**A Temporal Analysis of Macroeconomic Indicators and Environmental Degradation in Emerging and Developing Asian Countries**

**Abstract**

Developing Asian countries have witnessed rapid economic expansion, it has also become increasingly vulnerable to severe environmental challenges, including rising carbon emissions, deforestation, climate induced disasters. This region face acute environmental stress that threatens long term sustainability.

This paper aims to examine the trends and patterns of Environmental Degradation, Economic Growth, Energy Consumption and FDI inflows, along with other controlled variables in Asian Emerging and Developing Economies from 1995 to 2022. For this purpose, this study computed the descriptive statistics, estimated time trend regression and various graphs have been demonstrated to highlight the trends and patterns in these nations. Results of time trend regression show that GHG emissions and Globalisation are continuously increasing while population and GDP depict a declining trend. There is significant heterogeneity among countries for GHG emissions, Energy Consumption, FDI inflows and Industrialisation, while stable or gradually increasing patterns were observed for economic growth and globalisation index.

These findings will be useful for policymakers to formulate policies to promote growth, keeping in view their environmental repercussions.

Keywords: Trends and Patterns, Economic Growth, Environmental Degradation, Environmental challenges

1. **Introduction**

The delicate association between economic growth and environmental sustainability has drawn significant attention, particularly within the rapidly developing Asian nations, in recent decades. These countries stand at the critical crossroads where the pursuit of growth often comes at the cost of environmental degradation. While economic growth has contributed significantly to infrastructure development, poverty reduction, etc, across Asia, it has also intensified ecological stress. Several countries are undergoing the outcomes of environmentally unsustainable development approaches that neglect environmental externalities. This region went through rapid economic prosperity that has led to a considerable rise in income level, along with enhanced quality of life, but all this has concurrently triggered environmental alarm. The environmental influence of this rapid expansion is intense and complex. Many countries in the area are facing the severe effects of rising air and water contamination, deforestation and loss of biodiversity. Globalisation and growing manufacturing activities have raised the requirement for energy usage, the majority of which is still generated by fossil fuels, further stimulating the ecological deterioration. Such as particulate matter concentrations in urban areas of China, India and Bangladesh frequently exceed the threshold levels, leading to severe public health emergency. Forested regions in Southeast Asia have been depleted at alarming rates due to unsustainable agricultural practices, illegal mining and land conversions. Moreover, many Asian developing nations lie in climate-sensitive zones, making them disproportionately subject to the detrimental outcomes of climate change. Increasing levels of sea, floods, unpredictable monsoons and heatwaves have intensified in frequency and magnitude, severely affecting food security, infrastructure, agriculture and livelihoods. The rural poor, coastal communities and informal labor sectors- already socioeconomically vulnerable-are the most affected. Nations such as Phillippines, Bangladesh and Myanmar are regularly listed among the most climate-vulnerable countries in the world, highlighting the region’s acute exposure to environmental shocks.

The balance between economic prosperity and environmental preservation in these nations is further complicated by institutional limitations, policy gaps and the pursuit of short-term growth targets. Many of these nations lack robust environmental governance, adequate implementation of policies and access to cleaner technologies. The developmental approach mostly concentrates on short-term economic returns over long-term sustainability, with ecological threats overlooked in the national development plan. The scarce fiscal competence of governments, reliance on fossil fuels and hurdles in switching to green infrastructure lead to the continuation of pollution-intensive development trends. Ecosystem balance, along with long-term economic dependence and societal well-being, is vulnerable to the region’s sustainability concerns. The intensity of the problem in this region is extremely worrisome, as rising industrialisation, urban sprawl and energy usage have triggered a rapid surge in carbon footprint. Additionally, the demographic burden of the region and expanding consumer needs sustain to exert pressure on natural resources, generating a self-perpetuating cycle that endangers the long-term viability of development actions. This area retains the pivotal role for the worldwide discussions of sustainable development due to significant development strains coupled with a rigorous regulatory approach.

