

Foreign Direct Investment, Economic Growth, and Environmental Degradation in Indonesia: Evidence from Ecological Footprint Data

Ahmad Hadi Hafidi^{1*}, Neli Aida², Dedy Yuliawan³

^{1,2,3}Faculty of Economics and Business, University of Lampung, Indonesia

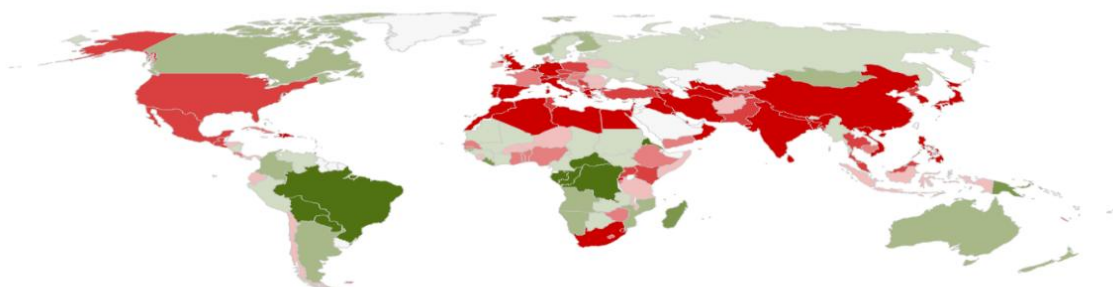
ABSTRACT: This study investigates the effects of foreign direct investment (FDI), economic growth, and population growth on environmental degradation in Indonesia over the period 1972–2022. Environmental degradation is proxied by the ecological footprint, which captures comprehensive pressure on natural resources. Using annual time-series data employing the Autoregressive Distributed Lag (ARDL) bounds testing approach, the empirical results reveal that FDI has a positive and statistically significant impact on the ecological footprint, thereby supporting the Pollution Haven Hypothesis. Economic growth exhibits a positive but statistically insignificant effect, indicating that economic expansion alone does not necessarily exacerbate environmental pressure. In contrast, population growth shows a negative and statistically significant relationship with environmental degradation, suggesting improvements in resource efficiency, urbanization dynamics, and environmental awareness over time. Overall, the findings underscore the importance of strengthening environmental regulations within investment policies and promoting sustainable development strategies to mitigate environmental degradation in developing economies such as Indonesia. This study contributes to the literature by providing long-run and short-run evidence on the FDI–environment nexus in Indonesia using ecological footprint data over a long historical period.

KEYWORDS: ecological footprint; foreign direct investment; economic growth; population growth; Indonesia

