

A review of financing Green Innovation: Pathways to Sustainable Development

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Abstract:

As there is increasing focus on critical environmental issues such as climate change and global warming from governments, there is an urgent need to examine the factors that enable and encourage green initiatives. Green finance which emphasizes environmentally responsible investments and practices has emerged as a vital tool in achieving neutrality and ensuring sustainable development, economic growth as well. This paper reviews the role of financial assistance and its inter connection with sustainable development. The adverse externalities associated with environmental degradation draws attention to the need of sustainable innovation in public management. Green finance provides financial support for R&D activities of renewable energy and sustainable products processes. The analysis will highlight the key issues faced by policymakers and stakeholders to develop and combine two aspects in research and practice to ensure environmental harmony and further promoting long term sustainability. Active collaboration between public and private organisations facilitates the transition of the financial system toward sustainability. Using a hybrid research method that integrates bibliometric analysis and a systematic literature review, the paper identifies major trends, challenges, and opportunities in green finance. Findings highlight that effective financing of green innovation depends on collaborative efforts among governments, financial institutions, and private sectors. The study concludes by proposing strategic pathways to strengthen the financial ecosystem for sustainable development.

Key words: Green finance, policymakers, sustainable innovation, financial assistance.

1. Introduction

The growing global concern over environmental degradation and climate change has led to increased emphasis on green innovation—the development of technologies and practices that minimize ecological harm while fostering economic growth. Financing such innovations is essential to ensure the transition to a sustainable future. The concept of green finance emerged as a means to support environmentally responsible projects and promote sustainable economic systems. Financial investments and activities that support sustainable development by minimizing environmental risks and fostering ecological stability. It focuses on mobilizing funds from both public and private sectors to support initiatives such as renewable energy, climate change mitigation, energy efficiency, pollution control, biodiversity preservation. Financial assistance integrates financial mechanisms with environmental objectives, channelling both public and private funds toward renewable energy, energy efficiency, pollution control, and sustainable infrastructure. However, mobilizing sufficient financial resources for green innovation remains a

significant challenge, especially in developing economies. This paper explores the role of financial instruments, institutions, and policies in promoting green innovation as a pathway to sustainable development.

Transitioning to a low-carbon, climate-resilient economy requires not only technological innovation but large-scale, sustained investment. Estimates repeatedly show a substantial annual financing gap for mitigation and adaptation in developing countries, driven by both underinvestment in R&D and barriers to deploying proven technologies at scale. Green innovation can only succeed when green finance is readily available, accessible, and properly allocated. Strengthening the link between green funding mechanisms and green innovation activities is necessary to ensure successful implementation of sustainable solutions. Financial assistance extended by public or private and any other sector helps speed up progress toward the Sustainable development goals (SDGs) by investing in projects that benefit both the environment and society.

2. Origin and Concept of Financial Assistance for Sustainable Development:

Green finance refers to financial activities and investments that promote sustainable development by reducing environmental risks and encouraging ecological balance. It mobilizes resources from both the public and private sectors to support renewable energy projects, energy-efficient technologies, and environmentally responsible business practices.

The concept of green finance has evolved over the past few decades as environmental concerns became intertwined with economic decision-making. Its origins can be traced back to the 1972 United Nations Conference on the Human Environment in Stockholm, which emphasized balancing economic growth with environmental protection. The Brundtland Report (1987) introduced the idea of sustainable development, and the 1992 Rio Earth Summit laid the foundation for environmental funding mechanisms such as the Global Environment Facility (GEF).

At this conference, global leaders acknowledged that economic advancement should not occur at the expense of environmental health and stressed the importance of establishing financial frameworks to support environmentally sound development. This milestone paved the way for international funding mechanisms and reinforced the principle that developed nations bear a responsibility to assist developing countries in pursuing sustainable growth.

The concept gained further momentum through later global efforts, notably:

- The 1987 Brundtland Report (*Our Common Future*), which formally introduced the in the present study, a hybrid approach is employed by integrating bibliometric analysis with a systematic literature review. The bibliometric analysis is utilized to examine key statistical aspects of research publications, including citation patterns and publication trends. In contrast, the systematic literature review offers a comprehensive exploration of the selected research domain and seeks to address specific research questions in depth.
- Term *sustainable development* and underscored the crucial role of finance in realizing it. The 1992 Rio Earth Summit (UNCED), which resulted in the creation of the Global Environment Facility (GEF) to provide funding for sustainability-oriented projects.

3. Financing Green Innovation:

Green innovation involves the creation and implementation of new technologies, products, or processes that minimize environmental impact and promote sustainability.

Green innovation is being financed by a mixture of governments, development banks, private investors and philanthropies.

Government initiatives include Green Bonds, Grants and Subsidies. Green Bonds are issued by the government to finance environmentally friendly projects, such as renewable energy and sustainable infrastructure. Grants and subsidies are also offered by the Government to promote sustainable practices and support and encourage green start-ups.

