https://doi.org/10.69974/glskalp.05.04.02

GLS KALP
Journal of Multidisciplinary Studies
Volume 5; Issue 6
October - December 2025

Green Finance and Sustainable Development: India in Comparative Perspective with Japan and the USA

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Abstract

This research paper examines the phenomenon of "green finance" and its key impact in the shift towards a "low-carbon economy" in India, with specific consideration to the financial hindrances to the adoption of sustainable energy technologies. It identifies several hurdles, including regulatory impediments, institutional blockages, and a set of market characteristics biased towards more conventional energy projects because of quicker return on investment. The paper traces the history of sustainability in India with particular attention to traditional systems, including sacred groves and rainwater harvesting, as well as post-1990s liberalization, environmental governance upheavals. Along with India's pledges under the Paris Agreement, this analysis includes the dependence on enormous funding to fulfill its Nationally Determined Contributions (NDCs). Moreover, this includes discussion about some of the renewable energy and clean technology sectors which are ripe for investment and their associated green financing policies or initiatives prospects from domestic and international players. The paper describes the sustainable development and green financing policies of various Indian, Japanese, and American companies and their contributions and innovations to green financing. Looking at Japan and the United States provides insight into varying approaches to "green finance", stressing the role of regulations, frameworks, & unique financing tools in meeting sustainable development objectives. Increased investment needs were identified as constraining India's ability to move towards a sustainable low-carbon economy, demonstrating that more effective mechanisms of green finance are essential for overcoming these financing gaps.

Keywords: Green Finance, Sustainability, Development, Solar, Green Bonds

Introduction

The term "GREEN" is a veneration for the homage to nature and for thanking her for how gracious she has been with humanity, while putting time and resources into apologizing for what human beings have done. The term Green has been quoted by various organizations and conferences in various nations, and how the country aims to achieve their promises they make. Domestic sustainable development in India has shifted with the changes in its economic policies, along with the environmental context, and global sustainability goals. It arose from the interplay of laws, their policies, environmental regulatory frameworks, and international standards aimed at economically constructive development, environmental protection, and societal welfare. Strong mechanisms of green finance are vital to overcome these barriers to make India shift towards an economy that has a low "carbon footprint".

India's conversion to a "low-carbon economy" needs to be facilitated through strong "green finance" products and services to finance the shift or transformation towards

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"green energy"; however, significant financial barriers exist. The changes such as regulatory barriers such as Lack of Standardization (example: globally agreed definition of green finance is lacking), (Gupta & Jain, 2021), Institutional barriers such as Low awareness among stakeholders (Reddy & Acharya, 2020) and Market barriers such as high initial cost of green projects when compared to traditional projects which offer quicker returns (Bhardwaj & Malik, 2022), financial risk such as loan defaulting risk, sale of scrap in case of default.

History and existence

A new concept emerged within the umbrella term of sustainable development. It first emerged during the conference of United Nations in 1992 for *Environment and Development*. The conference was attended in *Rio de Janeiro*, and the event hosted more than 100 heads and 178 sovereign government representatives were present. "Sustainable Development" as a term had gained huge popularity & also limelight during the conference.

Pre-1970s Traditional Sustainability Practices in India

Indian culture, religion, and traditional practices have been promoting the sustainability of the environment long before green laws were written and adhered to. The traditional Indian constructs place heavy emphasis on environment protection, biodiversity conservation, and sustainable agriculture. The religious scriptures, indigenous conservation knowledge systems and community effort together contribute to the sustainable traditions.

1. Sacred Groves and Biodiversity Protection: In most cultures, the term "sacred" refers to something that is sanctified, holy, or cherished, as well as something that is hidden or forbidden to ordinary people. According to (Saikia, 2006), sacred groves are small patches of forest that can range in size from just a few hectares to several kilometres. These groves are protected by local communities because they are considered sacred homes of local deities. In India, the term "Puneet Van" is often used to describe such sacred groves. The sacred groves are major reservoirs of floral and faunal diversity, as well as a set of microorganisms that local people have maintained (Asokan et al., 2015). The vegetative cover also helps to recharge the aquifers (Asokan et al., 2015).
2. Traditional Water Conservation Systems: India has a long history of rainwater harvesting and irrigation systems to manage water sustainably. Stepwells found in Gujarat and Rajasthan are an excellent example of how people traditionally conserved water. These structures were built to store rainwater, allowing communities to access water during dry periods. The design of stepwells, with their deep, stepped sides, made it easier to reach water at different levels as the water rose and fell, showing how people adapted their water management to the local climate and needs. Johad – A small earthen dam structure that is used to collect rainwater. It is used for drinking water, irrigation, as well as various domestic requirements; this highly governs the northern states of Rajasthan, Punjab, and Western UP.
3. Sustainable Agriculture and Organic Farming: Old practices in Indian agriculture like crop rotation, mixed farming, and the use of organic manure prevent soil erosion and conserve the environment. Additionally, these practices prevent the use of chemical fertilizers.
4. Vedic Texts and Environmental Ethics: Vedas and Upanishads, which are considered some of the most important ancient Indian scriptures, preach and

emphasise on the importance of peaceful interaction between nature and human beings. Atharva Veda, for instance, mentions and refers to the Earth as a mother figure, showing purity of nature (Gottlieb, 2004).

