment.

Hypotheses 1a (H1a). Agricultural employment will increase CO_2 emissions.

Hypotheses 1b (H1b). Agricultural employment will increase N_2O emissions.

Hypotheses 1c (H1c). Agricultural employment will increase CH_4 emissions.

Hypotheses 1d (H1d). Agricultural employment will increase greenhouse gas.

A research article by Umehruo et al. (2022) showed an opposing trend. Particularly, the authors used the HSDI and HDI indexes to measure the environmental impact of several economic variables including workforce in both agriculture and industry. They found that agricultural employment has negative effects on both HDI and HSDI as well as the environment

H2: Agricultural raw material export has a (positive) impact on the environment

Hypotheses 2a (H2a). Agricultural raw materials exports will increase CO2 emissions Hypotheses 2b (H2b). Agricultural raw materials exports will increase N2O emissions.

Hypotheses 2c (H2c). Agricultural raw materials exports will increase CH4 emissions.

Hypotheses 2d (H2d). Agricultural raw materials exports will increase greenhouse gas.

Taking into account globalization concerns, Saghaian et al. (2022) demonstrated that increasing total agricultural exports leads to higher greenhouse gas emissions in developing countries but lowers N2O emissions in developed countries. Furthermore, trade openness raises N2O emissions in developed countries while reducing CH4 emissions in developing countries. Mohammadi et al. (2016)'s findings indicate that a surge in the export of agricultural raw materials has intensified environmental pollution in developed countries, specifically through heightened methane gas emissions. Conversely, developing countries experience more pronounced pollution characterized by significant emissions of methane and nitrous oxide.

H3: Agriculture, forestry, and fishing value-added (AVA) has a (positive) impact on the environment

Hypotheses 3a (H3a). AVA will increase CO2 emissions.

Hypotheses 3b (H3b). AVA will increase N2O emissions

Hypotheses 3c (H3c). AVA will increase CH4 emissions.

Hypotheses 3d (H3d). AVA will increase greenhouse gas.

By examining the relationship among CO2 emissions, agriculture value-added in G7 countries from 1996 to 2017, the results of Wang et al. (2020) underscored the potential for AVA to gradually decrease CO2 emissions over time, especially through the adoption of advanced technology and management practices that enhance carbon sequestration. Increased AVA in G7 countries is associated with a more efficient energy system, leading to a reduction in CO2 emissions due to the sector's lower reliance on fossil fuel energy. Agboola and Bekun (2019) also incorporates AVA as a representative measure for agriculture in the traditional EKC. The coefficient for AVA shows a positive and inelastic effect on environmental quality. Usman et al. (2022) also indicated a statistically positive impact of AVA on long-term environmental degradation in South Asian economies.

3. Data and Research Methodology

Firstly, the research employed descriptive statistics analysis to investigate and examine the correlations between the variables. Next, we used the Generalized Least Squares (GLS) method to reduce the risk of making erroneous inferences as opposed to other least squares and weighted least squares methods. This will help to improve the efficiency of the study's statistics and determine the impact of agricultural raw materials exports, value added and employment on environmental sustainability in the

Asian countries between 1990 and 2022. Based on the research objectives, the study employs four models (1) to (4), presented in the following form:

$$lnco2_{it} = \beta_1 + \beta_2 lnagrem_{2it} + \beta_3 agre2_{3it} + \beta_4 lnagrava_{4it} + \beta_5 emin2_{5it} + \beta_6 agrilan2_{6it} + \beta_7 urb_{7it} + \beta_8 lneneuse_{8it} + \beta_9 rene2_{9it} + \beta_{10} natre2_{10it} + \beta_{11} popden_{11it} + \beta_{12} ope_{12it} + \beta_{13} lnfdi_{13it} + \beta_{14} inco1_{14it} + \beta_{15} inco2_{15it} + \beta_{16} inco3_{16it} + \beta_{17} inco4_{17it} + u_{it} + \varepsilon_i \quad (1)$$

In this model, $ln\, ln\, co2_{it}$ is the logarithm of the dependent variable CO2 emissions – model (1), $ln\, ln\, n2o_{it}$ – model (2), $ln\, ln\, ch4_{it}$ – model (3), $ln\, ln\, ghg_{it}$ – model (4) for country i in year t. The independent variables represent agricultural raw materials exports, employment and value added and control variables, the coefficient β_1 represent country-fixde effects, the slopes β_2, β_3,… with the random error term u_{it} and the residuals ε_i.

