

RESEARCH PAPER

Green Financing, Development Aid and Economic Growth: An Empirical Investigation of India's Experience

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ABSTRACT

The growing interest in sustainable development has enhanced the necessity to determine the role played by green financial flows and development assistance in facilitating economic growth. The research paper analyses how green finance and official development assistance affect economic growth in India over the period 2002-2022. The analysis uses important macroeconomic variables, such as net official development assistance (NET_ODA), environment-related aid (ENV_ODA), foreign direct investment (FDI), renewable energy investment (REI), domestic credit (DC), and trade openness (TRADE). The study uses Autoregressive Distributed Lag (ARDL) bounds testing method to capture both short-run and long-run dynamics. The findings establish a long-run cointegration relationship between the variables. Empirical evidence shows that total development assistance plays a significant role in economic growth whereas environmentally oriented aid plays a positive role in sustainable development in the long run. Investments in renewable energy also exhibit long term growth benefits despite short run adjustment costs. The impact of FDI and domestic credit on economic performance is however mixed in the study period. The results indicate that the strategic distribution of development aid to environmentally friendly sectors and the reinforcement of green financial institutions can improve the economic stability and help India to move to the low-carbon economy. The research has some policy implications in enhancing the performance of external financial flows towards the realization of sustainable economic development.

HIGHLIGHTS

- ① Green financial flows significantly influence India's economic growth dynamics.
- ② Environment-focused development aid assists long-term sustainable economic development.
- ③ ARDL analysis testifies to the existence of a stable long-run relationship between green finance and development aid with the macroeconomic variables.
- ④ REI result in sustainable growth in spite of short-run adjustment costs.

Keywords: Green finance, environmental aid, renewable energy investment, trade, ARDL model

The issue of climate change, environmental degradation and exploitation of unsustainable resource -has continued to dominate global development discourse over the past few decades. Governments and international bodies are now paying more attention to ensuring that environmental sustainability is factored in the strategies of economic development. In this respect, green finance has gained a significant attention since it is the way of channeling financial resources to environmentally friendly projects

such as development of renewable energy, climate mitigation projects and green infrastructure projects. Green finance is now a popular tool in the process of transitioning to low-carbon economic and environmentally friendly economic systems. In the meantime, the external financial assistance,

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particularly the ODA continues to play a significant role in financing development activities in the emerging economies.

When a fast-growing economy such as India is involved, the availability and effective utilization of financial resources play a role in achieving sustainable economic growth and environmental concerns. Despite a rich literature on foreign aid and economic growth, little has been done in comparison with how green finance and environmental-oriented development assistance relate to economic performance. The relationship is particularly applicable to the emerging economies that tend to balance both growth and environmental sustainability. It is against this background that the present research aims to investigate the relationship between green finance, development aid and economic growth in India. The objectives of the study are:

1. To study the effect of green finance and green development aid on economic growth in India in the short run and long run over the period 2002-2022.
2. To assess the impact of green financial flows on sustainable economic growth and offer policy suggestions to improve green finance and development assistance to India.

This study contributes to the existing body of literature in several aspects. To begin with, it provides empirical evidence on the relationship between green finance, development aid, and economic development in India that had hitherto received little research attention in the earlier studies. Second, this paper examines the macroeconomic effects of green financial flows and environmental assistance as compared to other past researches that primarily focus on the environmental results. Third, the research offers more specific information on the impact of external financial support and the green finance mechanisms on the sustainable economic development since it performs an analysis of long-run and short-run dynamics, relying on the use of time-series econometric approaches. These findings will yield at least a few good policy implications on how to improve the performance of green finance and development aid in the emerging economies.

LITERATURE REVIEW

The increasing global concern on climate change and environmental degradation has led to the increasing interest on the role of green finance and environmentally oriented development assistance in attaining sustainable economic growth. Green finance in general terms is any financial investment that promotes ecologically friendly operations such as renewable energy projects, climate reduction efforts, and green technology. Over the past few years, scholars are starting to pay more attention to the role of such financial mechanisms in not only protecting the environment but also developing the economy in the long term.