5. Community-Driven Conservation Movements: The Bishnoi Movement of the 1730s is considered one of the important events in the history of environmental conservation in India. The Bishnois are considered India's earliest environmentalists. They were born nature lovers. For centuries, they have combined eco-conservation with their faith, resulting in one of today's most ecologically relevant orders. (Alam, Khabirul & Halder, Ujjwal 2018). Chipko Movement under the leadership of Sunderlal Bahuguna was successful in challenging the acts of state forest officials, as well as establishing a 15-year moratorium on commercial tree felling in the Himalaya and announcing that as an area which is protected (Barnali, 2015). The campaign inspired many future environmentalists, environmental movements, and protests around the world, setting a precedent for nonviolent protest. It happened at a time when there was little environmental movement in the poor countries, and its success meant that the entire globe took notice of this nonviolent effort (Barnali, 2015).

Environmental legislations and institutional development in India, 1970-1990

A shift in the tides of the Indian approach to environmental governance was observed between the 1970s and the 1990s. India was seen embracing and adhering to institutionalized laws and regulations, and discarding the traditional conservation techniques. Global environmental movements, industrial expansion, and rising pollution concerns all contributed to India's establishment of its first environmental laws, agencies, and action plans.

1. Stockholm Conference (1972) and its impact: The main aim of "Sustainable Development" is to attempt to satisfy the requirements of today in such a manner that the future generation can also benefit from the resources. The term *"Sutainable development"* first gained global recognition in 1972 during the United Nations Conference on the Human Environment, held in Stockholm. This conference marked a key moment in raising awareness about the need to balance environmental protection with economic and social development.
2. 42nd Amendment to the Indian Constitution (1976): The Indian constitution introduced article 48-A which mandates that the state will work to maintain and improve the environment, as well as to preserve the country's forests and wildlife (*The Constitution (Forty-Second Amendment) Act, 1976| National Portal of India*, n.d.). Article 51-A(g) of the Indian Constitution urges citizens to protect the environment and show compassion for all living beings, including care for forests, lakes, rivers, and wildlife (*The Constitution (Forty-Second Amendment) Act, 1976| National Portal of India*, n.d.).
3. The Water (Prevention and Control of Pollution) Act of 1974: The Act established the Central Pollution Control Board (CPCB) to carry out its tasks regarding water prevention and pollution too (*Water Prevention and Control of Pollution Act,* 1974).
4. Forest Conservation Act, 1980: "The Forest Conservation Act" which was passed in 1980 was made to help preserve the forests across the nation (Tandon et al., 2017). It strongly prohibits and regulates the de-reservation of forests and the use of forest land for other uses without prior consent from the Central Government (Ministry of Environment, Forest and Climate Change, n.d.).

5. The Air (Prevention and Control of Pollution) Act of 1981: The Air (Prevention and Control of Pollution) Act was passed in 1981 and it was later updated in 1987. It talks about the prevention, control as well as reduction of air pollution in India (Central Pollution Control Board, n.d.).
6. Bhopal Gas Tragedy (1984) and Its Aftermath: The unfortunate event that took a toll on the lives of many people, and led to the death of thousands in Bhopal. Short-term effects such as coughing, breathlessness, stomach-ache, eye irritation, etc, were noticed. Long-term effects such as impairment of memory, chronic bronchitis, scars on the cornea, and mental disorders, not limited to but including Post Traumatic Stress Disorder, were observed. As an aftermath of the tragedy, the government created the Environment (Protection) Act in 1986. The purpose of the act is to protect and develop the environment. Under section 3(3)002C, the Central government is given the power under the act to establish different authorities that are aimed at reducing and mitigating environmental pollution in all its forms. The authorities are also tasked with handling the specific environmental issues that are unique to different parts and regions of the country. The revision for the same took place in 1991 (Central Pollution Control Board, n.d.). The revision led to the creation of the Public Liability Act (1991). The new act was established to provide immediate help to anyone harmed by an accident that could occur while handling any hazardous substances. This includes any incidents that are related to the same.

Post-1991: Economic Liberalization and Strengthening Environmental Policies

Following 1991, economic liberalization, globalization, industrial growth, and rising environmental concerns led to important changes in India's environmental governance. Liberalization sped up economic development, but it also brought forth new environmental problems like industrial pollution, deforestation, and the threats posed by climate change (Mariyankari & Rathod, 2024). It has created a fear that 'dirty industries' now tend to move to developing nations where they have lenient environmental regulations compared to those of industrial countries (Burguet & Sempere, 2003).