1. INTRODUCTION

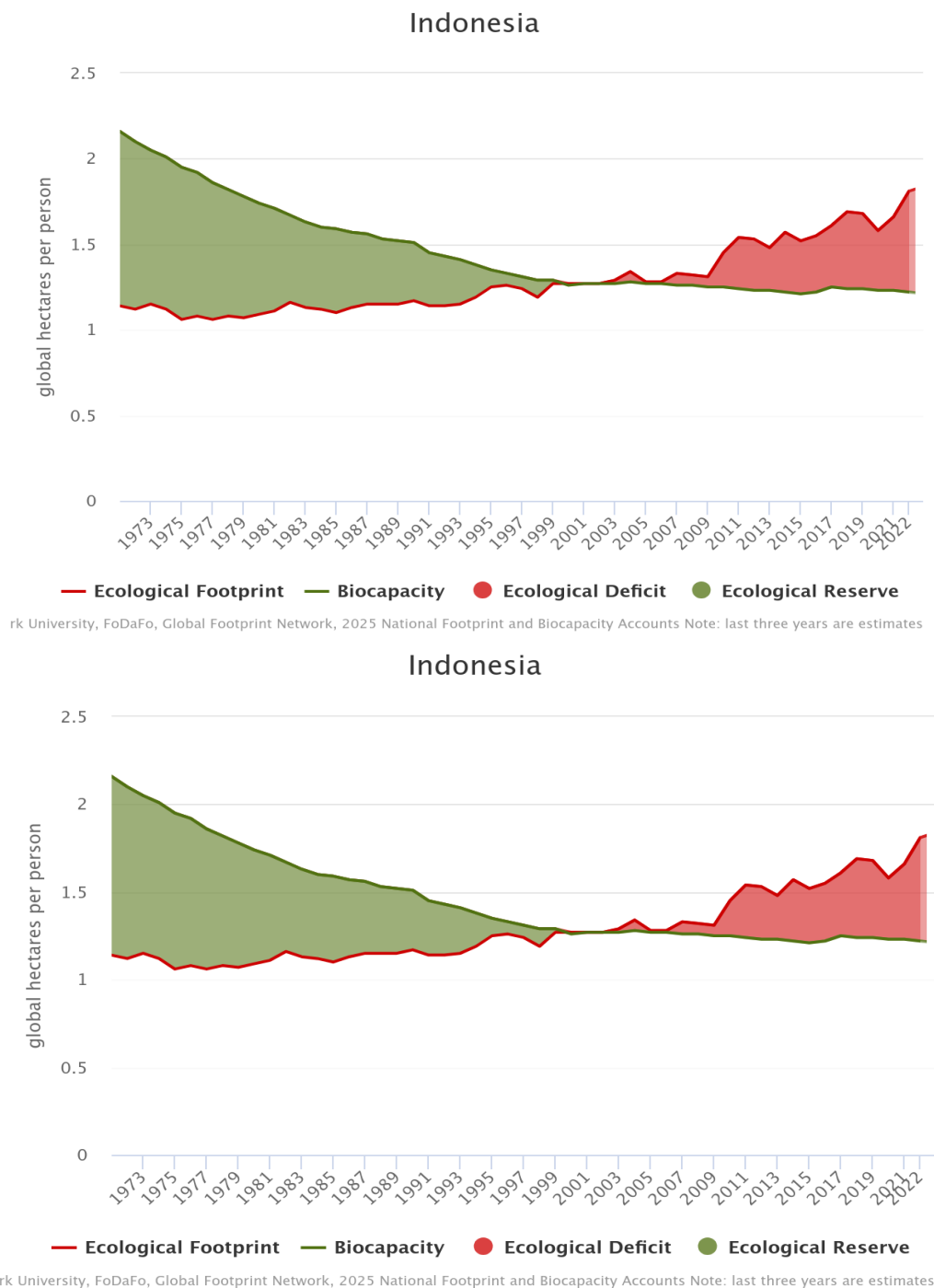
Environmental degradation has become a major challenge to achieving sustainable development, particularly in developing countries experiencing rapid economic growth and increasing foreign investment. Indonesia has experienced substantial economic expansion, demographic transition, and increased foreign direct investment (FDI) inflows over the past five decades. While these dynamics contribute to economic performance, they can also exacerbate environmental pressures through increased production, energy consumption, and natural resource exploitation.

Figure 1 Global Ecological Footprint in 2024



Source: GFN, 2024

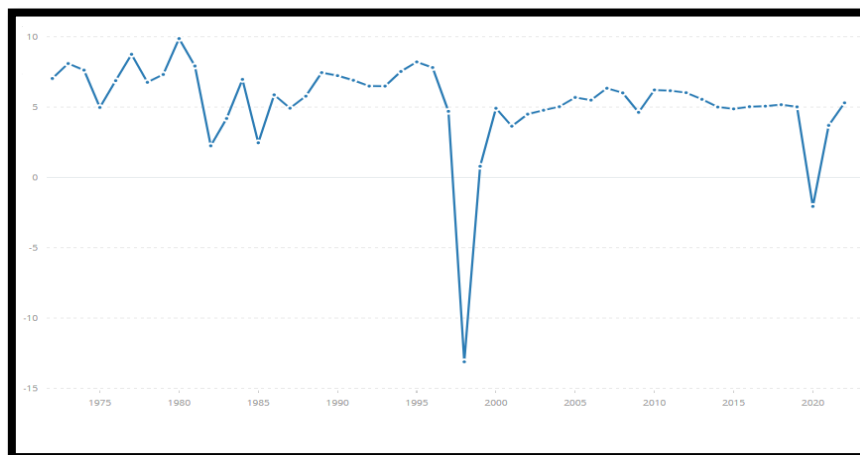
Figure 2 Indonesia's Per Capita Ecological Footprint from 1972-2022



Source: GFN, 2024

The relationship between economic growth and environmental degradation remains inconclusive. Some studies suggest that economic expansion worsens environmental quality, while others argue that technological progress and increased efficiency can reduce environmental degradation, consistent with the Environmental Kuznets Curve (EKC) hypothesis (Grossman & Krueger, 1995).