An increasing body of empirical evidence shows the positive association between the green finance and sustainable economic performance. Such as Dong *et al.* (2024) discovered that green financial systems in China were greatly instrumental in promoting inclusive growth through the encouragement of environment friendly investments and promotion of technological innovation. Similarly, Hou *et al.* (2023) in a cross-country survey of 53 economies found that green finance is significant in speeding up the renewable energy agenda, by allocating funds to environment friendly technologies and energy infrastructure. Along with the expansion of green energy, green financial flows have been linked to increased energy efficiency and the overall sustainability improvements. Sultanuzzaman *et al.* (2026) showed that growth of green finance with substantial effect on enhancing energy efficiency in the developing economies and Henneh and Awunyo-Vitor (2026) showed evidence in Ghana that green financing contributes to inclusive growth in the form of fostering investment and employment in environment friendly sectors. Apergis *et al.* (2024) examined the topic of green aid flows allocation and discovered that their efficiency is mostly determined by the distribution of funds among the sectors like renewable energy, environmental protection. Previous studies by Costantini and Mele (2018) also highlighted the growing relevance of environmentally oriented assistance in the promotion of climate mitigation measures in the developing economies. Empirical findings also indicate that there are chances that environmental aid can help in improving the environment and mitigating emissions. Debel and Wang (2025)

discovered that environmentally oriented aid flows are important in mitigating carbon emission by promoting renewable energy use and sustainable development projects.

Recent research also lays emphasis on the contribution of financial innovation and alternative financing measures in enhancing green development. According to Asongu *et al.* (2025), new tools like fintech-based funding and crowd-funding can supplement the traditional development finance by deploying more resources to the sustainable projects. Similarly, Liu and Liu (2025) have maintained that green bonds and other green financial instruments can also be employed in the financing of renewable energy and low-carbon technologies. The studies on the area also indicate that external financial flows can contribute to the environmentally sustainable development as long as there is an adequate institutional establishment. Tang and Chen (2026) found that sustainable development in African countries is associated with foreign aid and investment, but Gourouza and Kouni (2025) found that green finance is a significant contributor to energy transition and protection of the biodiversity.

Overall, the literature indicates that green finance and environment-specific development aid may be used to boost the development of renewable energy, improve the quality of the environment, and facilitate sustainable economic growth. The effectiveness of these financial mechanisms depends, to a large extent, on the capacity of the institution, coordination of policies and building of financial sector.

Even though the literature has been growing more and more, gaps still exist. Much of the literature available focuses on cross country or regional research, particularly in Africa or China, with little empirical evidence available on India. Second, many studies center on the environmental outcomes such as the decrease of carbon emissions or the creation of renewable energy and comparatively little attention is paid to the macroeconomic impact of the green financial flows. Third, green finance and environmental aid tend to be examined independently, and how they affect each other on the economic development has been scarcely empirically examined. Also, few studies employ more advanced time-series econometric models to

analyses the dynamicity of the relationship between these variables in one country.

To address these gaps, this research paper examines the short-term and long-term relationship between green finance and ODA and the Indian economic growth using an ARDL modeling approach. The research study aims at providing empirical information on the potential to utilize external financial resources to facilitate sustainable economic development within the Indian setting by the analysis of the cointegration process between the variables.

METHODOLOGY

The paper examines the relationship between development aid, green finance and economic growth in India using time-series analysis over the period 2002-2022. The selected period will include the significant shifts of the policy of sustainable finances, expansion of renewable energy, and the streams of foreign development aid. The analysis was based on reliable global databases to gather the data of the variables in Table 1, including World Development Indicators (WDI) of World Bank, Organization of Economic Co-Operation and Development (OECD), Creditor Reporting System (CRS) and International Renewable Energy Agency (IREA).

Table 1: Variable Definitions

Variable	Description	Source
GDP	GDP Growth (annual%)	WDI
NET_ODA	Net ODA received (% of GNI)	WDI
ENV_ODA	Environment-focused ODA (% of Total ODA)	OECD, CRS
FDI	FDI, net inflows (% of GDP)	WDI
REI	Renewable Energy Investment Growth Rate (%)	IREA
DC	Domestic Credit to Private Sector (% of GDP)	WDI
TRADE	Trade (% of GDP)	WDI

Source: Researcher's computations based on secondary data.

In particular, the General Environment Protection group under the multi-sector and cross-cutting sector was employed as a proxy of environmentally oriented aid. Variable can be calculated as:

$$ENV_ODA(\%) = \left(\frac{\text{Environment-focused ODA(US\$)}}{\text{Total ODA (US\$)}} \right) \times 100$$

Likewise, the renewable energy investment is indicated as a ratio of investment in renewable energy to total energy investment:

$$REI(\%) = \left(\frac{\text{Investment in Renewable Energy}}{\text{Total Energy Investment}} \right) \times 100$$

Moreover, a growth indicator is taken to reflect the annual growth in REI. These indicators give an idea about the level as well as dynamic development of green investment in India in the period of study.

$$REI \text{ Growth Rate } (\%) = \left(\frac{REI_t - REI_{t-1}}{REI_{t-1}} \right) \times 100$$

