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A Simultaneous Equation Approach to Examining Linkages Between Income Inequality and Environmental Degradation in Lower Middle-Income Economies in ASEAN

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ABSTRACT

This study aimed to foster sustainable prosperity in lower middle-income economies in ASEAN, comprising Indonesia, Cambodia, Vietnam, the Philippines, and Laos. It also investigated the relationship between income inequality and environmental degradation from 2010 to 2022. A simultaneous equation approach was applied in the study, with consideration given to two endogenous variables (income inequality and environmental degradation) and several exogenous variables (unemployment, corruption, human capital, industry, renewable energy consumption, and poverty). The results showed that environmental degradation significantly impacted income inequality by 0.53%, while income inequality influenced environmental degradation by 0.16%. Income inequality was enhanced by unemployment and alleviated by human capital. In addition, environmental degradation was enhanced by industry and poverty, but mitigated by renewable energy consumption. This study recommended that the government address environmental degradation and unemployment while improving human capital to mitigate income inequality. It was also crucial to control industrial activities, promote renewable energy usage, and reduce poverty to enhance environmental sustainability and resilience.

1. INTRODUCTION

Economic disparities, both between regions and countries, as well as income groups, are essential issues in recent years. Moreover, the current global economic situation is increasingly precarious and uncertain. Some parties believe that, in certain limits and contexts, income inequality positively contributes to national economic growth performance [1-3]. It also tended to damage environment, and in certain cases, led to economic and environmental instability, resulting in developmental volatility.

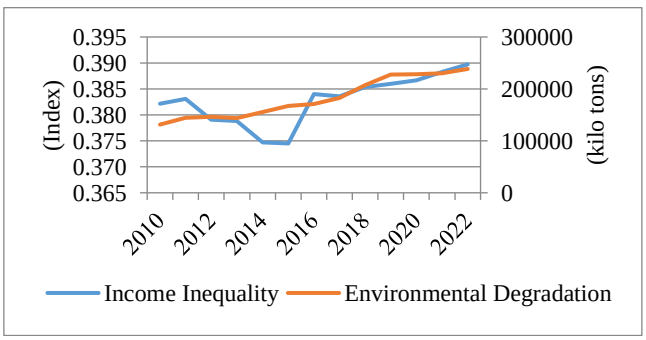

Figure 1. Conditions of income inequality and environmental degradation of lower middle-income economies in ASEAN [4]

The reduction of income inequality and the enhancement of environmental quality are issues prioritized by lower middle-income economies in Association of Southeast Asian Nations (ASEAN). The relationship between income inequality and environmental degradation in the economy group raises two crucial questions. First, will high-income inequality adversely affect environment? Second, will high environmental degradation exacerbate income inequality issues? It was crucial to address these questions because income inequality among lower middle-income group has increased on average over the past seven years, specifically from 2016 to 2022. Meanwhile, environmental degradation has shown an average increase over the last nine years, spanning from 2014 to 2022. These trends are presented in Figure 1.

Figure 1 provides data on the general upward trend in both income inequality and environmental degradation in lower middle-income economies in ASEAN (Indonesia, Cambodia, Vietnam, the Philippines, and Laos) over the past five years. However, the persistence of this trend could reduce the level of sustainable welfare. The development in this group primarily shows growth, such as increasing per capita income, often at the expense of neglecting income distribution. Income inequality not only leads to poverty, but also contributes to environmental damage [5-7]. It tends to foster environmental degradation as affluent and influential groups prioritize economic gains without due consideration for environmental impact, subsequently reducing environmental quality. High

environmental degradation can increase income inequality since poor environmental quality is a significant challenge for impoverished communities. The degradation of environment, which is a primary source of livelihood and sustenance, can negatively affect welfare and increase income inequality. Moreover, this dynamic relationship between income inequality and environmental degradation, supported by relevant studies, is intricately based on economic growth [8-10].

The relationship between income inequality and environmental degradation has been a significant concern for study experts. Some even argued that high income inequality contradicted sustainable economic development [11-13], while several others supported the positive correlation between income inequality and environmental degradation [14-16]. The increase in income inequality can be related to societal negligence of environment [17-19], particularly evident in the behavior of lower middle class, whose livelihoods depend on nature. Meanwhile, fairer income distribution tends to yield better environmental quality [20-22]. Several studies showed a negative correlation between income inequality and environmental degradation [23-25]. This could be attributed to the implementation of strict environmental policies and the promotion of environmental awareness among lower middle class, providing alternative economic avenues. A trade-off exists between both variables [26, 27]. Reducing poverty through income redistribution can increase carbon emissions and environmental degradation [28-30]. Therefore, a shift in the consumption pattern of the affluent from low-polluting to high-polluting goods may occur when income is redistributed from the rich to the poor. This study primarily aimed to achieve sustainable prosperity in lower middle-income economies in ASEAN by investigating income inequality and environmental degradation, considering various influencing factors.