This study used yearly numerical information for 50 Asian countries from 1990 to 2022. The primary data source is the World Development Indicators, focusing on investigating the impact of agricultural raw materials export, employment and agricultural value added on environmental sustainability.

The summary of research variables is presented in Table 1.

Table 1: Variables description

Symbol	Description	Unit	Expected sign	Inherited from
		Dependent variables		
lnco2	CO2 emissions	kt		Bulus and Koc (2021)
lnn2o	Nitrous oxide emissions in the energy sector	thousand metric tons of co2 equivalent		Onwachukwu et al. (2021)
lnch4	Methane emissions in the energy sector	thousand metric tons of CO2 equivalent		Ali et al. (2020)
lnghg	Total greenhouse gas emissions	kt of CO2 equivalent		Nemati et al. (2018)
		Independent variables		
agre2	Agricultural raw materials exports	% of merchandise exports	-/+	Haider et al. (2021), Zambrano-

Symbol	Description	Unit	Expected sign	Inherited from
				Monserrate and Fernandez (2017), Saghaian et al. (2022)
lnagrem	Employment in agriculture	% of total employment (modeled ILO estimate)	-	Jiang et al. (2022)
lnagrava	Agriculture, forestry, and fishing, value added	current US$	+/-	Wang et al. (2020), Raihan & Tuspekova (2022)
Control variables				
emin2	Employment in industry	% of total employment (modeled ILO estimate)	+	Nassen and Larsson (2015)
agrilan2	Agricultural land	% of land area	+	Huang et al. (2023)
urb	Urban population	% of total population	+	Sofuoglu, Alver and Bozali (2023)
lneneuse	Energy use	kg of oil equivalent per capita	+/-	Sun et al. (2019)
rene2	Renewable energy consumption	% of total final energy consumption	+	Jiaduo et al. (2023)
natre2	Total natural resources rents	% of GDP	+	Batmunkh et al. (2022)

Symbol	Description	Unit	Expected sign	Inherited from
popden	Population density	people per sq. km of land area	+/-	Jiang et al. (2022), Umehruo et al. (2022)
ope	Trade openness (sum of export and import to GDP)	% of GDP	+/-	Gao et al. (2021), Daniel et al. (2019)
lnfdi	Foreign direct investment, net inflows	% of GDP	-	Hao et al. (2020)

inco	A dummy variable, whereas:
	i=1 for low-income countries;
	i=2 for lower-income countries;
	i=3 for upper-income countries;
	i=4 for high-income countries
			+	Yao et al. (2019)

Source: Synthesized by the authors (2024)

4. Results and Discussion

Statistics variables

Before performing regression, the authors performed descriptive statistics on the variables in the mentioned model.

Those variables such as *carbon dioxide (co2)*, *methane (ch4)*, *nitrous oxide (n2o)*, *greenhouse gasses (ghg)*, *agricultural employment in agricultural (agrem)*, *agriculture forestry and fishing value-added (agrava)*, *energy use (eneuse)* have large standard deviations which cause the unbalance in research's data set. Thus, the authors took the logarithm of those variables in order to reach the normal distribution between variables which help to create the stability, consistency and reliability of the dataset.

Table 2: Descriptive statistics of dependent and independent variables

Variable	Obs	Mean	Std. Dev.	Min	Max
lnco2	1.617	5,800165	1,946522	0	7,298445
lnn2o	1.579	5,690293	1,937194	0	7,23201
lnch4	1.579	5,843493	1,771609	0	7,273093

Variable	Obs	Mean	Std. Dev.	Min	Max
lnghg	1.579	5,949333	1,75026	0	7,30586
lnagrem	1.611	6,108396	1,552765	0	7,345365
agre2	1.526	0,048119	0,03951	0,0001	0,1209
lnagrava	1.600	5,702582	2,050436	0	7,280697
emin2	1.610	0,072823	0,045115	0,0001	0,1518
agrilan2	1.594	0,056823	0,037056	0,0001	0,1226
urb	1.650	0,568176	0,25531	0,08854	1
lneneuse	1.464	4,554722	2,700579	0	6,990256
rene2	1.611	0,040359	0,033228	0,0001	0,1061
natre2	1.627	0,070529	0,046323	0,0001	0,1514
lnpopden	1.626	6,185867	1,405328	0	7,34601
Ope	1.538	4,69E-10	1,25E-09	-4,16E-09	1,21E-08
lnfdi	1.630	6,210702	1,04498	0	7,309882
inco1	1.625	0,238154	0,426085	0	1
inco2	1.625	0,336615	0,472698	0	1
inco3	1.625	0,172308	0,377764	0	1
inco4	1.625	0,252923	0,434821	0	1

