

## **EXAMINING THE IMPACT OF CLIMATE ADAPTATION STRATEGIES, CPO AND METAL EXPORTS ON POVERTY REDUCTION IN INDONESIA**

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### **ABSTRACT**

Global climate change presents serious challenges for Indonesia, especially since its economy heavily relies on the agricultural sector and the extraction of natural resources, including metal exports and palm oil. (CPO). This study aims to analyze the impact of climate adaptation strategies, metal exports, and palm oil on poverty reduction in Indonesia. Secondary data from the year 2000 to 2023 was analyzed using multiple linear regression. The research results indicate that reforestation, as a climate adaptation strategy, has a significant positive effect on increasing poverty, while CPO exports show a significant negative impact on poverty reduction. Conversely, metal exports do not have a significant impact on poverty. This finding shows that although reforestation has the potential to improve the environment, its implementation, which lacks attention to social aspects, can exacerbate poverty. The export of CPO, while providing positive economic impacts, needs to be balanced with sustainable practices to reduce negative effects on the environment. This research provides recommendations for policymakers to strengthen more inclusive and sustainable climate adaptation strategies to reduce poverty amid the challenges of climate change.

Keywords: climate change, reforestation, metal exports, CPO, poverty, Indonesia

### **1. INTRODUCTION**

Global climate change has become a major challenge for many countries, including Indonesia, which is one of the developing nations with an economy reliant on the agricultural sector and natural resource extraction. One significant impact of climate change is the increased frequency and intensity of natural disasters, which can potentially devastate important economic sectors such as metal exports and Crude Palm Oil (CPO). In this context, climate adaptation strategies become crucial to mitigate the economic and social losses caused by climate change, especially in efforts to reduce poverty (Agus et al., 2022).

Indonesia is one of the main producers of metals and CPO in the world, with both commodities playing a vital role in the country's economy. The export of metals and CPO not only contributes to national income but also affects the welfare of the community, especially in areas that rely on these sectors. However, unpredictable climate change can threaten the sustainability of production and exports, potentially worsening poverty in regions dependent on these industries (Gütschow et al., 2021). The increase in the frequency and intensity of natural disasters such as floods, droughts, and tropical storms can damage infrastructure and disrupt production, ultimately threatening the stability of metal and CPO exports. Furthermore, massive deforestation for the expansion of palm oil plantations and mining activities has worsened environmental conditions, reducing the forests' ability to absorb carbon and increasing the risk of natural disasters (Group, 2015)

This study aims to determine how climate adaptation strategies, metal exports, and Crude Palm Oil (CPO) influence poverty reduction in Indonesia. To achieve this goal, the research will focus on research questions regarding the extent of the impact of climate adaptation strategies, metal exports, and CPO on poverty reduction in Indonesia, both partially and simultaneously. As a country with an economy heavily reliant on the export of primary commodities, Indonesia faces significant challenges in designing and implementing effective adaptation strategies. This research aims to fill the knowledge gap regarding how adaptation strategies can directly influence the success of the export sector and its impact on poverty reduction.

Although many studies have been conducted on the impact of climate change on the agriculture and forestry sectors, such as the research conducted by Akbar et al., 2023; Aprilia & Sisdianto, 2024; Cheng et al., 2017; Khoirunisa Wahida & Hoirul Uyun, 2023, there is still a knowledge gap regarding how climate change specifically affects the metal and CPO export sectors in Indonesia. Previous research has tended to focus on production and environmental aspects, but has paid less attention to the broader economic and social impacts, particularly related to poverty in areas that depend on this industry (Levin et al., 2022; Saba et al., 2024). In addition, effective adaptation strategies to address these challenges have not been explored in depth.

## 2. LITERATURE REVIEW

### 2.1. Climate Adaptation Strategies

Climate change has become a global challenge that requires effective adaptation and mitigation measures. One important adaptation strategy is reforestation, which not only helps in carbon absorption but also increases ecosystem resilience to climate change (Psistaki et al., 2024).