International commitments, new environmental laws, judicial activism, and the rise of green finance all influenced India's sustainability framework throughout this perio d.

1. 1991 Economic Reforms and Industrial Growth: India opened up its economy and accelerated industrialization and urbanization in a shift away from socialism, led by Prime Minister Mar Simha Rao and Finance Minister Dr. Manmohan Singh.Rising Environmental Degradation: Having a large consumer base in India with low resource labour cost, it has opened up the window to exploit natural resources. Its growing industrial sector has created issues such as water, sewage, and waste disposal, along with problems of poverty as well as diseases, chemical usage in agriculture (D'Souza & Peretiatko, 2002). Economic development is linked to industrialization as a tool to reduce unemployment and poverty, and hence, the priority is given to 'industrialization' rather than 'clean manufacturing' (D'Souza & Peretiatko, 2002). As India's past reliance was majorly on agriculture, industrialization was the focus to achieve development. The merits and demerits of the same were a common topic for debate (D'Souza & Peretiatko, 2002).

2. Judicial Activism and Public Interest Litigations (PILs): Right to Life (Article 21), which explains no one shall be deprived of his well-being or personal liberty unless in accordance with the law. This means that everyone has the right to life, and it cannot be taken away except in line with legal procedures. The right to life includes a variety of aspects, such as the right to live with dignity, the right to a decent living, and the right to an environment that is healthy (*Article 21 in the Constitution of India*, n.d.).
3. Landmark Environmental Cases in Judicial Activism: The Taj Trapezium Case (1997) was concerned with Air pollution, which was damaging the Taj Mahal due to industrial emissions. Environmental law principles that were applied in Taj Trapezium Case were of Sustainable Development, Precautionary principle, Polluter pays principle, Article 21 of Indian Constitution (protection of life and personal liberty), Article 47 (raise nutrition level and SOL (standard of living) for improving public health, Article 48 A (protection of environment and wildlife) and Article 51A (g) (having compassion for all living things and preserving environment which includes forests, lakes, wildlife, rivers, etc.) (thelegalquorum, 2024) - M.C.MEHTA VS UNION OF INDIA
4. The polluter pays – The "Polluter Pays" principle, as interpreted by this Court, means that absolute accountability for environmental harm includes not just compensating pollution victims, but also the cost of rectifying environmental degradation. According to a preliminary survey conducted by the Tamil Nadu Agricultural University Research Centre, Vellore, over 35,000 hectares of agricultural land in the Tanneries Belt have become partially or completely unsuited for cultivation. The principle of polluter pays has been accepted as part of the law of the land. In addition to identifying the individuals and families who have suffered as a result of the pollution, the authority will also determine the amount of compensation that should be given to those individuals and families. This will be done with the assistance of expert opinions and after the concerned polluters have had a chance to speak. The authority will also decide how much money should be collected from the polluters to repair the environment that has been harmed. The authorities will establish a fair and reasonable process for carrying out the exercise (indiankanoon.org, 1996).

Paris Agreement and India's role

The Paris Agreement addresses the reasons for the change in climate and the concerns that are being faced by governments. The UN Climate Change Conference held in Paris on December 12, 2015, was attended by 195 member countries. (UNFCCC, n.d.). It came into effect on November 4, 2016 (UNFCCC, n.d.). The convention's major purpose is to make governments aware of climate change and undertake measures to limit the temperature to 1.5 degrees Celsius above pre-industrial levels (unfccc.int, n.d.).

The agreement is a cycle that takes place every 5 year of progressively determined action for preventing climate -- or scaling up -- implemented by governments. Countries have started submitting national climate action plans, or NDCs (Nationally Determined Contribution), since 2020. Each subsequent NDC is intended to demonstrate a higher level of ambition than the prior one. Through the Paris agreement, the countries can provide support to each other in the form of finance, technology, and capacity building (unfccc.int, n.d.).

These goals aren't easy or convenient to achieve. Huge efforts from governments are expected. The governments, states, as well as cities and businesses, have been setting up goals to achieve and reduce carbon (Azmi et al., 2022). This trend is particularly visible in the electricity and transportation industries, and it has opened numerous new commercial opportunities for early adopters (unfccc.int, n.d.).

India? Where does it stand?

The goals of India's first National Development Goal (NDC) include lowering the emissions intensity of its GDP by 45% by 2030 and advocating for a healthy and sustainable way of living founded on customs and values of moderation and conservation through a large-scale campaign for "LIFE"—"Lifestyle for Environment" (Gyani & Chandel, 2024) (climateactiontracker.org, n.d.).

It has also aimed to achieve approximately 50% cumulative electric power installed with the help of non-fossil fuel-based energy resources (renewable sources), creation of additional forest cover by 2030, and increasing investments in sectors such as agriculture, coastal areas, disaster management, etc. establishing capacities, construct a domestic framework and an international architecture for the rapid dissemination of cutting-edge climate technology in India, as well as jointly conducting research and development for such technologies in the future (iea.org, n.d.).