In this context, this paper illustrates an extensive trend and patterns of selected variables across Emerging and Developing Asian Economies from 1995 to 2022. The visualisation of these trends across countries give critical preliminary insights into dynamics of growth environment nexus and sets the stage for the econometrics analysis that follows.

In a nutshell, this paper visually maps the trajectory of key indicators relevant to sustainable development in Asia. It not only provides the foundation for understanding the underlying data but also reinforces the urgency of addressing environmental degradation in the context of continued economic expansion. Given the heterogeneity in developmental stages and environmental performance of Asian economies, it is essential to understand how macroeconomic activities and environmental degradation co-evolve over time. This research is grounded in the rationale that temporal patterns offer valuable diagnostic insight, especially for policymakers and development planners working toward sustainability goals. The patterns thus observed, will provide valuable implications for policy design. The patterns thus observed, will provide valuable implications for policy design.

1. **Literature Review**

**Halicioglu (2009)** acquired data for Turkey, utilised the ARDL bound test of co-integration, and observed the positive bidirectional association between Energy Consumption and CO2 release from 1960 to 2005.

Using the ARDL methodology and the bounds cointegration method, **Jayanthakumaran et al. (2012)** compared the association among economic prosperity, trade, energy consumption and structural breaks for India and China. They concluded that per capita energy usage has a significant direct influence on CO2 release in both the short and long term.

**Akin, C. S. (2014)** studied the influence of energy usage and some other variables on CO2 emission for a group of 85 countries from 1990 to 2011 by using panel data cointegration techniques DOLS and FMOLS and observed that rise in energy usage increases the CO2 release i.e. there is a direct association between energy usage and CO2 emission.

**Abdouli and Hammami (2017)** studied the influence of FDI inflows and other variables on ecological deterioration in 17 MENA countries from 1990-2012 utilising static and dynamic panel data methods. Both for static as well as dynamic models, they observed a positive association between both the variables.

**Fan and Hossain (2018)** have taken CO2 emissions as one of the determinants of economic prosperity in China and India between 1974 and 2016. By using the ARDL bound test and Toda–Yamamoto Granger causality test, they observed that CO2 release has a significant direct effect on the economic prosperity of China and India at one percent and five percent levels of significance, respectively.

From 1995 to 2017, **Gulistan et al. (2020)** examined how environmental degradation was affected by economic growth and a few other factors in 112 different nations. They confirmed the existence of the EKC hypothesis and discovered that economic prosperity is detrimental to the environment using pooled OLS, fixed and random effect models and GLS for estimation.

**Rajeshwari U (2020)** conducted a study in which she collected data from the World Bank database for India from 1960 to 2017 and applied the ARDL model. The findings reveal that both in the long run and short run, GDP per capita has a significant positive impact on CO2 release, which implies that economic growth leads to environmental deterioration.

**Omoke et al.(2021)** assessed the influence of ecological degradation and other variables on economic progress in Venezuela over the period 1980 - 2019 by utilising the non-linear ARDL model. They found that carbon emissions do not influence the economy of Venezuela, both in the long run as well as the short run.

**Afriyie et al. (2023)** examined trends in GDP per capita and CO₂ emissions per capita in African countries from 1996 to 2019 and found that there was regular rise in GDP per capita across most countries but trends were uneven for CO2 emissions, with some nations displaying increase while others remained stagnant or declined. The correlation heat map showed that renewable energy use and governance quality were negatively associated with CO₂ emissions, while urbanization was positively associated.

**Alshehry and Belloumi (2024)** explored the association between energy usage and CO2 release by controlling certain variables for MENA nations between 1990 and 2020. They used linear and nonlinear panel ARDL models and observed that a rise in energy usage leads to higher CO2 release both in the long run and short run. The robustness of the result was also verified by utilising fully modified OLS and dynamic OLS.

**López‑Milla et al. (2025)** analysed the BRICS countries from 1991 to 2023 through time-series trend plots of CO₂ emissions and GDP per capita and highlighted that there is persistent emission growth in India and observed a peak in China’s emissions early in the 2010s followed by decline. These visualizations explained heterogeneity in economic growth and environmental impact across BRICS nations.