Reforestation, or the replanting of forests in areas that have experienced deforestation, plays an important role in climate adaptation strategies. Reforestation can enhance the genetic diversity of forests, which is crucial for adapting to climate change. This genetic diversity helps forests become more resilient to disturbances such as drought and pest attacks. Reforestation is not only ecologically beneficial but also economically advantageous, increasing forest productivity and providing sustainable natural resources. It can also reduce the risk of natural disasters such as floods and landslides, which are often exacerbated by climate change (Abbass et al., 2022; Hazarika et al., 2021).

### 2.2. Export of Metals and Palm Oil (CPO)

The export of metals and Crude Palm Oil (CPO) are two important sectors in Indonesia's economy. Metals, such as nickel and copper, are used in various high-tech industries, including electric vehicle batteries, which are in increasing demand. Meanwhile, CPO is one of Indonesia's main export commodities, used in a range of products from food to cosmetics. However, both of these sectors also have significant environmental impacts, such as deforestation and land degradation, which exacerbate climate change (Kwan, 2022). To address these negative impacts, climate adaptation strategies such as

reforestation become very important. Reforestation, or the replanting of forests, can help reduce carbon emissions and improve the quality of soil damaged by mining activities and palm oil plantations. Additionally, reforestation can enhance biodiversity and provide habitat for endangered wildlife. Thus, reforestation not only aids in climate change mitigation but also supports ecosystem sustainability (Ghufron, 2024).

The implementation of the reforestation strategy requires collaboration between the government, the private sector, and the community. The government can provide incentives for companies that are committed to carrying out reforestation, while companies can integrate sustainable practices into their operations. The local community can also be involved in tree planting programs, which not only provide environmental benefits but also economic ones through job creation. With a holistic and collaborative approach, the export of metals and CPO can continue to contribute to the economy without sacrificing the environment (Priyanto et al., 2021).

### 2.3. Poverty

Poverty in Indonesia remains a significant challenge, especially in rural areas that heavily rely on natural resources. Climate adaptation strategies such as reforestation can help reduce poverty by creating new job opportunities in the planting and maintenance of forests. Research shows that reforestation can increase the income of local communities and lower poverty levels by providing stable and sustainable employment (Lestari et al., 2023). In addition, reforestation can enhance food security and reduce the risk of natural disasters. A healthy forest provides additional food sources such as fruits and nuts, and helps reduce the risk of floods and landslides that often destroy the assets and livelihoods of poor communities (Lestari et al., 2023). Thus, reforestation not only helps protect the environment but also enhances the well-being of local communities. Reforestation also plays a role in improving environmental quality, which positively impacts public health. Reforested forests can improve air and water quality, which in turn reduces healthcare costs and boosts community productivity (Irvanie & Panjawa, 2023). By integrating reforestation into climate adaptation strategies, Indonesia can reduce the impacts of climate change while also providing direct benefits for poverty reduction in local communities (Asra, 2020).

### 2.4. The Relationship Between Climate Adaptation Strategies, CPO and Metal Exports in Relation to Poverty Reduction.

The relationship between climate adaptation strategies, particularly reforestation, metal exports, and Crude Palm Oil (CPO) exports, is very close and mutually influential in reducing poverty. Reforestation as part of a climate adaptation strategy aims to reduce the impacts of climate change by increasing carbon absorption and restoring damaged ecosystems. According to research, reforestation can enhance food security and the economy of local communities by providing sustainable natural

resources (World Bank, 2010). In addition, reforestation can also create new job opportunities in the forestry and agriculture sectors, which contributes to poverty reduction (Kristianto, 2020).

The export of Crude Palm Oil (CPO) also has a significant impact on poverty reduction, especially in producing countries like Indonesia. The CPO industry provides jobs for millions of people and makes a significant contribution to national income (Levin et al., 2022; Zahra & Yafiz, 2022). However, this industry also faces serious environmental challenges, including deforestation and greenhouse gas emissions. The implementation of effective climate adaptation strategies, such as reforestation and sustainable agricultural practices, can help mitigate these negative impacts and ensure that the economic benefits from CPO exports are sustainable and contribute to poverty reduction.