Literature Review

The definition of Green Investment and Green Finance is different in different arenas. Researchers have defined the term "green investment" as the total cost of capitalizing the shift to a green economy, including lowering greenhouse gas emissions, boosting resilience, protecting food systems, and managing waste, transportation, water, and forest systems. Unlike green investment, which often focuses mainly on funding eco-friendly technologies or infrastructure, this approach also covers capital costs along with operating expenses, such as project planning, land acquisition, and other ongoing costs (Zadek & Flynn, 2013).

According to India, a "Green Project" promotes resource and energy efficiency (Department of Economic Affairs, 2022).. It encourages climate adaptation and/or resilience while lowering greenhouse gas emissions and carbon emissions. It prioritizes and enhances biodiversity and natural ecosystems, particularly in line with SDG principles (Department of Economic Affairs, 2022).

As per the research conducted by (Akomea-Frimpong et al., 2022), their main goals were to analyse the annual publications on bank green finance from 1990 to 2019, evaluate the journals, authors, nations, and institutions that actively contributed to the publication of studies on bank green finance, and pinpoint the relevant topics in bank green finance, particularly the most popular products and factors that influence bank green finance. They discovered that between 2012 and 2019, the number of publications on banks' green finance increased steadily as the subject gained popularity among scholars and the global economy provided the economic justification for this expansion (Akomea-Frimpong et al., 2022).

With data spanning 15 years, the study by (Khan et al., 2022) sought to investigate the impact of green finance on environmental sustainability, taking into account five regions: South Asia, Southeast Asia, China, Middle Eastern countries, and European countries. According to their findings, to confirm and safeguard "environmental sustainability," is to invest in renewable energy sources through public-private

partnerships. R&D spending on environmentally friendly projects (REDE) is positively correlated with environmental quality and significantly correlated negatively with CO2 emissions (Khan et al., 2022).

The examination of green bond markets was the goal of the research by (Taghizadeh-Hesary et al., 2021) in Asia and the Pacific, but they focused predominantly on those markets. Compared to green bonds issued in Europe or North America, the green bond features from issuance in Asia and the Pacific regions behave differently. In Asia, green bonds typically exhibit greater returns, but they also carry greater risks and heterogeneity.

The study by (Fu et al., 2023) refers to the core link between green finance and sustainable development by highlighting the need for financing green initiatives as part of mitigating climate change and achieving carbon neutrality. It also emphasizes how important it is to evaluate and communicate political unpredictability and climate risks in order to minimize potential losses related to environmental variables, in addition to encouraging investments in sources for renewable energy with the aim of economic growth with respect to sustainability (Fu et al., 2023). The study also highlights the importance of international cooperation and trade openness in tackling sustainability issues, emphasizing the need for stakeholders to work together to support green finance initiatives and guarantee access to thorough data for well-informed decision-making (Fu et al., 2023).

In addition to measuring the effect of sustainable environmental performance on the firm's profitability, the study by (Jain & Sharma, 2023) sought to investigate how green banking practices affected the firm's sustainable environmental performance. Their study found a link between a bank's profitability and its environmental performance, suggesting that better environmental practices may positively influence financial outcomes (Jain & Sharma, 2023).

By looking at a diverse group of 30 emerging nations, the study which was done by Chen et al., 2024) to assess and also highlighted the variables influencing the growth of green finance. The study concluded that, in comparison to non-renewable energy consumption, financial stability has an increasing effect on consumption pertaining to renewable energy. They added that market capitalization, asset quality, and managerial inefficiencies are important factors in high-income nations (Chen et al., 2024).

India presents major obstacles in attaining its sustainable development goals and climate obligations, necessitating a transition from traditional funding to more environmentally friendly ways (Rout & Sahoo, 2021). The country has undertaken efforts to promote sustainable development and reduce carbon emissions, with a focus on green financing projects (Lokesha, 2024).

Green Finance is indirectly related to having growth in the economy, but also has benefits to our environment. It assists in channelling and directing the funds from the people, private businesses, and government to sustainable development activities (Jha & Bakhshi, 2019). India, on the other hand, requires funding for green infrastructure, amounting to 4.5$ trillion by 2040 (Jha & Bakhshi, 2019). Green financing is critical for India's sustainable development, solving environmental issues, and boosting economic progress (Jha & Bakhshi, 2019). It connects the financial industry, environmental improvement, and economic growth by recognizing the value of natural capital and working to increase human well-being and social equality (Soundarrajan and Vivek, 2016). Changes in national laws and regulations, harmonizing public

financial incentives, boosting green financing from various sectors, aligning public sector financing decision-making with the Sustainability Development Goals' environmental dimension, raising investment in clean and green technologies, financing for climate-smart blue economies and sustainable natural resource-based green economies, increasing the use of green bonds, and more are some ways to promote green financing (Environment, 2018). Financial markets, through which banks and investors distribute cash to other sectors, are at the heart of today's worldwide economy. (Environment, 2018).