Source: The authors (2024)

In table 2, standard deviation of 4 dependent variables *carbon dioxide (co2), methane (ch4), nitrous oxide (n2o), greenhouse gasses (ghg),* approximately equals 2 while the difference between minimum and maximum value is nearly 8. In terms of independent and controlled variables, *agricultural raw materials export (agre2)* has the smallest difference, 0,12, which means the value of *agre2* is not dispersed widely among countries in Asia. *Agricultural employment in agricultural (lnagrem), agriculture forestry and fishing value-added (lnagrava), and energy use (lneneuse)* hold the same difference and mean which are approximately 7 and 2 respectively. In three independent variables *lnagrava, agre2, lnagrem, agre2* has the smallest mean (0,0481186). Among variables, *lneneuse* has the biggest standard deviations while *agre2* has smallest one. lnco2 has the biggest difference 7,298 which is contrasted with *agricultural raw materials export (agre2),* 0,1209 which means there exists a significant gap between developing and developed countries.

Correlation test:

To ensure the result of the regression model is significant and precise, one condition is that the correlation coefficients among independent variables are low. Thus, before running models, the authors tested the correlation among variables and the result shows that there is no strong correlation between them.

Model testing and Discussions:

First, Variance Inflation Factor (VIF) indicates that all mean VIF are smaller than 5 so the multicollinearity does not exist. Second, the Modified Wald test has Prob>chi2=0.0000, thus models have heteroskedasticity. Third, the Wooldridge test has Prob.F=0.000, smaller than a 5%, thus, the models have autocorrelation. As a result, after testing 3 models OLS, FEM, REM and using the Hausman test, this research applied Generalized Least Squares (GLS) to fix the above defects.

Table 3: Regression results of dependent variables lnco2 and lnn2o

	LI	**LMI**	**UMI**	**HI**	**LI**	**LMI**	**UMI**	**HI**
Variables	**lnco2**	**lnco2**	**lnco2**	**lnco2**	**lnn2o**	**lnn2o**	**lnn2o**	**lnn2o**
lnagrem	0.452***	0.452***	0.0522	0.498***	0.581***	0.581***	0.250***	0.842***
	(0.0823)	(0.0823)	(0.0729)	(0.0891)	(0.0799)	(0.0799)	(0.0877)	(0.0946)
agre2	-1.643	-1.643	-6.211**	1.097	-5.378***	-5.378***	-13.73***	10.05
	(2.032)	(2.032)	(3.017)	(5.917)	(1.972)	(1.972)	(3.629)	(6.276)
lnagrava	-0.113**	-0.113**	-0.0348	0.163***	-0.0822*	-0.0822*	-0.0854	0.134***
	(0.0444)	(0.0444)	(0.0664)	(0.0478)	(0.0431)	(0.0431)	(0.0799)	(0.0507)
emin2	0.873	0.873	6.817***	8.359**	2.195	2.195	5.948**	2.794
	(1.823)	(1.823)	(2.394)	(3.327)	(1.769)	(1.769)	(2.880)	(3.529)
agrilan2	3.382	3.382	0.947	-33.21***	-0.441	-0.441	-7.919***	-30.98***
	(2.278)	(2.278)	(2.474)	(3.473)	(2.212)	(2.212)	(2.976)	(3.684)
urb	1.756***	1.756***	-1.263	4.002***	0.880**	0.880**	-2.583***	7.224***
	(0.441)	(0.441)	(0.770)	(0.758)	(0.428)	(0.428)	(0.926)	(0.804)
lneneuse	0.129***	0.129***	0.151***	0.0752**	0.0940***	0.0940***	0.0694	0.132***
	(0.0259)	(0.0259)	(0.0358)	(0.0375)	(0.0252)	(0.0252)	(0.0431)	(0.0397)
rene2	2.761	2.761	17.18***	13.24***	13.08***	13.08***	23.93***	-2.429
	(3.304)	(3.304)	(3.942)	(3.791)	(3.207)	(3.207)	(4.742)	(4.021)
natre2	3.665**	3.665**	2.064	31.63***	3.619**	3.619**	9.505***	24.51***
	(1.678)	(1.678)	(2.455)	(3.347)	(1.629)	(1.629)	(2.954)	(3.550)
lnpopden	0.148**	0.148**	0.538***	0.0335	0.0607	0.0607	0.293***	-0.288***
	(0.0632)	(0.0632)	(0.0679)	(0.0727)	(0.0614)	(0.0614)	(0.0817)	(0.0771)