1. **Research Methodology**
   1. **Data Sources and Model Construction**

The purpose of the present study is to identify the trends and patterns of environmental deterioration, Economic Growth, FDI inflows, Energy Consumption and other controlled variables in Asian Emerging and Developing Economies. Greenhouse Gas and Gross Domestic Product have been taken as the proxy for environmental degradation and economic growth, respectively. As per the World Economic Outlook 2023, there are thirty emerging and Developing Economies, out of which fifteen have been chosen for the present study. All the variables are expressed in natural logarithmic form for comparability and to stabilise variance (except FDI, I and P as these variables are already expressed in percentage). This study adopts a descriptive and trend based analytical approach. Time series plots were used to illustrate the direction and magnitude of changes in variables over 1995 to 2022 period. The study adopts a non-parametric and descriptive statistical approach to reveal how these variables have evolved over time. Each variable is visually examined through country-wise plots to facilitate clear comparison of progress, stagnation or divergence across economies. Time trend regression was used to detect statistically significant linear or nonlinear temporal changes in the variables. Descriptive statistics were used to characterise variability and distribution. This approach is consistent with exploratory studies focused on identifying preliminary patterns before causal modelling (Afriyie et al., 2023; Shahbaz et al., 2015).

General Trend Equation:

Yit =α i + βit + µit

where

Yit is GHG, GDP, EC, FDI, G, I, P

αi is country specific constant

βi is trend coefficient

µit is error term

**Table 1: Description of Variables**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable Name | Source | Notation | Units |
| Greenhouse Gas Emissions | EDGAR | GHG | GHG per capita, CO2 equivalents |
| Gross Domestic Product | World Bank | GDP | GDP per capita, constant 2015 US$ |
| Energy Consumption | Our World in Data | EC | kWh per person |
| Foreign Direct Investment | World Bank | FDI | Net inflows (% of GDP) |
| Globalisation Index | Swiss Economics Institution | G | KOF index |
| Industrialisation | World Bank | I | Industry value added (% of GDP) |
| Population Growth | World Bank | P | Annual % |

EDGAR: Emissions Database for global atmospheric research

The above table shows the data sources, notation and units for various variables under consideration.

**4. Results and Discussion**

This section shows the empirical outcomes of the study, which aims to find out the trends and patterns of selected variables in Asian Emerging and Developing Countries. The discussion begins with descriptive statistics.

**Table 2: Descriptive Statistics**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Variables | Obs. | Mean (Overall) | Std. Dev. (Overall) | Min. | Max. | Std. Dev. (Between) | Std. Dev. (Within) |
| lnGHG | 420 | 1.021378 | .611951 | -.0852183 | 2.393714 | .5954814 | .2067267 |
| lnGDP | 420 | 33.21497 | .9849397 | 28.21006 | 34.53719 | .3246319 | .9335477 |
| lnEC | 420 | 16.53074 | 1.133817 | 11.73746 | 18.4556 | .2810958 | 1.100736 |
| FDI | 420 | 3.03e+14 | 2.86e+14 | -9.89e+14 | 9.83e+14 | 7.19e+13 | 2.78e+14 |
| G | 420 | 3.938955 | .2519874 | 3.091043 | 4.394449 | .2144652 | .1430602 |
| I | 420 | 29.76188 | 10.50604 | 5.251095 | 48.53032 | 9.885426 | 4.353439 |
| P | 420 | 1.39684 | .8245641 | -.0577971 | 4.422534 | .7124151 | .4528529 |