Figure 3 Indonesia's Economic Growth from 1972-2022



Source: World Bank, (accessed 2025)

Similarly, FDI can contribute to environmental degradation if multinational corporations move pollution-intensive activities to countries with relatively weak environmental regulations, a phenomenon known as the Pollution Haven Hypothesis. Conversely, the Pollution Halo Hypothesis argues that FDI can improve environmental quality through technology transfer and better management practices (Pao, H.-T., & Tsai, 2011).

Population growth is often considered a driver of environmental degradation due to the increasing demand for natural resources. However, recent studies have shown that population growth does not always worsen environmental conditions if accompanied by increased efficiency, urbanization, and environmental awareness (Dietz, Rosa, and E. Ugene A., 1997). An analysis of the relationship between population growth and environmental degradation was undertaken by Pimm et al. (2014). and (Crist et al., 2017) who concluded that the rapid development of the human species does not protect biodiversity. (Rashid Audil et al, 2018) concluded that Pakistan's biocapacity is unable to meet its population's needs due to population growth. (Ahmed Zahoor, et al., 2020) (D. and Z. Wang, 2019), (Lanouar & Mrabet, 2017), (Ul-haq et al., 2023), (J. Wang & Kangyin, 2019), reported evidence indicating that urbanization contributes to greater ecological footprint levels. Meanwhile (Naseem et al., 2023) population growth increases emissions.

Given these mixed theoretical and empirical findings, further investigation is warranted. This study contributes to the literature by examining the impact of economic growth, foreign direct investment, and population growth on environmental degradation in Indonesia, using the ecological footprint as a comprehensive environmental indicator. The long sample period (1972–2022) and the use of robust estimation techniques provide valuable insights into the environmental consequences of economic and demographic changes in a developing country context.

2. LITERATURE REVIEW

The Environmental Kuznets Curve (EKC) hypothesis proposes a nonlinear relationship between income and environmental degradation, where environmental pressures initially increase with economic growth and decline after reaching a certain income level (Grossman & Krueger, 1995). Empirical evidence regarding this

EKC is still diverse, especially when alternative environmental indicators such as ecological footprint are used (Al-mulali et al., 2015).

The relationship between foreign direct investment and environmental quality has been extensively researched. The Pollution Haven Hypothesis argues that differences in regulatory stringency encourage multinational enterprises to transfer environmentally damaging activities to countries with less strict environmental standards. Several empirical studies support this hypothesis in developing countries (Pao, H.-T., & Tsai, 2011), (Nathaniel, S., et al., 2020) . More recent evidence using ecological footprint indicators also confirms the environmental pressures associated with FDI inflows (C. Wang & Uctum, 2024).

Population growth has traditionally been associated with increased environmental pressures due to higher resource consumption. However, recent research suggests that population growth may not necessarily worsen environmental conditions if it is accompanied by increased efficiency and institutional improvements (Dietz, Rosa and, E Ugene A., 1997).

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Based on existing literature, this study investigates whether economic growth, foreign direct investment, and population growth significantly influence environmental degradation in Indonesia.

3. METHOD

3.1 Data

This study employs annual time-series data for Indonesia covering the period 1972–2022, resulting in 51 observations. Environmental degradation is proxied by the ecological footprint (EF), measured in global hectares per capita, obtained from the Global Footprint Network. Foreign direct investment (FDI) is measured in current US dollars and transformed into its natural logarithm (LNFDI) to reduce scale effects and heteroskedasticity. Economic growth (EG) and population growth (PG) are measured as annual percentage changes. All data are sourced from the World Bank and the Global Footprint Network.

3.2 Model Specifications

To examine the long-run and short-run relationships between foreign direct investment, economic growth, population growth, and environmental degradation, this study adopts the Autoregressive Distributed Lag (ARDL) modeling framework developed by Pesaran, Shin, and Smith (2001). The ARDL approach is particularly suitable for small sample sizes and allows variables to be integrated of order zero $I(0)$ or one $I(1)$, but not $I(2)$.