The following questions were addressed in this study: 1) What is the influence of environmental degradation, unemployment, corruption and human capital on income inequality in ASEAN group of lower middle-income economies? 2) What is the influence of income inequality, industry, renewable energy consumption and poverty on income inequality in ASEAN group of lower middle-income economies? The article is structured as follows: Section 2 discusses the literature review, Section 3 details the methodology, Section 4 analyzes the results in the context of the existing knowledge, and Section 5 presents the conclusions and policy recommendations.

2. LITERATURE REVIEW

Several investigations have been conducted on income inequality and environmental degradation, but this current study specifically focused on literature reviews from the past five years to identify study gaps and contribute novelty. Firstly, a negative and significant relationship was shown between income inequality and environmental degradation. For instance, an analysis of short and long term impacts of income inequality on environmental quality in Turkey suggested that income inequality could reduce environmental degradation [31]. Similar results were observed in OECD country group, showing that an increase in the Gini index could potentially reduce carbon emissions, in line with the marginal propensity approach [32]. In China, an increase in income inequality contributed to improvements in environmental governance [33]. A comparative analysis between developed and developing countries in the G-20 group suggested that income distribution might reduce carbon emissions in developing countries [34]. In Pakistan, poverty, population density and per capita income led to a decline in the carrying capacity of environment in short and long term. However, income inequality only weakened environmental quality in long term, having no short term effect [35].

Secondly, a positive and significant relationship was found between income inequality and environmental degradation. For instance, in Sub-Saharan Africa, income inequality and poverty were observed to exacerbate environmental degradation [36]. Similar results in Turkey suggested that low income distribution negatively impacted environmental quality [37]. Continued income inequality was also related to high carbon emissions in short term in the US [38]. In China, unequal income growth contributed to a decline in environmental carrying capacity [39]. In another instance, investigations across the Next Eleven (N-11) countries indicated that economic growth, income inequality, and energy consumption fostered carbon emissions [40]. A study across 18 developing countries in Asia showed a positive relationship between carbon emissions, ecological footprint, and income inequality [41]. In an analysis of the development in Chinese provinces, income inequality hindered the role of technological innovation in reducing air pollution, as an indicator of environmental degradation [42]. Meanwhile, an investigation of 68 countries suggested that controlling income inequality was a solution to reducing carbon emissions [43].

Thirdly, ambiguous results were found regarding the relationship between income inequality and environmental degradation. For instance, an investigation of the G7 group of countries showed that income inequality had a positive effect on carbon emissions from 1870 to 1880, and a negative effect between 1950 and 2000 [44]. An in-depth investigation in the United Kingdom showed that income inequality asymmetrically impacted environment in short term, and had a positive effect in long term [45].

Based on the explanation from the relevant literature, income inequality and environmental degradation were significant challenges across all countries, but the nature of their relationship remained a subject of debate. Several investigations have been carried out on the relationship between income inequality and environmental degradation in both developed and developing nations. However, the results have not yielded a definitive conclusion due to disparities among studies exploring the same theories and hypotheses. The relationship between income inequality and environmental degradation has been neglected in several developing countries but prioritized in developed countries due to industrial sector economies. The novelty of this study was addressing the issue of income inequality and environmental degradation which had previously received limited attention. A greater emphasis was placed on developing countries, particularly lower middle-income economies in ASEAN. Various determinants influencing income inequality and environmental degradation were also investigated, including unemployment, corruption, human capital, industry, renewable energy consumption, and poverty. In summary, the literature reviewed in this section was relevant as it pertains to the variables currently considered. Previous studies often analyze income inequality and

environmental degradation in isolation from independent variables. Therefore, this current study aimed to consolidate these elements in a more comprehensive framework, using a simultaneous equation model.