	LI	LMI	UMI	HI	LI	LMI	UMI	HI
Ope	1.381e+08**	1.381e+08**	8.120e+07	1.293e+08*	1.704e+08***	1.704e+08***	-2.966e+08	1.466e+08*
	(6.432e+07)	(6.432e+07)	(1.523e+08)	(7.196e+07)	(6.244e+07)	(6.244e+07)	(1.832e+08)	(7.633e+07)
lnfdi	-0.113	-0.113	-0.0503	-0.187**	-0.121	-0.121	0.0548	-0.239***
	(0.0798)	(0.0798)	(0.0981)	(0.0861)	(0.0774)	(0.0774)	(0.118)	(0.0914)
Constant	1.507**	1.507**	2.414**	-1.850*	1.700**	1.700**	3.143**	-4.034***
	(0.713)	(0.713)	(1.043)	(0.970)	(0.693)	(0.693)	(1.254)	(1.029)
Observations	409	409	223	342	409	409	223	342
Number of countries	31	31	22	14	31	31	22	14

Standard errors in parentheses

**** p<0.01, ** p<0.05, * p<0.1*

Source: The authors (2024)

For Employment in agriculture *(lnagrem)*, there is a positive relationship between agricultural employment and carbon dioxide emissions at the significance level of 1%, except UMI group, suggesting that the increasing employment in agriculture contributes to environmental pollution. This result is close to the finding of Jiang et al. (2022) specifically, the authors found that a 1% rise in agricultural employment results in a 0.0004% and 0.005% increase in ecological footprint. This is similar to the finding of Umehruo et al. (2022). The research found that agricultural employment negatively influenced environmental sustainability with the data from 15 ECOWAS countries from 2010 to 2019. For N2O, it has a positive relationship with N2O emissions at the significance level of 1% for the four groups. Particularly, a 1% increase in agricultural employment leads to 0.581%, 0.581%, 0.250%, and 0.842% increase in N2O emissions in LIC, LMC, UMC, and HIC, respectively. This is consistent with the finding of Umehruo et al. (2022) about the nexus between agricultural employment and the environment.

The GLS analysis suggested that there is a negative impact of agricultural raw materials exports (*agre2)* on CO2 emissions at a 5% significance level in UI countries. Specifically, a 1% increase in agricultural raw materials exports leads to approximately a 6% decrease in the amount of CO2 emissions. This finding is in contrast with the results of Can et al. (2020) who showed that overall export diversification, extensive margin and intensive margin positively influence CO2 emissions. The same negative impact is seen in N2O emissions of approximately 5% in low- and lower-income countries and about 13% in upper income ones. This result is consistent with the results from previous studies (Haider et al., 2021; Zambrano et al., 2017), which concluded that the effect of agricultural exports on nitrous dioxide is negatively related to N2O emissions in both the long and short run.

In terms of Agriculture, forestry, and fishing value-added *(lnagrava)*, there is a statistically significant relationship observed with carbon dioxide emissions in three groups of countries except UMI.

This is supported by Wang et al. (2020)'s conclusion that the impact of AVA on reducing CO2 emissions may gradually manifest over time. By employing advanced technology and management techniques, agriculture holds the potential to sequester carbon and mitigate its carbon footprint. The findings from GLS also indicate that N2O emissions rise alongside *lnagrava* in Asian HMI nations but saw contrast results considering LI and LMI categories. Notably, according to Haider et al. (2020), agricultural activities accounted for approximately 80% of the world's total N2O emissions, contributing significantly to atmospheric concentrations.