Model Specification

In order to test the association between development assistance, green finance, and economic growth, the next baseline econometric model is formulated:

$$GDP_t = \beta_0 + \beta_1 NET_ODA_t + \beta_2 ENV_ODA_t + \beta_3 FDI_t + \beta_4 REI_t + \beta_5 DC_t + \beta_6 TRADE_t + \varepsilon_t$$

This research uses the ARDL bounds testing model to estimate the dynamic relationship among the variables. Once cointegration has been determined, the short-run dynamics is estimated with the help of the Error Correction Model (ECM):

$$\Delta GDP_t = \alpha_0 + \alpha_1 \Delta GDP_{t-1} + \alpha_2 \Delta NET_ODA_t + \alpha_3 \Delta ENV_ODA_t + \alpha_4 \Delta FDI_t + \alpha_5 \Delta REI_t + \alpha_6 \Delta DC_t + \alpha_7 \Delta TRADE_t + \lambda ECM_{t-1} + \varepsilon_t$$

The coefficient of the ECM is a measure of how quickly short-run deviations correct themselves to long-run equilibrium. Diagnostic tests are done to ensure the reliability of estimated model.

RESULTS AND DISCUSSION

The descriptive statistics provide the picture of the distributional characteristics of the variables during the study period in India. Table 2, showed

the variability in economic growth was moderate, indicated variability in the performance of macroeconomic variables in the sample period. The skewness of development assistance and foreign investment was positive, which implies that the inflows were more in particular years. The investment in renewable energy is quite volatile, and this implies that the flows of green investments have been highly uneven as a result of policy changes and evolving energy priorities.

The stationarity of the variables was also tested prior to the estimation of the econometric model through the Augmented Dickey-Fuller Test (ADF) and Phillips-Perron Test (PP). The unit root test of Table 3 indicates that certain variables stationary at level, whereas others are stationary at first difference. This combined order of integration (I (0) and I (1)) justifies the use of ARDL framework to estimate empirically.

Table 4 indicates the estimation of ARDL Model that the influence of ODA on the growth of an economy is positive and statistically significant. This observation suggests that development aid acts to boost the economic performance in terms of development of infrastructure, institutional capacity building and sustainable in nature investment. Similarly, environmental development assistance positively affects growth and has a lag effect, such that the economic impacts of green-based aid may not manifest themselves in the short-term but will in the Long-run. On the other hand, REI and economic growth have a negative and statistically significant relation in the estimated model. This result could be explained by the short-term adjustment costs of energy transition that include high capital requirements and changes in technology. The effects of FDI and trade openness are statistically insignificant showing that their growth effects may be contingent on structural and institutional factors. The positive contribution of development assistance and environmental aid to economic growth is also supported by the long-run. These findings suggest the potential role of green financial flows to sustainable economic development. However, the coefficient of REI is negative, which means that to decrease transitional economic costs, policy support and efficient allocation of green finance must be utilized.

Table 2: Descriptive Analysis

	Mean	Median	Max	Min	S.D.	Skewness	Kurtosis
GDP	6.259268	7.410228	9.689592	-5.777725	3.242086	-2.575512	10.16802
NET_ODA	0.13896	0.121936	0.339832	0.068002	0.059904	1.911153	7.157161
ENV_ODA	2.404555	2.375897	4.032963	1.076702	0.717528	0.211132	2.807967
FDI	1.718772	1.635034	3.620523	0.605888	0.681804	0.7935	4.194971
REI	24.25521	0.776926	419.5007	-67.29675	105.2732	2.649173	10.61022
DC	47.17933	50.14216	54.50529	31.62627	6.62512	-1.352913	3.561837
TRADE	44.45306	45.42309	55.79372	29.50866	7.338619	-0.275944	2.538962

Source: Researcher's computations.

Table 3: Unit Root Test

Variable	ADF		PP		Stationarity
	At Level	1 st Diff.	At Level	1 st Diff.	
GDP	0.0029*	0.0018	0.0029*	0.0000	Stationary at Level
NET_ODA	0.0001*	0.0000	0.0002*	0.0000	Stationary at Level
ENV_ODA	0.1173	0.0016*	0.1001	0.0001*	Stationary at First Difference
FDI	0.1290	0.0006*	0.1290	0.0006*	Stationary at First Difference
REI	0.0001*	0.0002	0.0001*	0.0000	Stationary at Level
DC	0.0848	0.0078*	0.0570	0.0067*	Stationary at First Difference
TRADE	0.1983	0.0191*	0.1983	0.0191*	Stationary at First Difference

Source: Researcher's computations.