Green finance can offer additional funds to purchase clean technology, develop sustainable infrastructure, renewable energy for clean development, and environmental protection. Considering the environment with regard to financial systems and institutional investment choices will help drive economic development, improve people's quality of life, and eventually, build a resilient and sustainable future (Devi, 2023).

The effectiveness of climate technology transfer will be impacted by the technological demands of the nation receiving it and the technology development needs of the contributing nation at the planning phase, as well as stakeholder harmonization, trust, comprehension, and cooperation at the time of implementation. (*Taxonomy of Climate Change.Pdf*, n.d.). The international community has prioritized technological transfer to combat climate change. However, it is difficult to debate effective technology transfer between donor and recipient countries since the scope and meaning of climate technology have not been thoroughly evaluated. (*Taxonomy of Climate Change.Pdf*, n.d.).

Opportunities for Green Finance for India and the world

India provides considerable green investment opportunities for international capital in priority areas such as cleantech, clean energy, renewable transportation, electric vehicles, industrial decarbonization, water, and nature-based solutions, which could stimulate green growth (Kashyap & Pal, 2023). Meeting its Nationally Determined Contributions (NDCS) targets by 2030 would require India to achieve $170 billion each year of green investments.

Similarly, decarbonizing the Indian economy by 2050 would require green investments of somewhere between 3.5% to 6% of GDP (Gupta et al., 2022).

Market Insights and initiatives

When it comes to installing solar energy facilities, India is a very favorable country. In the past nine years, the installed solar energy capacity has grown 26 times, reaching 73.32GW as of December 2023 (India's Renewable Energy Growth, 2025).

By authorizing 20,000 MW of projects in 2.5 years and increasing solar pump storage to 55,000 MW, Maharashtra is accelerating its expansion in solar energy.

Shirdi is set to become Maharashtra's first solar-powered town, with plans to build a solar plant that will meet the energy needs of both the temple and the surrounding community (Botekar, 2024). The aim is to generate clean, sustainable power while eliminating energy bills for local facilities (Botekar, 2024)

According to the International Hydropower Association (IHA), India has surpassed Japan to become the country with the fifth-largest hydropower production capacity in the world, with a total installed base of about 51.77GW, headed by the United States, Canada, Brazil, and China. (ETEnergyworld, n.d.)

Radiance Renewables, a clean energy company from India, has teamed up with the UK's Private Infrastructure Development Group to create a new company called

Radiance InfraCo Renewables. Their goal is to help India reduce pollution and reach its net-zero emissions target by 2070. This partnership brings together global support and local efforts to build a cleaner and greener future for everyone (India's Renewable Energy Growth, 2025). It is a joint venture that is going to build greenfield solar and wind-solar hybrid projects for commercial and industrial businesses in India. (ETEnergyworld, n.d.)

Time-bound renewable resources like solar and wind can only generate electricity when there is enough sunshine and wind. By combining different renewable energy sources, round-the-clock (RTC) supply systems can overcome the natural limitations of individual sources, ensuring a more stable and reliable power supply (IISD, 2021). To put it simply, a stable and sustainable power grid can be created by combining conventional and non-conventional resources (India's Renewable Energy Growth, 2025).

Back in 2008, as part of a small pilot project, Selco Solar Pvt Ltd started installing solar panels in slum areas that didn't have access to electricity. What began as a local effort has since grown, reaching more communities across different states, bringing clean and reliable energy to those who need it most (India's Renewable Energy Growth, 2025). To encourage the slum dwellers to switch from kerosene to solar electricity, they have also employed standardized financial packages. (IBEF) Karnataka Bank and SELCO Solar Light Private Limited, which designs, assembles, sells, and maintains solar energy products, have inked a Memorandum of Understanding (MOU). In order to help individuals, HUFs, farmers, traders, businessmen, proprietorship concerns, professionals, salaried individuals, institutions, and others buy solar energy products from SELCO Solar Light Private Limited in India, Karnataka Bank is offering financial support under this cooperative effort. (Shetty, 2022)