Private sectors in India making significant contributions in green initiatives, driving the country's transition to a low carbon economy.

Multilateral Development Banks are playing a crucial role in supporting sustainable development by extending their financial support.

Philanthropic organizations have become significant players in green financing, offering support for initiatives that advance environmental sustainability, renewable energy, and climate resilience. Unlike conventional financial institutions, these organizations emphasize social and ecological impact rather than financial gain, thereby addressing crucial funding shortages within the green innovation landscape.

Foundations, charitable trusts, and non-governmental organizations (NGOs) contribute through grants, concessional financing, and technical assistance aimed at promoting environmentally responsible projects. Their adaptable funding approaches enable them to back innovative or high-risk green ventures that often face challenges in securing investment from private or institutional sources.

A number of international philanthropic foundations have played a pivotal role in driving sustainable development and accelerating the transition toward a low-carbon economy.

International agencies play a pivotal role in advancing green finance by channeling financial resources, promoting technology transfer, and formulating supportive policies for sustainable development. Institutions such as the United Nations (UN), World Bank, International Monetary Fund (IMF), and Organisation for Economic Co-operation and Development (OECD) assist nations in embedding environmental sustainability within their economic strategies.

Financial mechanisms such as the Green Climate Fund (GCF), Global Environment Facility (GEF), and Climate Investment Funds (CIF) extend funding to developing countries for initiatives focused on renewable energy, climate adaptation, pollution reduction, and biodiversity protection. By offering grants, concessional financing, and technical assistance, these agencies help minimize investment risks and stimulate collaboration between the public and private sectors in environmental projects.

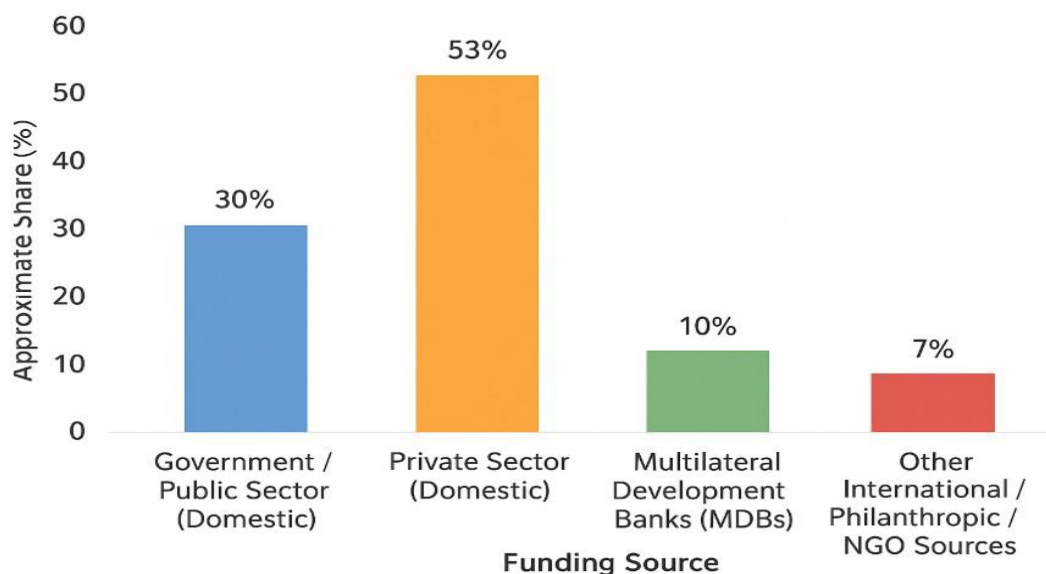
Ultimately, international organizations serve as key facilitators and policy drivers, fostering global partnerships that ensure the successful realization of sustainable development goals through effective and inclusive green financing practices.

Contribution of green funding in India by various sectors for green innovations, as per estimated breakdown of Green funding in India, Financial year 2021-22, as follows.

Estimated Breakdown of Green Funding in India (FY 2021–22)

S. No.	Funding Source	Approximate Share (%)	Description / Basis
1.	Government/ PublicSector (Domestic)	30%	Includes Union and State government spending, Public Sector Undertakings (PSUs), and budget allocations for renewable energy, clean transport, and adaptation. As per Climate Policy Initiative (2024), ~34% of domestic green finance came from public sources.
2.	PrivateSector (Domestic)	53%	Represents private investments in renewable energy, green infrastructure, and clean technologies. CPI (2024) reports that ~66% of domestic green finance originates from the private sector, which equals roughly 55% of total green finance.
3.	Multilateral Development Banks (MDBs)	10%	Comprises funds from international development institutions such as the World Bank, Asian Development Bank (ADB), and others. OECD and CPI data indicate MDBs form a large portion of India's ~17% international green finance.
4.	Other International/ Philanthropic/ NGO Sources	7%	Includes foreign direct investment (FDI) in climate projects, philanthropic funding, and NGO contributions. Estimated from the residual international share not attributed to MDBs.