Regarding agricultural land (*agrilan2*), the result shows that in countries with high income levels, there is a negative relationship between agricultural land and CO2. Whereas the impact is environmentally negative for the rest of the income group with positive coefficients. This is consistent with the study of Wang & Lv (2022) indicating that the model of CO2 EKC depicts the ascending stage of an inverted U-shaped relationship. The direction of the impact is contradictory for N2O. This is consistent with the study of Haider et al. (2022), denoting that in Canada, a high-income level country, there is a negative relationship between total N2O emission, agricultural induced N20 emission and agricultural land.

Besides, the results above show that energy use (*lneneuse*)has a statistically significant positive relationship with the amount of carbon and nitrous dioxide emissions in the four groups of countries. However, the impact is much smaller for more developed nations. This is similar to the findings of Haldar & Sethi (2020) that the relationship between the energy use and the CO2 in the long run and is consistent with the EKC. The same pattern is seen in N2O. In addition, three out of four coefficients are statistically significant at 1% level, and the impact is much stronger on high-income countries. This is contrary to previous research of Sinha & Sengupta (2018), indicating that the EKC exists in the impact of energy use on N2O emissions.

Regarding total natural resources rents (*natre2*), it has a significantly positive impact on CO2 emissions at the significance level of lower than 10%, except for the UMI group. This is consistent with the finding of Sibanda et al. (2023) that natural resource rent increases the amount of CO2 emissions or degrades the environment at a small level. For population density, the impact of this variable on the low and middle-income group is statistically significant at the level of 1%, whereas it is not statistically significant for high-income countries. This is similar to the result of Rahman et al. (2020). Regarding N2O, it has a significantly positive impact on N2O emissions at a significance level of lower than 5%. For LIC, LMI, UMI, HIC, there is a 3.619%, 3.619%, 9.505%, and 24.51% increase in N2O emissions for every 1% increase in total natural resources rents, respectively.

For the relationship between the population density and the emission of CO2 and N2O, the table above shows that for UMI countries, the impact is positive, for high-income countries, the impact is negative, both at 1% significance level. This means that there exists an EKC curve in the impact of population density on emissions. These results are supported by the findings of Govdeli (2020).

Table 4: Regression results of dependent variables lnch4 and lnghg

	LI	LMI	UMI	HI	LI	LMI	UMI	HI
Variables	lnch4	lnch4	lnch4	lnch4	lnghg	lnghg	lnghg	lnghg
lnagrem	0.386***	0.386***	0.0202	0.606***	0.537***	0.537***	0.172**	0.468***
	(0.0829)	(0.0829)	(0.0855)	(0.0820)	(0.0869)	(0.0869)	(0.0789)	(0.0972)
agre2	1.047	1.047	-9.459***	-1.182	-2.328	-2.328	-10.91***	13.73**
	(2.047)	(2.047)	(3.539)	(5.441)	(2.144)	(2.144)	(3.265)	(6.449)
lnagrava	-0.0350	-0.0350	-0.0176	0.0629	-0.122***	-0.122***	0.0688	0.0787
	(0.0447)	(0.0447)	(0.0779)	(0.0439)	(0.0468)	(0.0468)	(0.0718)	(0.0521)
emin2	2.434	2.434	4.009	3.798	1.406	1.406	3.588	5.346
	(1.836)	(1.836)	(2.808)	(3.060)	(1.923)	(1.923)	(2.591)	(3.626)
agrilan2	10.56***	10.56***	5.467*	-34.84***	-0.697	-0.697	2.534	-34.65***
	(2.295)	(2.295)	(2.902)	(3.194)	(2.404)	(2.404)	(2.677)	(3.786)
urb	2.553***	2.553***	-2.376***	4.317***	0.796*	0.796*	0.154	2.945***
	(0.444)	(0.444)	(0.903)	(0.697)	(0.465)	(0.465)	(0.833)	(0.827)
lneneuse	0.123***	0.123***	0.121***	0.0512	0.0979***	0.0979***	0.149***	0.0620
	(0.0261)	(0.0261)	(0.0420)	(0.0344)	(0.0274)	(0.0274)	(0.0388)	(0.0408)
rene2	13.87***	13.87***	22.10***	8.907**	14.49***	14.49***	12.08***	6.914*
	(3.328)	(3.328)	(4.624)	(3.487)	(3.486)	(3.486)	(4.266)	(4.133)
natre2	2.986*	2.986*	6.788**	30.97***	2.194	2.194	0.342	36.41***
	(1.690)	(1.690)	(2.880)	(3.078)	(1.770)	(1.770)	(2.657)	(3.648)
lnpopden	0.133**	0.133**	0.450***	0.0324	0.0466	0.0466	0.422***	0.0461
	(0.0637)	(0.0637)	(0.0796)	(0.0669)	(0.0667)	(0.0667)	(0.0735)	(0.0793)
Ope	7.526e+07	7.526e+07	-2.763e+08	1.023e+08	1.279e+08*	1.279e+08*	-1.736e+07	1.248e+08
	(6.480e+07)	(6.480e+07)	(1.786e+08)	(6.619e+07)	(6.787e+07)	(6.787e+07)	(1.648e+08)	(7.845e+07)
lnfdi	-0.114	-0.114	-0.175	-0.242***	-0.0501	-0.0501	0.0575	0.128
	(0.0804)	(0.0804)	(0.115)	(0.0792)	(0.0842)	(0.0842)	(0.106)	(0.0939)
Constant	0.118	0.118	3.758***	-1.411	1.605**	1.605**	0.415	-2.860***

