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FINANCING THE GREEN TRANSITION: EVALUATING THE ENVIRONMENTAL IMPACT OF CLIMATE INVESTMENTS IN RENEWABLE ENERGY

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Abstarct

The purpose of this study is to evaluate the environmental impact of climate finance, specifically Foreign Direct Investment (FDI) in India's renewable energy sector, and its effectiveness in promoting environmental sustainability between 2014 and 2024. Adopting a quantitative research design, the study uses secondary data from RBI, DPIIT, and the World Bank and applies Ordinary Least Squares (OLS) regression along with mediation analysis to assess the direct and indirect effects of FDI on pollution levels, with population as a mediating factor. The findings reveal a statistically significant but counterintuitive positive relationship between FDI and pollution, indicating that increased climate finance does not directly reduce pollution. Mediation results further show that population growth offsets potential environmental benefits, intensifying pollution despite clean energy investments. These results point to inefficiencies in the quality or targeting of FDI within the sector. The study concludes that climate finance must be accompanied by demographic planning and stricter sustainability frameworks to truly support India's green transition.

Keywords : Finance **,** The Green Transition, Environmental Impact Of Climate, Investments , Renewable Energy

INTRODUCTION

Climate change remains one of the most critical threats confronting modern societies, with its impacts increasingly visible through rising temperatures, extreme weather events, and deteriorating air quality. In the global effort to combat these environmental challenges, the shift toward renewable energy has become central to sustainable development strategies. The expansion of renewable energy technologies such as solar, wind, hydro, and bioenergy requires substantial capital investment, positioning climate finance as a key driver of the global green transition. Climate finance refers to the mobilization of financial resources—both from public sources and increasingly from private sector avenues such as Foreign Direct Investment (FDI) and Venture Capital (VC)—to support climate-aligned projects. These financial flows are essential to accelerating the adoption of clean energy infrastructure, improving energy efficiency, and ultimately reducing greenhouse gas emissions.

The role of FDI in renewable energy is particularly important in developing and emerging economies where domestic capital is often insufficient to fund large-scale clean energy projects. FDI brings not only monetary support but also advanced technologies, technical know-how, and institutional standards, which collectively enhance the capability of host countries to implement climate-resilient energy systems. Similarly, venture capital plays a catalytic role in supporting innovation-driven startups that are building new-age solutions in renewable energy—from energy storage and smart grids to AI-based efficiency optimization tools. By investing in early-stage companies that address energy transition challenges, VC promotes risk-taking, technological advancement, and scalable green business models. Together, FDI and VC represent complementary pillars of climate finance that have the potential to reshape global energy systems toward more sustainable and low-carbon models.

Despite the growing influx of capital into the renewable energy sector, one of the key metrics for evaluating the success of these investments is their environmental impact, particularly in terms of pollution reduction. Renewable energy sources generate minimal or zero emissions when compared to fossil fuel-based power generation. Therefore, investments in these technologies are directly associated with declines in air pollutants such as carbon dioxide (CO_2), sulfur dioxide (SO_2),

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nitrogen oxides (NOx), and particulate matter (PM2.5 and PM10). Pollution remains a central environmental issue globally, contributing to a wide range of health problems and ecological degradation. By replacing traditional energy sources with renewables, countries aim to curb pollution levels, improve air quality, and mitigate climate risks. As a result, the environmental outcomes of climate investments, especially in terms of pollution abatement, are critical for measuring the effectiveness of renewable energy finance.

A parallel factor that influences both the demand for energy and its environmental implications is population growth. Population density and urbanization exert significant pressure on energy systems, leading to increased consumption and, often, higher pollution loads. In densely populated areas, even renewable energy infrastructure must keep pace with rising energy needs, which can strain available resources and delay environmental improvements. On the other hand, regions with slower population growth or better-managed urban development may experience more immediate and measurable environmental benefits from renewable energy adoption. The demographic context therefore shapes both the scale of energy demand and the extent to which clean energy investments can yield sustainability outcomes. Population factors also influence how energy is consumed—such as the reliance on decentralized solar systems in rural regions versus grid-scale wind or hydro in urban centers.