3. METHODOLOGY

3.1 Data and variables

This study adopted panel data, with a time series spanning from 2010 to 2022 and a cross-section comprising lower middle-income economies in ASEAN (Indonesia, Cambodia, Vietnam, the Philippines, and Laos). The data were sourced from reputable agencies, specifically the World Bank, and subsequently validated.

This study primarily focused on two categories of variables, namely endogenous, with income inequality and environmental degradation as determinants, and exogenous, with unemployment, corruption, human capital, industry, renewable energy consumption, and poverty as determinants. These determinants were selected based on a thorough review of relevant literature focusing on income inequality and environmental degradation. The phenomena of income inequality and environmental degradation were simultaneously analyzed in a conceptual framework that has not been previously explored. This has led to the formulation of policies aimed at sustainable welfare improvement. The relationship between endogenous and exogenous variables is represented in Figure 2.

Table 1 shows the detailed definition of each variable.

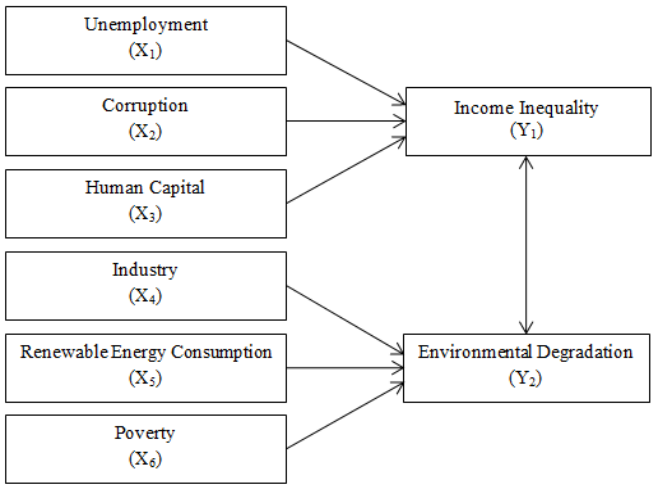

Figure 2. Variable linkages

Table 1. Variable operational definitions

Variable	Indicator	Source
Income Inequality (Y_1)	Gini index for lower middle-income economies in ASEAN from 2010 to 2022	[4]
Environmental Degradation (Y_2)	Carbon dioxide emissions from the combustion of solid, liquid and gas fuels, calculated in kilo tons, in lower middle-income economies in ASEAN from 2010 to 2022	[4]
Unemployment (X_1)	Unemployed labor force percentage demanding employment, relative to the total labor force, in lower middle-income economies in ASEAN from 2010 to 2022	[4]
Corruption (X_2)	Perception of corruption ranking within the public sector, calculated in an index among lower middle-income economies in ASEAN from 2010 to 2022	[4]
Human Capital (X_3)	Human capital index per capita, presented as a percentage, in lower middle-income economies in ASEAN from 2010 to 2022	[4]
Industry (X_4)	Annual growth of industry value added as a percentage in lower middle-income economies in ASEAN from 2010 to 2022	[4]
Renewable Energy Consumption (X_5)	Consumption of biofuels as a percentage of final energy consumption in lower middle-income economies in ASEAN from 2010 to 2022	[4]
Poverty (X_6)	Poverty calculation ratio based on the national poverty line, represented as a percentage of the population in lower middle-income economies in ASEAN from 2010 to 2022	[4]

3.2 Data analysis approach

The analysis model comprised income inequality and environmental degradation equations as presented below.

$$Y_{1it} = \alpha_1 + \alpha_2 Y_{2it} + \alpha_3 X_{1it} + \alpha_4 X_{2it} + \alpha_5 X_{3it} + U_{1it} \quad (1)$$

$$Y_{2it} = \beta_1 + \beta_2 Y_{1it} + \beta_3 X_{4it} + \beta_4 X_{5it} + \beta_5 X_{6it} + U_{2it} \quad (2)$$

where,

α and β are intercepts

i is the cross section (Indonesia, Cambodia, Vietnam, Philippines and Laos)

t denotes the time series (2010-2022)

U represents the residual

The analytical approach examined the relationship between income inequality and environmental degradation in lower middle-income economies in ASEAN through a simultaneous equation. This model comprised a set of equations where certain variables were both endogenous in one or more equations and exogenous in several others. Consequently, a variable in the system simultaneously functioned as both an endogenous and exogenous variable. The equation model explained the interdependency among endogenous and other endogenous variables. The equations were characterized by the possibility of an endogenous variable in one equation being exogenous in other equations in the system or model. An identification test was conducted using the following guidelines in order to apply the simultaneous equations:

The equation is identified when K–k=m–1

The equation is over-identified when K– k>m–1

The equation is unidentified when K–k<m–1

where, K is the total number of exogenous variables in the model; k is the number of exogenous variables in a specific equation; and m denotes the number of endogenous variables in a particular equation.