The long-run relationship is specified as follows:

$$EF_t = \beta_0 + \beta_1 EG_t + \beta_2 LNFDI_{t-1} + \beta_3 PG_t + \varepsilon_t$$

Where EF_t denotes the ecological footprint, $LNFDI_t$ represents foreign direct investment inflows, EG_t is economic growth, PG_t is population growth, and ε_t is the error term.

3.3 ARDL Bounds Testing Approach

Before estimating the ARDL model, unit root tests are conducted using the Augmented Dickey–Fuller (ADF) test to ensure that none of the variables are integrated of order two. After confirming the integration properties, the ARDL bounds testing approach is applied to test for the existence of a long-run cointegration relationship among the variables.

The unrestricted error correction representation of the ARDL model is expressed as:

$$\begin{aligned} \Delta EF_t = & \alpha_0 + \sum_{i=1}^p \alpha_1 \Delta EF_{t-i} + \sum_{i=0}^q \alpha_2 \Delta LNFDI_{t-i} \\ & + \sum_{i=0}^r \alpha_3 \Delta EG_{t-i} + \sum_{i=0}^s \alpha_4 \Delta PG_{t-i} \\ & + \lambda_1 EF_{t-1} + \lambda_2 LNFDI_{t-1} + \lambda_3 EG_{t-1} + \lambda_4 PG_{t-1} + \mu_t \end{aligned}$$

The null hypothesis of no cointegration is tested as:

$$H_0: \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0$$

Cointegration is confirmed if the computed F-statistic exceeds the upper bound critical value provided by Pesaran et al. (2001).

3.4 Long-Run and Short-Run Dynamics

Once cointegration is established, the long-run coefficients are estimated from the ARDL model. The short-run dynamics are captured through the Error Correction Model (ECM), which reflects the speed at which deviations from the long-run equilibrium are corrected following short-term shocks. The ECM is specified as:

$$\Delta EF_t = \theta_0 + \sum \theta_i \Delta X_{t-i} + \phi ECM_{t-1} + v_t$$

where ECM_{t-1} is the lagged error correction term and ϕ is expected to be negative and statistically significant, indicating convergence toward long-run equilibrium.

3.5 Diagnostic and Stability Tests

To ensure the robustness of the ARDL estimates, several diagnostic tests are performed, including tests for serial correlation, heteroskedasticity, normality, and model specification. In addition, CUSUM and CUSUM of Squares (CUSUMSQ) tests are employed to assess the stability of the estimated coefficients over the sample period.

4. RESULTS AND DISCUSSION

4.1 Unit Root and Bounds Test Results

Prior to estimating the ARDL model, unit root tests were conducted using the Augmented Dickey–Fuller (ADF) approach. The results indicate that all variables are stationary at level $I(0)$ or first difference $I(1)$, and none of the variables are integrated of order two. This confirms the suitability of the ARDL bounds testing approach.

The ARDL bounds test for cointegration reveals that the calculated F-statistic exceeds the upper bound critical value at the 5 percent significance level. This result confirms the existence of a long-run cointegration relationship between ecological footprint, foreign direct investment, economic growth, and population growth in Indonesia.

4.2 Long-Run Estimation Results

The estimated long-run coefficients from the ARDL model indicate that foreign direct investment (LNFDI) has a positive and statistically significant effect on the ecological footprint. This finding suggests that increased FDI inflows contribute to higher environmental pressure in Indonesia over the long run.

Economic growth exhibits a positive but statistically insignificant relationship with the ecological footprint, implying that long-term economic expansion does not necessarily intensify environmental degradation. This result may reflect improvements in production efficiency, technological progress, and gradual structural transformation of the Indonesian economy.

Interestingly, population growth is found to have a negative and statistically significant long-run effect on the ecological footprint. This indicates that, over time, population growth in Indonesia has been associated with lower environmental pressure, possibly due to improved resource efficiency, urbanization processes, and enhanced environmental awareness accompanying demographic transition.

4.3 Short-Run Dynamics and Error Correction Model (ECM)

The short-run dynamics are examined using the Error Correction Model (ECM). The estimated error correction term ($ECM_{(-1)}$) is negative and statistically significant, confirming the presence of a stable long-run equilibrium relationship among the variables. The magnitude of the ECM coefficient suggests that deviations from long-run equilibrium are corrected relatively quickly, indicating effective adjustment mechanisms in response to short-term shocks.