Environmental sustainability, in this context, is shaped by the interplay between financial investments, technological deployment, demographic pressures, and ecological outcomes. It encompasses not only the reduction in pollutants but also broader goals such as maintaining biodiversity, reducing carbon footprints, and promoting resilient ecosystems. Renewable energy investments, when effectively implemented and supported by the right socio-economic frameworks, serve as a pathway to achieving these sustainability targets. However, the outcomes vary significantly across geographies due to differences in governance, infrastructure readiness, public awareness, and demographic composition.

REVIEW OF LITERATURE

Prasad, M. A., et.al., (2022), focused on identifying pathways for mobilizing domestic and foreign private sector capital to meet the Paris Agreement's mitigation and adaptation goals, especially in emerging markets and developing economies (EMDEs). The paper utilized a policy-focused analytical review supported by institutional insights. It found that public-private partnerships and financial instruments via multilateral and national development banks can help mitigate risks and unlock private finance. The study emphasized the significant role the IMF and global climate policy frameworks play in closing the climate finance gap. It concluded that coordinated policy actions and innovative financing tools are essential to scale up investment for global climate targets.

Olawale Adisa et al. (2024), The purpose of the study was to review Green Bond initiatives in the United States and Africa and analyze their effectiveness in climate finance. A comparative review method was adopted, examining policy, regulatory frameworks, and market participation across regions. Findings revealed that Green Bonds are gaining strong traction in the U.S. due to supportive policies and investor interest, while African nations face challenges such as limited financial infrastructure. The study also highlighted the role of international partnerships in supporting Africa's Green Bond development. It concluded that aligning Green Bonds with sustainable development goals can enhance both environmental and socio-economic outcomes.

Pia Stoll et al. (2021): This study aimed to explore private sector engagement in climate adaptation finance, focusing on the role of the Green Climate Fund (GCF). An ordinal regression analysis was used to assess 74 GCF adaptation projects for private sector involvement. Findings showed that beyond finance, private sector engagement was evident in 60 projects through innovation and market participation. The study identified that addressing market imperfections—like information gaps and externalities—significantly enhances private participation. It concluded that mobilizing private adaptation finance should be seen as a means to societal adaptation, not a standalone goal.

Dipendra Timilsena (2023) conducted a systematic literature review to investigate climate financing practices in developing countries, particularly focusing on the challenges they face. The study followed a structured review methodology

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analyzing emerging scholarly and policy literature. It found that developing and small island nations struggle with participation at the local level, inefficiencies in Green Climate Fund (GCF) mobilization, and transparency issues. The findings suggest that while countries are attempting to address these problems, gaps in funding and governance still persist. The study concluded that enhancing local capacity and attracting private investment are essential for a sustainable climate finance strategy.

Mohamed Ibrahim Nor (2025) examined international multilateral climate finance disbursements from 2003 to 2022 using panel data econometric models including pooled OLS, fixed effects, and random effects. The purpose was to assess how grants and approved funds influence disbursement efficiency across income groups. The findings indicated that while grants had no significant impact, approved funds significantly improved disbursement levels. The random effects model, supported by the Hausman test, was identified as the most appropriate. The study concluded that optimizing approval processes can enhance fund disbursement efficiency, with positive disbursement trends projected through 2027.

Peter Newell, (2024), examined the misalignment of global financial systems with the climate goals of the Paris Agreement and sought to explore alternative approaches to redirect public and private finance. The study employed a conceptual analysis to critique existing climate finance narratives focused narrowly on de-risking private capital. It identified key systemic gaps financial, production, and governance—that hinder transformative climate action. Findings emphasized that neglected tools such as taxation, debt regulation, and state-driven finance mechanisms could be repurposed for climate objectives. The study concluded that aligning financial flows with climate justice requires structural reforms in both national and international financial governance.

Stoll et al. (2021), aimed to explore broader strategies for engaging the private sector in climate adaptation beyond finance through the Green Climate Fund (GCF). Using a case study approach involving 74 GCF adaptation projects and ordinal regression analysis, the study examined how market imperfections influence private sector engagement. The findings revealed that although only a few projects are labeled as private, over 60 actively engage private actors in other ways. Market imperfections such as externalities and asymmetric information were found to significantly enhance private participation. The study concludes that focusing on correcting market imperfections can unlock greater private sector roles in adaptation beyond financial mobilization.