Source: Author’s Calculation

The above table summarizes descriptive statistics based on 420 observations for panel data. The overall mean of lnGHG is around 1.021378, with an overall standard deviation of .611951. The minimum and maximum values are -.0852183 and 2.393714, respectively, which demonstrates a broad range of observations, i.e., some countries contribute disproportionately more to overall emissions. The between-standard deviation of 0.60 is significantly higher than the within variations, which shows that emissions levels vary more across countries than they do over time within the same country. Mean GDP stands at 33.21497, with overall standard deviation 0.9849397. Here, within-country variation of 0.9335477 is much higher than between-country variation of .3246319, which signifies that GDP levels have shown notable year-to-year fluctuations within countries, probably due to policy shifts, business cycles or external shocks. The average of EC is 16.53074, with an overall standard deviation of 1.133817. There is a large within-standard deviation compared to between-standard deviation, which indicates that energy usage trends change substantially over time within countries, possibly prompted by the adoption of technology or energy policies. Mean of FDI is around 3.03\*1014, indicating a massive scale. Within-country standard deviation is extremely higher than the between-country standard deviation, highlighting that FDI is extremely inconsistent across years, rather than consistently different across countries. The large range between maximum(9.83\*1014) and minimum( -9.89\*1014) values shows the presence of sharp inflow adjustments. The average G is 3.938955, with a small standard deviation of .2519874, suggesting relative stability. Between variations are slightly higher than within-country variations, showing globalisation differs moderately across countries and remains mostly stable over time. Mean of I is 29.76188, with a relatively high standard deviation of 10.50604. Between-country variation (9.885426) is more than double the within variation (4.353439), indicating between gaps are more significant than time-based changes. Mean of P is 1.39684, with a standard deviation of .8245641, both between and within variations are high, reflecting that population levels vary notably both across countries and over time.

Several prior studies (Shahbaz et al., 2015; Afriyie et al., 2023; Acheampong, 2019) have emphasized the importance of time series methods in environmental economics for assessing change without immediately inferring causation. This study builds upon that foundation by integrating multi-country, multi-variable visualizations and descriptive regressions to portray the evolution of the economic-environment nexus.

**Table 3: Time Trend Regression Estimates**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dependent Variable | Coefficient on Year | Std. Error | R2 | Obs. |
| lnGHG | .0182706\*\*\* | .0035915 | 0.0583 | 420 |
| lnGDP | -.0117957\*\* | .0059288 | 0.0094 | 420 |
| lnEC | -.0000792 | .0068572 | 0.0000 | 420 |
| FDI | -1.81e+12 | 1.73e+12 | 0.0026 | 420 |
| G | .7041598\*\*\* | .0670271 | 0.2089 | 420 |
| I | .036292 | .0635146 | 0.0008 | 420 |
| P | -.0302758\*\*\* | .0047619 | 0.0882 | 420 |

Source: Author’s Calculation

The above table demonstrates that greenhouse gas emissions (lnGHG) have increased significantly over time, as shown by a positive and statistically significant coefficient. This suggests a rising environmental burden over the concerned time frame. Conversely, GDP exhibits a slight but statistically significant declining trend, possibly reflecting economic volatility or post-crisis adjustments.

Energy consumption, FDI inflows and industrialisation show no statistically significant time trends, suggesting these variables have remained relatively stable or fluctuated randomly over time.

The globalisation index has increased substantially over time, with a large and highly significant coefficient. The population exhibits a statistically significant downward trend, which may reflect demographic transitions or decreasing growth rates in the countries studied.

Now, to visually complement the above regression, Figures 1 to 7 present the trends of various variables under consideration over the period 1995 to 2022 for Asian Emerging and Developing economies. Time series trend analyses have been used in environmental economics to highlight temporal changes without inferring causality (Shahbaz et al., 2015).

**Greenhouse Gas**



**Figure 1: Trends of GHG over time**

The above figure reveals significant heterogeneity across countries. Malaysia and China consistently recorded the highest emission levels, with China showing a significant upward trend. India, Vietnam and Indonesia followed with moderate but steady increases. In contrast, countries such as Myanmar, Fiji and Papua New Guinea maintained relatively low and stable emission levels. There are fluctuating trends in Nepal and Sri Lanka. These trends stress the need for country-specific environmental strategies that account for both temporal and structural dynamics.