The conclusion from this identification test determines the subsequent method to be adopted: The Two Stage Least

Square (2SLS) method is used when the result of the comparison is over-identified and continued, while the Indirect Least Square (ILS) method is adopted when the result is exactly identified. The identification calculations are presented in Eqs. (3) and (4).

Income inequality identification test:

$$6 - 3 > 2 - 1(over - identified) \quad (3)$$

Environmental degradation identification test:

$$6 - 3 > 2 - 1(over - identified) \quad (4)$$

2SLS was adopted based on Eqs. (3) and (4), a method for estimating parameters in a structural equation whose estimation has multiple values in the over-identified equation. It serves as an extension of OLS method, commonly used in regression analysis calculations, particularly when there is a correlation between the independent variables and errors.

4. RESULTS AND DISCUSSION

4.1 Analysis of income inequality

Analysis of income inequality equation and the influencing determinants (environmental degradation, unemployment, corruption, and human capital) is presented in Eq. (5).

$$Y_{1it} = 3.25 + 0.53Y_{2it}^{**} + 0.15X_{1it}^{**} - 0.20X_{2it} - 0.41X_{3it}^{*} \quad (5)$$

** significant at α=5%, * significant at α=10%

R-squared = 0.728390

Eq. (5) shows that the adjusted R-squared value for income inequality equation is 0.728390. This showed that the contribution of exogenous variables (environmental degradation, unemployment, corruption and human capital) to the endogenous variable (income inequality) was 72.8390 percent, while the remaining 27.161% was influenced by other variables. The equation also showed the significance and directional coefficient of each determinant influencing income inequality in lower middle-income economies group in ASEAN.

First, environmental degradation (Y_2) had a positive and significant impact on income inequality (Y_1) in lower middle-income economies in ASEAN. High environmental degradation tended to increase income inequality due to its crucial role in the lives of the impoverished. Poor environmental quality significantly impacted livelihoods and welfare, further exacerbating income inequality. This result was in line with previous studies [46-49]. Active governmental and societal intervention was essential in controlling environmental degradation and preventing adverse impacts on social welfare.

Second, unemployment (X_1) had a positive and significant effect on income inequality (Y_1) in lower middle-income economies in ASEAN. Representing individuals temporarily out of work or actively in need of employment, unemployment resulted in income loss. Higher unemployment rates showed larger segments of the workforce experiencing income deprivation. This situation could decrease wages for low-income groups, consequently increasing income inequality. In line with previous studies [50-52], this study affirmed that high unemployment correlated with reduced social welfare, leading to increased income inequality.

Third, corruption (X_2) had a negative but insignificant impact on income inequality (Y_1) in lower middle-income economies in ASEAN. These countries were collectively committed to eradicating corruption, showing the importance of controlling corruption and ensuring governmental transparency in government in addressing income inequality. Recognizing the need for collaboration across all social facets, ASEAN members were dedicated to eradicating corruption. This effort transcended law enforcement, focusing on preventive measures such as early childhood corruption education programs that incorporated anti-corruption education, fostering integrity in future generations. This result was in line with previous studies [53-55], showing that anti-corruption policies not only enhanced economic growth rates and income distribution globally but also contributed to reducing income inequality and bridging regional disparities.

Fourth, human capital (X_3) had a negative and significant impact on income inequality (Y_1) in lower middle-income economies in ASEAN. High levels of human capital signified improvements in the Human Development Index and enhanced societal access to the benefits of economic development which include income, health and education. Enhanced human development could increase workforce and population productivity, fostering more equitable income distribution within a country. The result was supported by previous studies [56-58], showing that investment in human capital enhanced societal productivity and presented a viable solution to mitigate income inequality. Therefore, governmental prioritization of human capital development was crucial in addressing income inequality.