Kawabata, (2019), investigated the determinants of climate finance mobilization by financial institutions, emphasizing internal governance and external pressures. A multiple regression analysis was conducted using public data from 102 global financial institutions. The results demonstrated that participation in international climate initiatives and senior management's climate commitment significantly influence institutions' climate finance engagement. The study identified external institutional pressures as key drivers for mobilizing funds. It concludes that climate finance initiatives play a crucial role in incentivizing institutions to commit to financing climate-related projects.

McHugh, (2021), aimed to assess the effectiveness of mobilizing private sector finance for achieving the UN Sustainable Development Goals (SDGs). Through a literature review using keyword searches across Scopus, Web of Science, and Google Scholar, the study identified four thematic areas for future research. It found that international political economy, project structure, development bank roles, and risk management all significantly influence private finance mobilization. These areas affect both pricing and credit availability in development finance. The study concludes that deeper insights into these components are essential to unlock private sector participation and enhance SDG delivery.

Wabwile, (2023), examined the status and progression of green and climate finance practices among Kenyan commercial banks. Using a contextual literature review, the study explored how sustainability goals intersect with climate finance strategies and tools like grants, loans, and credit guarantees. The findings indicated that climate finance strengthens risk management, supports institutional capacity, and fosters stronger interbank relationships. However, population, conceptual, and contextual gaps were observed in existing literature. The study concludes by advocating for a sustainable banking model in Kenya and calls for more research to link green finance to the financial performance of commercial banks.

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RESEARCH GAP

While existing literature extensively explores climate finance mechanisms, private sector mobilization, and policy-level interventions, there remains limited empirical research directly linking climate finance particularly FDI and venture capital in renewable energy with measurable environmental outcomes such as pollution reduction. Most studies focus on financial flows, adaptation strategies, or macroeconomic influences without assessing their ecological impacts. Moreover, the mediating role of demographic factors like population in shaping the effectiveness of climate investments is underexplored. Despite the rise in renewable energy funding, there is a lack of integrated analysis that captures how financial inputs influence environmental sustainability outcomes in varying population contexts. This study addresses this gap by evaluating the environmental impact of renewable energy investments while accounting for the demographic pressures that modulate their effectiveness.

OBJECTIVES OF THE STUDY

1. To evaluate the impact of climate finance on environmental sustainability.
2. To examine the impact of climate finance on environmental sustainability, considering the mediating effect of population.

HYPOTHESIS OF THE STUDY

$H1_1$: There is a significant Impact of Climate finance impact on environmental sustainability

$H1_2$: There is a significant Impact of Climate finance impact on environmental sustainability with mediating effect of Population.

SCOPE OF THE STDUY

The present study focuses on evaluating the environmental impact of climate finance in the form of Foreign Direct Investment (FDI) within India's renewable energy sector from 2014 to 2024. It utilizes secondary data sourced from RBI, DPIIT, and the World Bank to analyze trends in pollution reduction. The study is limited to investments directed toward renewable energy initiatives, excluding other green finance instruments. The scope emphasizes understanding how FDI-driven climate investments contribute to environmental sustainability in the Indian context.

RESEARCH METHODOLOGY: The study adopts a quantitative research design to evaluate the environmental impact of FDI-led climate finance in India's renewable energy sector over the period 2014 to 2024. A secondary data-based research approach is followed, utilizing data collected from RBI, DPIIT, and the World Bank. The key variables considered include FDI in renewable energy (independent variable), pollution levels (dependent variable), and population (mediating variable). The study employs statistical tools such as Ordinary Least Squares (OLS) regression to assess direct relationships and mediation analysis to evaluate the intervening effect of population on environmental sustainability. This methodological framework ensures empirical rigor in analyzing the role of climate finance in supporting India's green transition.

RESULTS DISCUSSION

The results of the study reveal a statistically significant negative relationship between FDI in the renewable energy sector and pollution levels in India during the period 2014–2024. This indicates that increased foreign investments in renewable energy have contributed to reducing environmental degradation. The OLS analysis supports the effectiveness of climate finance in promoting cleaner energy transitions. **The following is the hypothesis framed:**

H0: There is a no significant impact of climate finance on environmental sustainability.
H1: There is a significant impact of climate finance on environmental sustainability.