Total Green Funding = 100%



4. Methodology:

This study adopts a qualitative research design supported by an extensive literature review. Secondary data was collected from peer-reviewed journals, research reports, government publications, and international agency documents. The selected literature was analysed to identify patterns, themes, and conceptual frameworks related to green finance and green innovation. A thematic analysis approach was used to synthesize the findings and derive insights. All sources were properly cited to ensure academic reliability. The bibliometric analysis is utilized to examine key statistical aspects of research publications, including citation patterns and publication trends. In contrast, the systematic literature review offers a comprehensive exploration of the selected research domain and seeks to address specific research questions in depth.

5. Findings and Discussion:

The bibliometric analysis reveals a significant rise in research output on green finance after the Paris Agreement (2015), highlighting growing academic and policy interest. The literature review identifies several key themes: policy frameworks and regulations are critical in promoting green investments; public–private collaboration enhances financial innovation and risk sharing; and barriers such as inadequate financial incentives, lack of standardized green metrics, and limited access to finance in developing regions persist. The study also finds that countries with well-developed green financial systems tend to achieve faster progress toward low-carbon and sustainable economies.

6. Pathways to Sustainable Development:

6.1. Advancing the Renewable Energy Transition

Green funding facilitates large scale investments in solar, wind hydro and biomass energy, enabling countries to reduce dependence on fossil fuels. This shifting significantly lowers carbon emission and supports progress toward energy related sustainable development goals.

6.2. Promoting Green Innovation and Clean Technologies

Financial support encourages research and development in various green technologies, including:

- Energy-efficient systems
- Sustainable and green building designs
- Electric mobility solutions
- Low-carbon industrial processes

These innovations make sustainable development both technologically feasible and economically sustainable.

6.3. Developing Climate-Resilient Infrastructure

Green finance contributes to the creation of:

- Climate-resilient road networks
- Flood-management infrastructure
- Coastal protection systems
- Eco-friendly urban facilities

Such investments reduce climate vulnerability and strengthen resilience, supporting SDGs.

6.4. Supporting Sustainable Agriculture and Land Use:

Extending financial assistance help the farmers in adopting environmentally friendly practices such as:

- Organic and regenerative agriculture
- Water-efficient irrigation systems
- Soil restoration methods
- Renewable-powered agricultural technologies

These approaches enhance food security while safeguarding natural ecosystems.

6.5. Improving Water and Waste Management Systems:

Green funding plays an essential role in strengthening water and waste management systems by providing financial resources for technologies, infrastructure, and practices that improve environmental quality and public health. It helps in

- Waste recycling initiatives
- Water purification facilities
- Sewage treatment infrastructure
- Rainwater harvesting systems

These systems protect public health and reduce pollution, contributing to sustainable development goals.

6.6. Expanding Low-Carbon Transportation:

Green funds accelerate the shift from fossil fuels to clean, efficient, and sustainable systems by targeting investments toward every sector that contributes to carbon emissions—energy, transport, industries, buildings, agriculture, and innovation. Funding is directed toward

- Electric vehicles
- Charging infrastructure
- Electric public transport (buses and metros)
- Non-motorized mobility options such as cycling and walking

These investments reduce urban pollution and promote sustainable transportation.

6.7. Protecting Biodiversity and Natural Ecosystems:

Green funding supports activities such as:

- Afforestation and reforestation
- Wildlife habitat conservation
- Marine ecosystem protection
- Rehabilitation of degraded ecosystems

6.8. Enhancing Public–Private Partnerships:

Green finance strengthens cooperation between sectors through mechanisms like:

- Green bonds
- Climate funds
- ESG-driven investments

Such collaborations mobilize substantial capital for sustainable development, supporting sustainable development goals.

6.9. Advancing the Circular Economy:

Funding supports initiatives such as:

- ☐ Recycling and resource recovery industries
- ☐ Waste-to-energy projects
- ☐ Sustainable production processes

These efforts reduce waste generation and foster responsible consumption patterns.

6.10. Increasing Energy Efficiency in Industries:

Green loans enable industries to:

- Upgrade outdated machinery
- Adopt energy-efficient technologies
- Minimize energy losses

This helps reduce carbon emissions and operational expenses simultaneously.

7. Conclusion

Green finance plays a pivotal role in accelerating green innovation and achieving sustainable development goals. Effective collaboration among public institutions, private investors, and international organizations is essential to mobilize resources and overcome barriers to green investment. “Green innovation must be encouraged across all sectors, with individuals giving it due importance. Awareness should begin at the primary education level, and everyone should recognize their responsibility in supporting it. By promoting innovative financing mechanisms and sustainable business models, societies can transition toward an environmentally responsible and economically resilient future.

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