The export of metals, such as nickel and copper, plays an important role in the economies of developing countries. The mining sector can create jobs and increase regional income, which in turn can reduce poverty (Garinas, 2020; Levin et al., 2022; Priyanto et al., 2021). However, it is important to ensure that mining activities are conducted sustainably and do not harm the environment. Reforestation can help mitigate the negative impacts of mining by restoring degraded land and maintaining ecosystem balance (Hidayati & Suryanto, 2015). Thus, the combination of reforestation and sustainable mining practices can provide significant economic and environmental benefits.

### 3. METHODOLOGY

#### 3.1. Research Design

This research aims to analyze how climate adaptation strategies, proxied by the area of reforested forests, metal exports, and palm oil (Crude Palm Oil/CPO), can impact poverty reduction in Indonesia from 2000 to 2023. The metal and CPO sectors are major contributors to state revenue and a source of livelihood for many communities, especially in rural areas. However, the increasingly evident climate change can disrupt production and export stability, which ultimately affects the local economy and the well-being of the community. This research employs a quantitative approach with multiple regression analysis methods to assess the impact of climate adaptation strategies (the area of reforested land), metal exports, and CPO on poverty reduction. The model of the equation in this research is:

$$\text{Log}Y_i = \beta_0 + \beta_1 \log X_{1i} + \beta_2 \log X_{2i} + \beta_3 \log X_{3i} + e_i$$

Where:

Y	=	Poverty
X <sub>1</sub>	=	Reforestation
X <sub>2</sub>	=	Export of CPO (Crude Palm Oil)
X <sub>3</sub>	=	Metal Exports
β <sub>0</sub>	=	Constant
β <sub>1</sub> , β <sub>2</sub> , β <sub>3</sub>	=	Regression coefficients of independent variables

### 3.2. Data Collection

Secondary data will be collected from various sources, including the Indonesia Central Statistics Agency, the Ministry of Trade, and weather and climate reports from Indonesian Meteorology, Climatology, and Geophysics Agency. The independent variables to be analyzed include climate adaptation strategies proxied by reforestation activities measured in hectares (ha), CPO exports measured in thousands of US dollars, and metal exports measured in millions of US dollars. The dependent variable includes poverty proxied by the number of poor people in Indonesia measured in millions of individuals.

### 3.3. Data Analysis

To analyze how climate adaptation strategies in this study are measured through reforestation, CPO exports, and metal, as well as their impact on poverty reduction in Indonesia, multiple linear regression was used. Multiple linear regression is an appropriate method to use because it allows for the simultaneous analysis of several independent variables, such as reforestation, CPO exports, and metal. By using this approach, significant relationships between these variables can be identified and how they collectively influence the poverty level in Indonesia.

The analysis technique used involves the collection of quantitative data from various sources, including export data for CPO and metal, reforestation data, and poverty data from the Central Statistics Agency. After the data is collected, the first step is to conduct a normality test to ensure the distribution of residual data, as well as tests for heteroscedasticity, multicollinearity, and autocorrelation to ensure that the regression model meets classical assumptions.

The analysis tool used is EViews, a reliable statistical software for processing economic data. EViews allows for easy execution of multiple linear regression, as well as conducting various necessary diagnostic tests. With this tool, it is possible to interpret the regression coefficients to determine the impact of climate adaptation strategies and exports on poverty reduction. The results of this analysis are expected to provide valuable insights for policymakers in formulating more effective adaptation strategies and export sectors in Indonesia to reduce poverty amidst the challenges of climate change.

## 4. RESULTS AND DISCUSSION

### 4.1. Result

Before estimating the impact of reforestation, CPO exports, and metal exports on poverty, it is crucial to first conduct a classical assumption test to ensure the validity of the regression model used. Classical assumption tests include normality test, multicollinearity test, heteroscedasticity test, and autocorrelation test. The normality test ensures that the distribution of residuals follows a normal distribution, while the multicollinearity test examines whether there is a high correlation among independent variables that could affect estimation results. The heteroscedasticity test aims to detect the

presence of non-constant residual variance, and the autocorrelation test checks for correlation between residuals in one period with those in another period. By ensuring that all classical assumptions are met, the resulting estimates will be more accurate and reliable.