4.2 Analysis of environmental degradation

Analysis of environmental degradation equation and its influencing determinants (income inequality, industry, renewable energy consumption, and poverty) is predicted in Eq. (6).

$$Y_{2it} = -2.11 + 0.16Y_{1it}^{***} + 0.75X_{4it}^{*} - 0.26X_{5it}^{**} + 0.95X_{6it}^{*} \quad (6)$$

*** ** significant at α=1%, ** significant at α=5%, * significant at α=10%

R-squared = 0.853910

Eq. (6) shows that the adjusted R-squared value for environmental degradation equation is 0.853910. This showed that the contribution of exogenous to endogenous variables was 85.3910%, while the remaining 14.609% was influenced by other variables. The equation also delineated the significance and directional coefficient of each determinant influencing environmental degradation in lower middle-income economies in ASEAN.

First, income inequality (Y_1) had a positive and significant effect on environmental degradation (Y_2) in lower middle-income economies in ASEAN. Higher income inequality increased income gap between different socio-economic groups, making poverty alleviation increasingly challenging and impeding both economic growth and environmental quality. The pursuit of economic gains without considering environmental consequences by affluent individuals, as well as high dependence on nature by the impoverished increased environmental degradation. In addition, income inequality strained environmental carrying capacity, further reducing environmental quality. This result was supported by previous

studies [14, 15, 59, 60], showing that achieving more equitable power and wealth distribution in society contributed to enhanced environmental quality. Therefore, government intervention to address income inequality was crucial in mitigating economic issues that impacted environmental quality.

Second, industry (X_4) had a positive and significant effect on environmental degradation (Y_2) in lower middle-income economies in ASEAN. The increasing industrial sector necessitated enhanced natural consumption, resulting in depletion and environmental degradation. Intensive industrialization led to excessive resource use and high pollution levels, contributing to environmental degradation. This result was supported by previous studies [61, 62], showing that while industries might positively impact societal aspects such as reducing unemployment and enhancing welfare of local populations, they tended to have adverse environmental consequences, such as water and air pollution.

Third, renewable energy consumption (X_5) had a negative and significant effect on environmental degradation (Y_2) in lower middle-income economies in ASEAN. The use of renewable energy sources contributed to mitigating environmental degradation costs, such as the depreciation of natural resources and carbon emissions. The dominant use of renewable energy sources could enhance environmental carrying capacity due to its eco-friendly and low-carbon attributes. Moreover, reliance on renewable energy prevented resource depletion, mitigating the need for extraction and mining activities. This result was in line with [9, 63, 64], showing the crucial role of renewable energy consumption in mitigating environmental degradation.

Fourth, poverty (X_6) had a positive and significant effect on environmental degradation (Y_2) in lower middle-income economies in ASEAN. Impoverished communities highly relied on environment for sustenance, leading to increased exploitation of environmental carrying capacity and negligence of sustainability measures. Moreover, the high pressure on environment made it challenging to avoid environmental damage. This result was in line with [6, 29, 65], indicating the reliance of the poor on natural resources for survival, as well as the relationship between poverty and increased environmental strain.

5. CONCLUSION

In conclusion, income inequality and environmental degradation were highly interconnected issues crucial for sustainable prosperity. Analysis showed that environmental quality tended to decline as income inequality increased, and vice versa. High income gaps increased environmental degradation, since impoverished communities tended to over-exploit natural resources as a last resort for survival. Meanwhile, in wealthier societies, the rich often had a stronger influence on policymaking. Income inequality could lead to political instability, causing the rich to prefer policies that overexploited local natural resources and channel the profits abroad.

Governments of lower middle-income economies in ASEAN adopted fiscal policies focusing on taxation and expenditure to mitigate income inequality. These policies included relating and enhancing budgeting sectors by the Ministry of Finance to optimize the distribution of aid from central to local governments. The uniformity of information could help in precisely targeting direct and indirect aid, reducing income inequality and improving equality in healthcare, education, and public services. These measures consequently generated a skilled workforce crucial for sustainable growth. To address environmental degradation, policies implementing green economy programs were aimed at balancing economic growth and environmental protection while considering environment carrying capacity. These programs were carried out to maintain ecological functionality in all development processes and enhance access to renewable energy sources. The objective was to attain predetermined environmental quality standards.

This study was specifically limited by the lack of analysis of green variables. Therefore, future studies were recommended to integrate green economic growth as an endogenous variable. It was also important to acknowledge the collective impact of income inequality and environmental degradation in determining the level of green economic growth, a synthesis of conventional economic growth that internalized environmental externalities. The adoption of the error correction model approach in future analyses could offer insights into short and long term dynamics, enabling the formulation of more precise and impactful policies.

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