Table 4: Short-Run and Long-Run ARDL Estimates for India (2002–2022)

Variable	Short-Run Coeff. (Δ)	Prob.	Long-Run Coeff.	Prob.	Economic Interpretation
NET_ODA	37.670	0.008	70.285	0.040	Total ODA positively and significantly supports GDP growth in both short and long run.
ENV_ODA	0.208	0.850	4.062	0.080	Environment-focused aid shows lagged short-run effect and long-run positive contribution to sustainable growth.
FDI	-2.096	0.046	-1.376	0.376	FDI negatively affects GDP in short run and insignificant in long run.
REI	-0.022	0.006	-0.061	0.007	REI shows negative and statistically significant impact on economic growth means presence of transitional adjustment costs associated with the shift toward sustainable energy systems.
DC	-0.796	0.019	-0.983	0.096	Domestic credit has a short-term contraction effect, minor negative impact in long run
TRADE	0.172	0.322	0.212	0.407	Trade openness not significant in either period
Constant (C)	0.047	0.987	0.058	0.987	Intercept not significant

Note: Δ denotes first differences (short-run changes). Coefficients are estimated using the ARDL bounds testing approach. Lagged terms of NET_ODA and ENV_ODA are included in the short-run dynamics. DDC and DTRADE are interpreted as $Z = Z(-1) + \Delta Z$.

Source: Researcher's computations.

Table 5 was tested using the ARDL Bounds Testing Approach to determine whether there was any long-run relationship between the variables. The calculated F-statistic exceeds the upper critical level of the traditional significance level, which confirms the presence of cointegration between the economic growth and development assistance and the green finance variables with the other macroeconomic variables. The implications of this result are that such variables move in the long-run although they vary in short-runs.

Table 5: Bounds Test for Cointegration

Significance Level	10%	5%	2.50%	1%
I (0)	1.99	2.27	2.55	2.88
I (1)	2.94	3.28	3.61	3.99
F-statistic 11.23604				

Source: Researcher's computations.

Table 6: Diagnostic test

Tests name	F-stats	Prob.
Jarque-Bera Test	0.4356	0.8043
Serial Correlation Test	0.4497	0.5275
Heteroskedasticity Test	1.0466	0.4947

Source: Researcher's computations.

Lastly, the diagnostic tests such as Jarque Bera Test, Breusch Godfrey Serial Correlation LM Test, and Breusch Pagan Test in Table 6, were used to verify the reliability of the estimated model. The findings validate that the residuals are normally distributed and not serially correlated and heteroskedastic, which shows that the model is statistically sound and can be applied in policy interventions. On the whole, the empirical results indicate that development aid, environment-based financial flows are significant in promoting sustainable economic growth, but the shift to renewable energy systems can be accompanied by the short-term economic changes.

CONCLUSION

The paper analyses the dynamic nature of development aid, green finance and economic growth in India during the years 2002-2022 using ARDL bounds testing model to measure the short run and long-run effects. The empirical results show that total ODA plays a significant role in

the economic growth in both periods, whereas the environment-based ODA has a positive long-term effect, which supports the increasing applicability of green aid to sustainable development. REI are observed to create long-term economic resilience and low carbon transition despite their short-term adjustment costs. The analysis also reveals that FDI and domestic credit have a mixed effect, but trade openness has no significant effect on growth during the period under analysis.

These results emphasize the idea that a well-calculated mobilization of the green financial streams and green developmentally oriented financial aid will enable India to jump forward in its sustainable and inclusive economic trajectory. A policy intervention that are interest in the environmentally oriented assistance, the promotion of green investments, the strengthening of the institutional frameworks, and the complementation of the resources of the domestic finance are significant to maximize the economic and environmental results of the external assistance. India will not just be in a position to achieve economic growth with the development aid, which is geared towards a sustainability objective, but also environmental protection, energy transition, and climate change resiliency in the long-run. Overall, this paper has provided empirical evidence that green finance must be integrated into development policies to facilitate a low-carbon, climate-resilient, and inclusive economy and to offer practical information to policymakers, financial institutions, and other international development partners.

Limitations and Future Studies

This research has certain limitations. First, empirical analysis is also restricted to India using annual data alone, and this may be restrictive to uncover short-term changes that may be obvious in case of a more frequent data. Second, the research employs significant macroeconomic and financial variables, however, other pointers can provide a clear indication on the success of green financial flows such as carbon emissions, energy consumption patterns and sector specific ODA disbursements. The analysis can be advanced in future research by implementing cross-country panel research that could compare the relevance of green finance and development aid to the economies. In addition, the

examination of the interconnection between green finance, technological innovation, and foreign aid can be a deeper investigation of the processes of sustainable development. Further studies of the role that domestic policy structures play in enhancing the effectiveness of green aid would also offer useful policy implications.

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