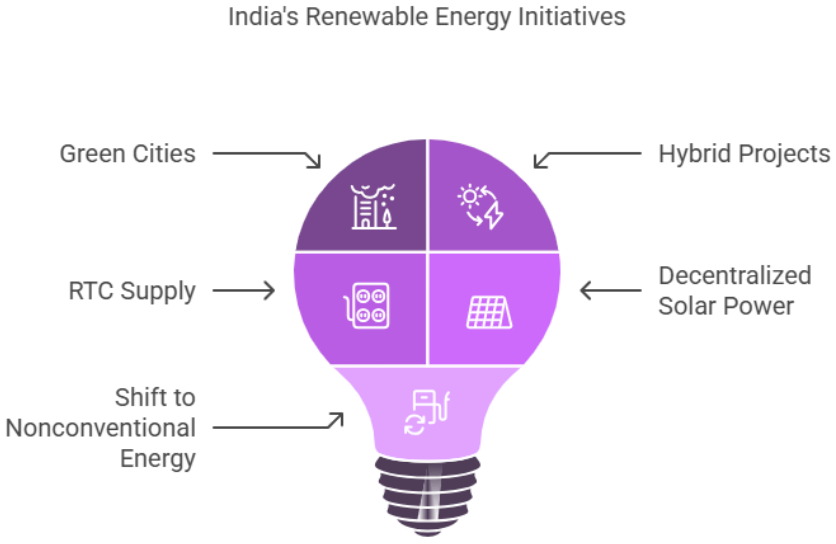

Fig 1: Representing India's renewable energy initiatives in pictorial form

Maruti Suzuki India is stepping up its green efforts by planning to invest ₹450 crore (about US$54 million) over the next three years in renewable energy projects. This includes setting up a biogas plant in Manesar and expanding its use of solar power. As

part of this plan, the pilot biogas plant, expected to be up and running in 2024–2025, aims to produce 1 lakh cubic meters of biogas each year—helping the company cut down around 190 tonnes of CO2 annually (India's Renewable Energy Growth, 2025). From 43.2 MWp to 78.2 MWp by FY26, solar power will support Suzuki's "Environment Vision 2050" (Singh, 2024).

Opportunities

India has set a goal to reach 450 GW of renewable energy capacity by 2030, with solar energy expected to make up a major share, around 280 GW, which is more than 60% of the total (Koundal, 2025). According to a report by the UK-based energy think tank Ember, there's a significant opportunity for solar energy in India's heavy industries like cement, steel, as well as aluminium (Koundal, 2025). These industries, which currently rely heavily on coal, could potentially shift towards cleaner sources through a 20 GW solar open access market (Koundal, 2025). The report also points out that about 40% of this opportunity is concentrated in the states of Chhattisgarh and Odisha, making them key players in the country's move towards cleaner industrial energy (Koundal, 2025)

Tata Power: Revolutionary entry in the Floating solar power plant. The water reservoir can act as a medium for not just saving water but also harvesting sunlight (Sadhwani, 2025). As the population grows and land becomes more scarce, the engineers have proposed floating solar panels. A floating solar power plant, or floating solar farm, is a bunch of photovoltaic (PV) panels on a structure that floats on a body of water, i.e. artificial basin or a lake. (Tata Power, n.d.)

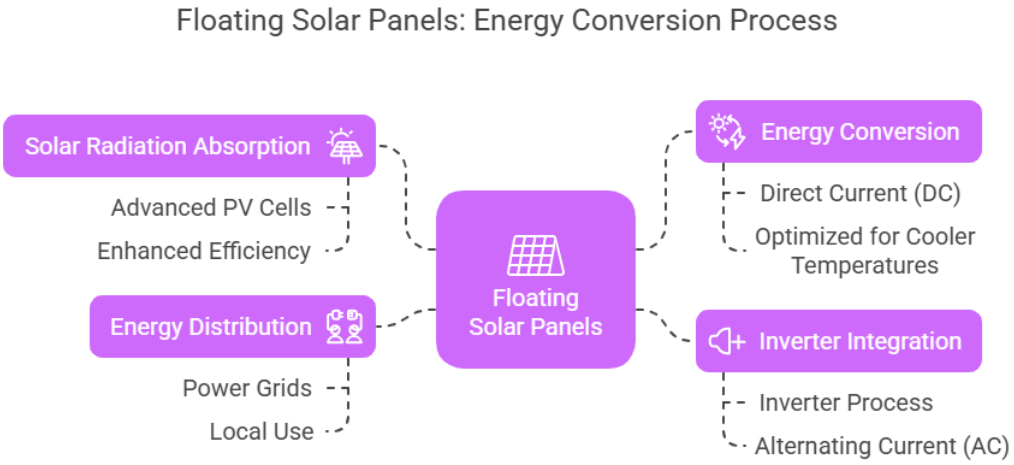

Fig 2: Figure representing Tata Power's process of floating solar panels

Major Installations:

A. Omkareshwar floating solar project: This project, spread across 260 hectares of water, is a massive 126 MW floating solar power plant (Tata Power, n.d.). It's said to be home to the world's largest inverter and can generate around 204,580 MWh of clean energy each year (Tata Power, n.d.). Not only does it help reduce around 173,893 tonnes of CO2 emissions annually, but it also conserves about 32.5 million cubic meters of water—making it a great example of how renewable energy can benefit both the environment and resource management. (Tata Power, n.d.)

B. Kayamkulam floating solar project: The said project is located in Kerala, which is a 101.6 MW plant spread across a 350-acre backwater area. It can generate 167150 MWh annually, which reduces 64142 tonnes of CO2. (Tata Power, n.d.) Moreover, these projects go beyond technology, reflecting the ideas of responsible and inclusive growth. Environmental impact evaluations are carried out rigorously to conserve ecosystems, while extensive community engagement ensures local residents share in the advantages. These programs encourage cooperation, improve local economies, and provide a brilliant illustration of how broad and significant ethical energy transformations can be.