### Normality Test

Table 1. Jarque-Bera Test

Normalitas	Jarquebera	Probability
	3.478936	0,175614

Source: Processed data, 2024

From Table 1, the p-value from the Jarque-Bera test is greater than the significance level (0.05), indicating that the data is normally distributed.

### Multicollinearity Test

Table 2 Multicollinearity Test, Variance Inflation Factors

Variable	Centered VIF
C	NA
LOG(reforestration)	1.152096
LOG(ekspor CPO)	2.348664
LOG(ekspor logam)	2.560611

Source: Processed data, 2024

From the table above, it can be seen that  $VIF < 10$ , indicating that there are no significant issues with multicollinearity. This value shows that the independent variables are not highly correlated with other independent variables in the model, or in other words, they are free from multicollinearity.

### Heteroskedasticity Test

Tabel 3. Breusch-Pagan-Godfrey Test

F-statistic	0.930315	Prob. F(3,20)	0.4443
Obs*R-squared	2.939004	Prob. Chi-Square(3)	0.4011

Source: Processed data, 2024

In Table 3, the Prob. Chi-Square value is greater than 0.05, indicating that there is no significant indication of heteroskedasticity in the model, and the variance of the regression errors can be considered constant; in other words, heteroskedasticity does not occur.

### Autocorrelation Test

Tabel 4. Uji Breusch-Godfrey Serial Correlation LM Test:

F-statistic	5.069204	Prob. F(1,19)	0.0364
Obs*R-squared	5.054629	Prob. Chi-Square(1)	0.0246

Source: Processed data, 2024

In the table above, the Chi-Square probability value is  $< 0.05$ , indicating that there is no autocorrelation.

### Multiple Linear Regression Estimation

Tabel 5. Regresi Linear Berganda

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.20128	0.276875	44.06779	0.0000
LOG (reboisasi)	0.036592	0.014622	2.502568	0.0211
LOG (ekspor CPO)	-0.135906	0.023675	-5.740389	0.0000
LOG (ekspor logam)	-0.005576	0.018710	-0.298049	0.7687
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R-squared	0.800052			
Adjusted R-squared	0.770060			
F-statistic	26.67535			
Prob (F-Statistic)	0.000000			

Source: Processed data, 2024

From the table above, it can be seen that if reforestation activities, CPO exports, and metal exports are valued at zero, the poverty rate during the period of 2000-2023 is 12.2013%. There is a significant positive relationship between reforestation and poverty, meaning that a 1% increase in reforestation will raise the poverty rate by 0.0366%. The CPO export variable shows a significant negative relationship with the reduction of poverty. Where every 1% increase in CPO exports will reduce poverty by 0.1359%. Meanwhile, the metal export variable has no effect and is not significant in reducing poverty in Indonesia during the period of 2000 – 2023.

In this study, 80% of the variation in the dependent variable (poverty) can be explained by the independent variables (reforestation, CPO exports, and metal exports) in the model. This indicates a strong model, which can be seen from the R-squared. Similarly, the adjusted R-squared of 0.770060 is a more conservative value, taking into account the number of variables in the model. This value still indicates a fairly good model. The F-statistic of 26.67535 with a p-value of 0.000000 indicates that the model is overall significant. This means that the independent variables collectively have a significant effect on the dependent variable.

#### 4.2. Discussion

The research findings indicate several important discoveries that need to be discussed further:

1. The positive coefficient on the reforestation variable of 0.0366 and a p-value of 0.0211 indicate that an increase in reforestation impacts an increase in poverty and is significant. This finding is consistent with several previous studies that show that reforestation projects do not always lead to economic improvements for local communities, and in some cases, may even exacerbate poverty. Reforestation projects,

if not designed with attention to the needs and rights of local communities, can result in the loss of access to primary livelihoods and increase poverty. Reforestation that does not take local interests into account often leads to the loss of agricultural land, which exacerbates poverty conditions. The REDD+ program, by restricting access to forests, often eliminates food and income sources for local communities, especially in tropical forest regions. Reforestation projects that focus on conservation often fail to reduce poverty due to a lack of community involvement and an excessive focus on tree planting rather than long-term economic benefits. In some regions of Asia and Africa, reforestation projects can lead to socio-economic dislocation, where communities lose access to fertile land they previously relied on, thereby increasing their vulnerability to poverty. The success of reforestation projects in reducing poverty greatly depends on the active involvement of local communities and planning that takes into account long-term economic benefits (Bayrak & Marafa, 2016; Levang et al., 2005; Luttrell et al., 2018).