**Gross Domestic Product**



**Figure 2: Trends of GDP over time**

The plotted GDP trends reveal that most countries experienced a relatively stable or gradually increasing pattern in economic growth over the study period. Malaysia, China and India consistently recorded higher GDP levels, reflecting their comparatively larger and more resilient economies. Conversely, countries like Bangladesh, Indonesia and Papua New Guinea displayed significant year-to-year volatility, probably due to economic shocks or structural issues. There are sharp fluctuations and sudden drops in several smaller countries, showing that GDP in these nations may be more prone to external disruptions.

**Energy Consumption**



**Figure 3: Trends of EC over time**

The graph showing trends in energy consumption reveals significant variability across countries. Stable energy use trends are shown by Malaysia, China and Philippines while sharp fluctuations are illustrated by India, Indonesia, Nepal and the Maldives, possibly due to changes in infrastructure policies or energy crises, Fiji and Papua New Guinea exhibits erratic trends. Overall, the heterogeneous trends emphasise on the relevance of nation-specific energy strategies and the varied speed of development of energy infrastructure in the Asiatic region.

**Foreign Direct Investment**



**Figure 4: Trends of FDI over time**

Majority of the countries show unstable movements, with sudden spikes and sharp declines, signifying that foreign investment flows are extremely responsive to modifications in national investment strategies, political events and macroeconomic shocks. Nepal, Thailand and Papua New Guinea illustrate noticeable variations, while Malaysia, China and Vietnam show relatively stable trends over time. Overall, the lack of steady long-term growth in FDI, emphasises its susceptibility and the requirement for stable investment environments to attract and retain foreign capital.

**Globalisation**



**Figure 5: Trends of G over time**

The above figure shows a broadly rising trends for almost all the countries, suggesting enhanced international integration. Malaysia experiences the highest globalisation levels, followed by China, Vietnam and Thailand. Modest growth is experienced by India and Nepal, while initiating at a lesser levels. On the other hand, smaller island nations like Fiji and Papua New Guinea continue to be relatively less globalised. Due to varying decision making approaches, economic openness and geopolitical positioning trends of globalisation have a varying pace throughout the area.

**Industrialisation**



**Figure 6: Trends of I over time**

The above figure reveals extensive variation in industrialisation among the selected nations. Industrialisation levels remained elevated and steady for China, Malaysia and Indonesia. Vietnam and Bangladesh are experiencing gradual increase whereas countries like India, Sri Lanka and Nepal either remain static or mildly deteriorate, showing that probably these economies are becoming increasingly service-driven. Broadly, minimal industrialisation in small island nations like Maldives and Fiji emphasise their economic dependence on non-industrial sectors.

**Population**



Figure 7: Trends of P over time

The above figure reveals an overall reduction of population pressure, adapting to regional growth paths and population shifts. Conversely, anomalies like Maldives exhibit a sudden rise, probably because of spikes in migration or tourism. Countries like India, Nepal and Bangladesh maintain moderate population pressure, whereas smaller or more developed countries like Malaysia, Sri Lanka and Fiji demonstrate stabilisation. These varying patterns emphasised the diverse possible effects of demographic changes on the environment and the economy.

1. **Conclusion and Policy Suggestions**

This paper determined the trends and patterns of Environmental Deterioration, Economic Growth, FDI inflows, Energy Consumption and other controlled variables in Asian Emerging and Developing Economies from 1995 to 2022.

There is general variability in the trends of GHG emissions, Energy Consumption and FDI among selected countries, thus emphasising the requirement for country-specific strategies, while GDP and Globalisation show general rising pattern. While population patterns are highly varied, indicating different demographic dynamics, industrial trends vary significantly.

The results thus obtained emphasised the requirement to analyse the growth and environmental degradation nexus in these countries. As these nations aim for higher growth, adequate focus should be placed on developing policies that closely monitor both environmental growth and degradation. Hence, there is need for proactive environmental regulations and clean technology adoption even in early development stages. Future studies should apply econometric models (e.g., ARDL, VECM) or panel data techniques to investigate causal relationships and include institutional and demographic variables to provide deeper insight into the environmental impacts of macroeconomic change.

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During the editing of this manuscript we have used OpenAI’s ChatGPT (GPT 4) to help in language editing. All content was reviewed by authors.

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