Adani Green Energy Limited - Setting up of projects for production of renewable sources of energy: In 2023, Adani Green Energy Limited (AGEL) became one of India's biggest players in the renewable energy sector (Shah, 2024). The company's total operating capacity crossed the 10,000 MW mark, with around 7,400 MW coming from solar projects, 1,400 MW from wind energy, and another 2,140 MW from hybrid wind-solar installations (Shah, 2024). AGEL is currently building the world's largest renewable energy project in Khavda, Kutch, Gujarat, with a massive planned capacity of 30,000 MW (Shah, 2024). What makes this project even more impressive is its sheer size—it spans about 538 square kilometres, which is roughly the size of Mumbai and nearly five times bigger than Paris (Shah, 2024). This project is a major step forward in India's journey toward a greener and more sustainable energy future. (Shah, 2024).

NTPC and ONGC: a JV for Renewable Energy. Through greenfield development and acquisitions, ONGC NTPC GREEN PRIVATE LIMITED (ONGPL) will investigate and establish Renewable Energy (RE) projects and assets. Among other relevant tasks, it will also evaluate the viability and implementation of offshore wind projects (ET Online, 2024). Additionally, it will examine the potential in the areas of e-mobility, storage, and ESG (Environmental, Social, and Governance)-compliant initiatives. It will also look at ways to move toward a low-carbon transition through Carbon Credits and Green Credits. (ET Online, 2024)

JSW Energy: A power back acquisition. JSW Energy is getting closer to reaching its 2030 clean energy target of 20 GW after making its largest acquisition to date, paying Rs 12,468 crore to O2 Power for a 4.7 GW renewable energy platform (Paul, 2025). According to a business statement, the agreement, which was carried out through its fully owned subsidiary JSW Neo Energy, adds 4,696 megawatts (MW) of capacity distributed among solar, wind, hybrid, and round-the-clock (RTC) renewable power. (Paul, 2025)

Japan's Green Finance Innovations: A Historical and Strategic Analysis

The gradual adoption of sustainable finance in Japan has been characterized by a rise in activity and the participation of numerous stakeholders in recent years (Schumacher et al., 2020). As a longtime supporter of global health and an active partner of the WHO, Japan is dedicated to making sure that no one is left behind and that everyone has access to healthcare (WHO, 2024).

The UNDP's (United Nations Development Programme) Regular (Core) Resources for 2024 have received USD 45.3 million from the Japanese government. Japan's significant contribution, which indicates Japan's steadfast dedication to multilateralism and the close relationship between Japan and UNDP, is greatly appreciated by UNDP (UNDP, 2024).

Areas of Progress and Positive Indicators:

The Japanese government has strongly supported sustainable finance through programs like the "Principles for Financial Action towards a Sustainable Society" and through a number of ministries, including the MOEJ (Ministry of Energy Japan), METI (Ministry of Economy, Trade, and Industry), and JFSA(Japan Financial Services Agency) (Schumacher et al., 2020). The Ministry of the Environment's (MOE) Green Finance Portal is Japan's first green debt database (Ministry of the Environment, 2025). It was created to support and grow the country's green finance market by improving access to information on green bonds and related investments (Ministry of the Environment, 2025). It includes market data as well as basic information about each green debt product, including green bonds and loans, and related policy information (Ministry of the Environment, 2025).

There are two primary factors that hinder green energy projects: There is (a) a lower rate of return and (b) a higher investment risk when compared to fossil fuel projects (Yoshino & Taghizadeh-Hesary, 2018). The Japan Bank for International Cooperation (JBIC) was set up on April 1, 2012, with a strong focus on promoting overseas business that helps protect the global environment and tackles climate change (Japan Bank for International Cooperation, 2024). One of its key initiatives, known as GREEN (Global action for Reconciling Economic growth and Environmental preservation), supports environmentally friendly projects in developing countries (Japan Bank for International Cooperation, 2024). JBIC works closely with international organizations and local financial institutions to back projects that aim to significantly cut greenhouse gas emissions (Japan Bank for International Cooperation, 2024). At the same time, it also helps bring advanced Japanese environmental technologies to the global stage, balancing economic growth with sustainability (Japan Bank for International Cooperation, 2024).

Toyota Motor Corporation: Sustainable revolution in India. Since 2004, Toyota's Lexus division has led the way in hybrid electric technology, fusing state-of-the-art systems to create luxury vehicles with low emissions and high performance, such as the ES, RX, NX, and LM. Toyota's commitment to the Indian market and the "Make in India" initiative is demonstrated by the fact that India is now the second country outside of Japan to produce Lexus cars (Toyota, 2024)

The company uses the 4R approach to optimize water usage efficiently.