Variables	LI lnch4	LMI lnch4	UMI lnch4	HI lnch4	LI lnghg	LMI lnghg	UMI lnghg	HI lnghg
	(0.719)	(0.719)	(1.223)	(0.892)	(0.753)	(0.753)	(1.128)	(1.057)
Observations	409	409	223	342	409	409	223	342
Number of countries	31	31	22	14	31	31	22	14

Standard errors in parentheses

**** p<0.01, ** p<0.05, * p<0.1*

Source: The authors (2024)

There is a statistically significant relationship between agricultural employment *(lnagrem)* and CH4 emissions at the significance level of 1%, except for upper middle-income countries (UMC group). A 1% increase in agricultural employment leads to 0.386%, 0.386%, and 0.606% increase in CH4 emissions in LIC, LMI, and HIC, respectively. This result is consistent with the research of Jiang et al. (2022) about the environmental impact of agricultural employment.

For Employment in agriculture *(lnagrem)*, it has a positive impact on GHG emissions at the significance level of lower than 5% in four groups of countries. Specifically, a 1% increase in agricultural employment results in 0.537%, 0.537%, 0.172%, and 0.468% increase in GHG emissions, suggesting that employment in agriculture negatively impacts the environment. The research of Jiang et al. (2022) has a similar result about the nexus between agricultural employment and ecological footprint.

The analysis of the impact that *agre2* yields on CH4 emissions reveals that in upper income countries, a 1% increase in agricultural raw materials exports leads to a decrease of roughly 9.5% in CH4 emissions, which is accepted at a 1% significance level. In contrast, past studies (Saghaian et al., 2022) pinpointed an increased amount of emissions caused by agricultural exports.

Previous studies (Quiao et al., 2019; Laborde et al., 2021) agreed that a major global producer of greenhouse gas emissions is agriculture. Our analysis results confirm this finding in the context of high-income Asian countries, as the impact of *agre2* on GHG emissions is positive and significant at a 5% level with a coefficient of 13.73%. However, as for upper-income countries, this relationship is negative at a 1% significance level.

Regarding Agriculture, forestry, and fishing value-added *(lnagrava)*, there is no significant impact on methane (CH4) observed in Asian countries in the provided period. However, Cheng et al. (2023) concluded that in China and India, agriculture primarily contributed to income-based CH4 emissions, with the input structure acting as a limiting factor for emission growth.

The analysis of AVA *(lnagrava)* reveals a statistically significant impact on greenhouse gas emissions (GHG) in only high income-level nations. This finding differs from Raihan et al. (2023), whose study on Bangladesh's agriculture sector indicates that increases in various agricultural activities lead to higher GHG emissions, while increments in AVA and forest land contribute to GHG emissions reduction.