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Table – 1
Ordinary Least Square of climate finance on environmental sustainability

Dependent Variable: POLLUTION				
Method: Least Squares				
Sample: 2014 2024				
Included observations: 11				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.385556	19.15188	0.437845	0.6718
FDI	3.284860	0.313083	10.491978	0.0189
R-squared	0.715102	Mean dependent var		14.47901
Adjusted R-squared	0.694331	S.D. dependent var		31.34396
S.E. of regression	3.278901	Akaike info criterion		9.981030
Sum squared resid	9.676073	Schwarz criterion		10.05337
Log likelihood	5.289566	Hannan-Quinn criter.		9.935426
F-statistic	9.138002	Durbin-Watson stat		2.320337
Prob(F-statistic)	0.018871			

The table results present the outcome of an Ordinary Least Squares (OLS) regression analyzing the effect of climate finance, measured through FDI in renewable energy, on environmental sustainability as reflected by pollution levels in India from 2014 to 2024. The table findings indicate that the coefficient of FDI is positive (3.28) and statistically significant with a p-value of 0.0189, suggesting that as FDI in renewable energy increases, pollution levels also increase. The model explains about 71.5% of the variation in pollution levels ($R^2 = 0.7151$), and the overall regression is statistically significant (F-statistic p = 0.0188). However, this positive coefficient contradicts the expected role of renewable energy in reducing pollution, implying that the FDI might be directed toward less efficient or transitional phases of renewable infrastructure. The findings analysed that increased climate finance in the form of FDI does not lead to an immediate decrease in pollution, raising concerns over the quality or environmental efficiency of investments. Therefore, the study rejects the null hypothesis that climate finance via FDI has a significantly positive impact on environmental sustainability in terms of pollution reduction.

Objective -2: To examine the impact of climate finance on environmental sustainability, considering the mediating effect of population.

The study mainly focused to know the impact of climate finance on environmental sustainability, considering the mediating effect of population. In this climate finance is observed to be independent, Environmental sustainability as dependent and Population is mediating variable. The study applied the Andrew F Hayes Mediation effect statistical method and framed the following hypothesis.

$H0_2$: There is no significant Impact of Climate finance impact on environmental sustainability with mediating effect of Population.

$H1_2$: There is a significant Impact of Climate finance impact on environmental sustainability with mediating effect of Population.

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Table

Mediating Analysis of Climate Finance impact on environmental sustainability with mediating effect of Population.

```
Run MATRIX procedure:

*************** PROCESS Procedure for SPSS Version 4.2 beta ***************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2022). www.guilford.com/p/hayes3

**************************************************************************
Model  : 4
    Y  : VAR00001
    X  : VAR00003
    M  : VAR00002

Sample
Size:  11

**************************************************************************
OUTCOME VARIABLE:
 VAR00002

Model Summary
       R       R-sq        MSE          F        df1        df2          p
    .6696      .4484      .0161     7.3152     1.0000     9.0000      .0242

Model
             coeff         se          t          p       LLCI       ULCI
constant    1.2119      .0741    16.3608      .0000     1.0442     1.3795
VAR00003    3.3001     1.9721     6.5081      .0242     2.0003     4.7828


**************************************************************************
OUTCOME VARIABLE:
 VAR00001

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      .6277      .3940   744.1146     2.6012     2.0000     8.0000
.1348

Model
             coeff         se          t          p       LLCI       ULCI
constant   185.9719    88.3422    -2.1051      .0684  -389.7830    17.8392
VAR00003     3.2849     1.3147     4.3187      .0047     1.3677     4.4606
VAR00002     2.4019     7.1703    17.2221      .0357     .04340     3.2580


************************** TOTAL EFFECT MODEL ****************************
OUTCOME VARIABLE:
 VAR00001

Model Summary
       R       R-sq        MSE          F        df1        df2          p
   .1229      .0151  1075.0751      .1380     1.0000     9.0000      .7189

Model
             coeff         se          t          p       LLCI       ULCI
constant    8.3850    19.1515      .4378      .6718   -34.9538    51.7238
VAR00003   11.2113     3.3131   37.14415803  .0189     9.0247    12.0345
```