In the short run, changes in foreign direct investment continue to exert a positive influence on the ecological footprint, although the magnitude is smaller compared to the long-run effect. This suggests that the environmental impact of FDI accumulates over time rather than occurring instantaneously.

Short-run changes in economic growth do not show a statistically significant effect on environmental degradation, reinforcing the view that economic fluctuations alone are not the primary drivers of ecological pressure in Indonesia.

Similarly, population growth exhibits a negative short-run effect on the ecological footprint, although the effect is weaker than in the long run. This implies that the environmental benefits associated with demographic changes materialize gradually through long-term structural and institutional adjustments.

4.4 Discussion

The empirical findings provide strong support for the Pollution Haven Hypothesis in the context of Indonesia. In the long run, foreign direct investment is found to increase the ecological footprint, reflecting the concentration of foreign investment in environmentally intensive sectors under relatively weak regulatory conditions. This result aligns with previous empirical studies that document the adverse environmental consequences of FDI in developing economies.

The lack of a statistically significant association between economic growth and environmental degradation indicates that economic expansion, by itself, does not necessarily result in greater ecological pressure. This finding is consistent with the Environmental Kuznets Curve (EKC) hypothesis, which posits that technological advancement and efficiency gains can offset the environmental costs of growth, particularly in economies undergoing structural transformation.

The negative association between population growth and ecological footprint challenges the conventional view that population growth necessarily exacerbates environmental degradation. In Indonesia, this result may reflect the role of urbanization, improvements in public infrastructure, declining fertility rates, and enhanced efficiency in resource utilization. These factors may enable the economy to accommodate population increases without proportionally increasing environmental pressure.

Overall, the ARDL and ECM results underscore the importance of distinguishing between short-run and long-run effects when analyzing environmental degradation. While foreign direct investment poses significant long-term environmental risks, demographic and economic dynamics can mitigate or amplify these effects depending on institutional quality and policy orientation.

5. CONCLUSION AND POLICY IMPLICATIONS

5.1 Conclusion

This study examines the effects of foreign direct investment, economic growth, and population growth on environmental degradation in Indonesia over the period 1972–2022 using the ecological footprint as a comprehensive environmental indicator. Employing the ARDL bounds testing approach, the results confirm the existence of a long-run cointegration relationship among the variables.

The long-run estimation results indicate that foreign direct investment has a positive and statistically significant impact on environmental degradation, providing empirical support for the Pollution Haven Hypothesis in the Indonesian context. This suggests that increased FDI inflows have been associated with greater ecological pressure over time.

Economic growth is found to have a positive but statistically insignificant effect on the ecological footprint, implying that long-term economic expansion alone does not necessarily exacerbate environmental degradation. This may reflect improvements in production efficiency, technological progress, and structural transformation within the economy.

Interestingly, population growth exhibits a negative and statistically significant relationship with environmental degradation, indicating that demographic expansion in Indonesia has been accompanied by improvements in resource efficiency, urbanization processes, and environmental awareness.

Overall, the findings highlight the importance of distinguishing between short-run and long-run effects when analyzing environmental sustainability and underscore the role of institutional and policy frameworks in shaping environmental outcomes.

5.2 Policy Implications

The findings of this study offer several important policy implications for Indonesia. First, the statistically significant positive relationship between foreign direct investment (FDI) and environmental degradation suggests that increased FDI inflows can intensify environmental pressure in the presence of inadequate environmental regulations. Therefore, policymakers should strengthen environmental standards in investment policies, including stricter environmental assessments and better enforcement, to ensure that foreign investment supports sustainable development.

Second, the insignificant impact of economic growth on environmental degradation suggests that economic growth alone does not necessarily worsen environmental conditions. This implies that policymakers should focus on improving the quality of growth by promoting cleaner production processes, technological innovation, and more efficient use of natural resources, rather than prioritizing growth quantity alone.

Third, the negative and significant relationship between population growth and environmental degradation indicates that population growth in Indonesia may be accompanied by improvements in resource efficiency and environmental awareness. This finding suggests that effective urban planning, infrastructure development, and environmental education can help reduce environmental pressure despite increasing population size.

Overall, these results highlight the importance of integrating environmental considerations into investment and development policies. Strengthening environmental regulations, promoting sustainable economic growth, and supporting efficient resource use are essential to reduce environmental degradation while maintaining long-term economic development.

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