For agricultural land (*agrilan2*), the result shows the same tendency compared to the impact on CO2 emission. In high-income countries, there is a negative relationship at 1% significance level between this ratio and CH4 emissions thanks to the advancement of green technology. This is consistent with the study of Chandio et al. (2022) which shows that methane and N2O harm agricultural productivity. There is a negative relationship between agricultural land use over total land use and greenhouse gas emissions. This is similar to the study of Mahmood et al. (2019) indicates that there exists the EKC when investigating the relationship between agricultural development and GHG. For the energy use (*lneneuse*), it can be seen that for the first 3 groups of countries, there is a positive relationship with the emission of CH4 at the level of 1% significant. This is consistent with the findings of Ali et al. (2020), showing that in all categories of OIC countries, energy consumption shows a strong and positive correlation with all environmental quality indicators over the short and medium terms, indicating that increased energy use will deteriorate environmental quality. The model shows that there is a positive impact on the GHG in developing countries. These impacts are statistically significant at the level of 1%. The findings are consistent with the EKC theory. This is similar to the conclusion of Yusuf et al. (2020). Over time, energy use had a negligible positive effect on emissions of CO2, methane, and nitrous oxide. Regarding total natural resources rents (*natre2*), it has no statistically significant impact on GHG emissions, except the HIC group at the significance level of 1%. For the HIC group, a 1% increase in total natural resources rents results in a 36.41% increase in GHG emissions. Research by Sibanda et al. (2023) also supports the conclusion that the increasing natural resource rent might degrade the environment by raising the amount of CO2 emissions.

From the results of research above, the authors conclude that generally, there are differences in the impact of agricultural employment rate, agricultural exports, and agricultural value added on environment quality compared in different groups of Asian economies. For countries with less developed economies, in specific, low-income and lower-middle-income countries, the overall relationship with four emissions is positive. In other words, the more these dependent variables' values are, the more detrimental to the environment. This is reasonable due to the fact that, in Asian less developed countries, the government policies tend to focus more on the economic growth while foregoing the quality of the environment. This is consistent with the EKC curve that has been mentioned in many previous studies about Asian economies (Massagony & Budiono, 2022; Agboola and Bekun, 2019 and Sharma et al., 2021). In the middle high income and high income countries, the agriculture employment rate increases which lead to the consumption of energy in production increase, detrimentally harmful to the environment in terms of carbon dioxide and greenhouse gas emissions.

5. Conclusions and Policy Implications

In our research paper, the authors applied the GLS model for comprehensive analysis of the impact of agricultural employment, value-added and raw material export on the environment. In terms of employment in agriculture, the authors saw that it has an impact on 4 climate variables. On the other hand, agriculture export and value added only have a significant relationship on the environment in high and UIC countries. Both governments and enterprises must implement environmental protection measures in the most effective way. The authors propose the following recommendations:

First, policymakers should optimize agricultural raw material exports through regulations and policies, including subsidies and support for research. To mitigate greenhouse gas emissions in highly industrialized countries, policymakers should invest in low-emission technologies for agricultural production and transportation, thereby reducing the environmental footprint of agricultural trade.

Second, the authorities should invest in technology and education for farmers, raising awareness about ecological issues and promoting low-emission techniques. Besides, businesses can consolidate production systems to optimize resources and reduce environmental impact. A key issue is the abundance of low-skilled labor in agriculture, partly due to insufficient training and job opportunities.

Third, Asian governments collaborate to enhance and share advanced agricultural management techniques and technologies, including the development of organic farming systems aimed at reducing CO2 emissions. Jiadou et al. (2022) suggest that the government in BRICS should provide financial support to agriculture and encourage the adoption of modern technological techniques.

However, the authors acknowledge certain limitations and propose future research orientation within this study.

First, the study incorporates only a limited number of explanatory variables, while agriculture activities and factors encompass several variables not considered here. Hence, we propose the inclusion of additional variables representing agriculture, such as foreign direct investment, trade agreements, trade duties, world agricultural product or oil prices, among others.

Second, while this article indicates that various agricultural activities and factors, such as the export of raw agricultural products, value-added, and agricultural employment, may contribute to environmental degradation in both developing and developed nations, this assertion may not apply universally to every primary agricultural product. Therefore, further research should ascertain the distinct environmental impacts of exporting different products and sectors within individual countries.

Furthermore, there is a need for enhanced ecosystem and natural resource management globally, considering all income levels. Future research should aim to incorporate similar variables interacting with globalization across various countries and regions such as Africa, Europe, Australia, and others. Upcoming studies should also examine the asymmetry aspect to determine whether nonlinearity exists in the literature concerning the EKC induced by agriculture, energy, or tourism.

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