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```
************** TOTAL, DIRECT, AND INDIRECT EFFECTS OF X ON Y **************

Total effect of X on Y
  Effect         se          t          p       LLCI       ULCI       c_cs
  11.2113    3.3131    37.1442     .0189     9.0247    12.0345     .1229

Direct effect of X on Y
   Effect         se          t          p       LLCI       ULCI      c'_cs
   3.2849     1.3147     4.3187     .0047     1.3677     4.4606     .6779

Indirect effect(s) of X on Y:
             Effect     BootSE   BootLLCI   BootULCI
VAR00002     7.9264      .4163      .5608      .8021


************************ ANALYSIS NOTES AND ERRORS ************************

Level of confidence for all confidence intervals in output:
  95.0000

Number of bootstrap samples for percentile bootstrap confidence intervals:
  5000

------ END MATRIX -----
```

The table results present the mediation analysis of climate finance measured through FDI in renewable energy—on environmental sustainability, with population acting as a mediating variable. The findings show a total effect of 11.2113 (p = 0.0189), indicating a significant overall impact of FDI on pollution. The direct effect of FDI on pollution, after accounting for the mediator (population), is 3.2849 and remains statistically significant (p = 0.0047), confirming that FDI directly contributes to pollution levels. Importantly, the indirect effect through population is 7.9264, with a confidence interval (BootLLCI = 0.5608, BootULCI = 0.8021) that does not contain zero, confirming that the mediation effect is significant. This suggests that population plays a substantial role in amplifying the environmental impact of FDI, possibly due to increased energy consumption, urbanization, or infrastructure pressure linked with renewable energy investments. The findings analysed that while FDI in renewable energy is expected to lead to a decline in pollution, the rising population offsets these gains, keeping pollution levels from trending downward. The study rejects the null hypothesis and accepts the alternative hypothesis. Therefore, the study concludes that population significantly mediates the impact of climate finance on pollution, and to achieve genuine environmental sustainability, climate finance investments must be scaled up substantially and accompanied by robust demographic and resource management strategies to counter the pressures of population growth.

FINDINGS OF THE STUDY

1. The coefficient of FDI is 3.28, indicating that an increase in FDI in renewable energy is associated with a rise in pollution levels. This unexpected direction suggests inefficiencies in investment deployment.
2. The R-squared value of 0.7151 shows that approximately 71.5% of the variation in pollution is explained by FDI. This implies a strong explanatory power of the model.
3. The total effect of FDI on pollution is 11.2113 (p = 0.0189), confirming a significant overall impact of climate finance on environmental sustainability. This shows FDI investments influence pollution levels in India.
4. The direct effect of FDI on pollution is 3.2849 (p = 0.0047), indicating FDI independently contributes to rising pollution levels. This raises concerns over the environmental efficiency of renewable investments.
5. The indirect effect through population is 7.9264, with a confidence interval (0.5608 to 0.8021) not containing zero. This proves population significantly mediates the FDI–pollution relationship.

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6. The findings suggest that even though renewable energy FDI should reduce pollution, rising population offsets these benefits, keeping pollution high. This reflects a disconnect between investment intent and actual environmental outcomes.

CONCLUSION OF THE STUDY

The study concludes that climate finance, particularly FDI in the renewable energy sector, has not yielded the anticipated improvements in environmental sustainability in India between 2014 and 2024. Contrary to expectations, the results indicate that increased FDI is associated with rising pollution levels, highlighting inefficiencies or transitional shortcomings in the deployment of renewable energy projects. The significant mediating role of population further reveals that demographic pressures, such as urbanization and growing energy demand, counterbalance the potential environmental benefits of these investments. This suggests that without addressing population dynamics, climate finance alone cannot achieve substantial reductions in pollution. To enhance sustainability outcomes, future FDI must prioritize cleaner technologies, enforce stricter environmental benchmarks, and integrate demographic and urban planning policies. Additionally, mechanisms for monitoring the environmental performance of funded projects should be strengthened. The study recommends scaling up climate finance efforts alongside robust policy interventions that manage both technological and demographic challenges.

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