2. Negative coefficient of CPO Exports

The finding that CPO (Crude Palm Oil) exports have a negative impact on poverty variables, with a coefficient of -0.1359 and a p-value of 0.0000. It indicates that the expansion of the palm oil sector has the potential to reduce poverty. This is in line with previous studies that state that the palm oil sector, through increased exports, can contribute to poverty reduction by boosting income, creating jobs, and stimulating investment in local communities (Ahmad et al., 2023; Awang Ali et al., 2011; Hasibuan et al., 2019; Rusliyadi et al., 2018).

3. Metal Exports Are Not Significant

The results indicate that metal exports are not significant (coefficient -0.0056, p-value 0.7687), suggesting that this sector does not have a clear impact on the dependent variable. This can be explained by several factors, such as the dominance of large companies in the metal industry that are more export-oriented and provide fewer direct benefits to the local community or poorer segments of the population. In addition, the metal industry is often capital-intensive and does not create many job opportunities for the local community. Thus, the increase in metal exports does not directly reduce poverty or improve social welfare. The results of this study are also supported by several findings from previous research that state that although this industry may contribute significantly to export revenue, its direct benefits to the local community are often limited. The contribution of the metal sector to poverty reduction may be limited if the industry is predominantly owned by large companies and lacks a focus on local development (Davis & Tilton, 2005; Live & Msn, 2011; Loayza & Rigolini, 2016).



#### 4. The Relationship Between Models and Literature

Overall, these findings are consistent with much of the literature indicating that sectors such as agribusiness and extractive industries often have negative impacts on vulnerable communities, especially if not accompanied by fair and sustainable redistribution policies. Environmental interventions such as reforestation tend to increase poverty because they do not involve local communities in the sustainable management of natural resources.

#### 5. Limitations and Suggestions for Further Research

One limitation of this study is that it does not consider other factors such as technological changes in the metal sector or the role of redistribution policies in the palm oil industry. Further research could incorporate additional variables such as access to education, health, and infrastructure to provide a more comprehensive picture of the factors influencing poverty. In addition, it is recommended to conduct analyses at a more local level to see how the effects of export sector policies play out in various regions with different economic and social characteristics.

### 5. CONCLUSION

This research analyzes the impact of climate adaptation strategies, Crude Palm Oil (CPO) exports, and metal exports on poverty reduction in Indonesia from 2000 to 2023. The results indicate that there is a significant effect of reforestation and CPO exports on poverty, while metal exports do not show a significant impact.

1. **Reforestation and Poverty:** It was found that reforestation has a significant positive relationship with poverty, where an increase in reforestation actually raises poverty by 0.0366%. This may be due to reforestation projects that do not optimally involve local communities, resulting in the loss of access to primary livelihoods. Poorly planned reforestation can worsen the economic conditions of communities, especially in rural areas that heavily depend on local natural resources.
2. **CPO Exports and Poverty:** CPO exports have a significant negative impact on poverty, where every 1% increase in CPO exports reduces poverty by 0.1359%. This indicates that the CPO sector still plays an important role in the national economy and poverty reduction, although this sector also faces environmental challenges such as deforestation and greenhouse gas emissions.
3. **Metal Exports and Poverty:** Metal exports do not have a significant impact on poverty reduction, indicating that an increase in metal exports does not necessarily lead to a direct improvement in community welfare. This may be due to the more limited and uneven distribution of economic benefits from the mining sector, particularly in remote areas.

Overall, this research shows that climate adaptation strategies, particularly reforestation, need to be designed with greater attention to the needs of local communities in order to provide broader economic benefits and effectively reduce poverty. In addition, CPO exports remain an important sector in the effort to alleviate poverty in Indonesia, although improvements in governance and sustainability in this sector are urgently needed to reduce negative environmental impacts.

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