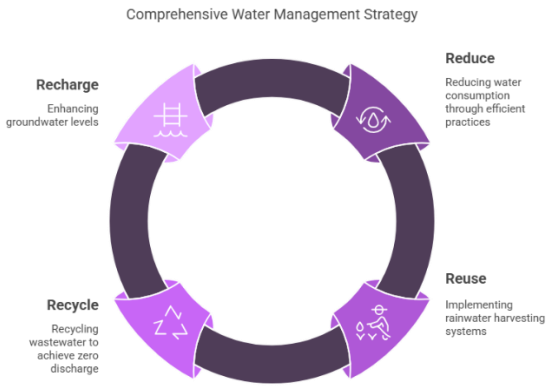

Fig 3: Figure representing Toyota's comprehensive water management strategy using 4 R

Toyota Environmental Challenge 2050: The Toyota Environmental Challenge 2050, or Challenge 2050, is a set of six big goals that go beyond just reducing harm to the

environment—they focus on creating positive changes for both the planet and society (Toyota, 2024). These challenges include reaching carbon neutrality by cutting CO2 emissions throughout a vehicle's life, from production to driving, as well as at Toyota's plants (Toyota, 2024). The challenge also focuses on using water more efficiently, building a recycling-based society, and creating a future that lives in harmony with nature (Toyota, 2024). Looking ahead, Toyota aims for 70% of its new cars sold in the US to be electric by 2030 (excluding performance models) (Toyota, 2024). Additionally, by 2026, the company plans to get at least 45% of the electricity it uses in North America from renewable sources. (Toyota, 2024)

Hitachi's Digital Green Bond: The 'Digitally Tracked Green Bond' is issued by Hitachi Ltd., JPX Market Innovation & Research, Inc., Nomura Securities Co., Ltd., and BOOSTRY Co., Ltd., and employs digital technology, including Blockchain and IoT (Hitachi, 2023). Digital green bonds use technology to make collecting data for green investments easier and clearer. By doing this, they help improve transparency and efficiency, which are really important for making sure green projects get the right support (Hitachi, 2023). To allow investors to easily view the bond's environmental impact, the bond will feature a corporate bond-type security tokens ("digital bond") scheme that uses a blockchain provided by BOOSTRY and a Green Tracking Hub that was co-developed by Hitachi and JPXI (Hitachi, 2023).

Fig 4: Figure showing Hitachi's process of digital tracked green bond

Sumitomo Mitsui Financial Group (SMFG): Sumitomo Mitsui Financial Group (SMFG), one of Japan's top financial institutions based in Tokyo, mainly focuses on banking, investment, and asset management. In recent years, SMFG has become a leader in green financing (*Green Bond/Loan | Sumitomo Mitsui Financial Group*, 2024). Taking climate change seriously and aligning with the Paris Agreement and Sustainable Development Goals (SDGs), SMFG has integrated ESG (Environmental, Social, and Governance) principles into its business strategies (*Green Bond/Loan | Sumitomo Mitsui Financial Group*, 2024). The group was also the first private financial institution in Japan to issue green bonds, and since then, the SMBC Group has continued to issue these bonds regularly to support environmentally friendly projects. (*Green Bond/Loan | Sumitomo Mitsui Financial Group*, 2024).

USA and its Leading contributions

Global warming and climate change are forcing economies all around the world to make significant changes in how they conduct business. As a result, sustainable development appears to be a useful instrument for this (Batrancea et al., 2020). Since 2014, the United Nations Environment Programme (UNEP) has promoted the

establishment of a sustainable financial system to raise capital for sustainable development and realize an inclusive and green economy (Batrancea et al., 2020).

Goldman Sachs: Commit to sustainable finance across the world: Goldman Sachs has been focusing on 2 major and interconnected themes pertaining to sustainability. – Climate transition and Inclusive Growth. Goldman has been making investments in sustainable and green finance across the world. Goldman Sachs funds have long supported Renew Power India – an Independent renewable energy firm, for initial investments in green bonds worth approximately $1.3 Bn, which also assisted the country by creating 4,000 new jobs in 95 villages. Northvolt raised $1 billion in equity capital in 2019 under the leadership of BMW, Volkswagen Group, and Goldman Sachs. This funding makes it possible to build the first gigafactory in Europe, Northvolt Ett, in Sweden, which will have a 16 GWh capacity for producing lithium-ion battery cells. The same is entirely fuelled by renewable energy (Goldman Sachs, 2024). According to Goldman Sachs Group Inc., it is more than 80% of the way to reaching its 2030 target of allocating $750 billion to promoting "inclusive growth" and aiding in the shift to a low-carbon economy (Marsh, 2025).

Apple Inc.: Revolution in green financing and sustainable development: Apple has released a total of $4.7 billion to speed up the company's supply chain's transition to carbon neutrality by 2030. Since 2016, Apple has released three Green Bonds, each with a project that demonstrates how the funds may lower global emissions and provide sustainable energy to local communities worldwide (Apple Inc., 2022). Apple keeps pushing forward with renewable energy by using its Green Bonds, which are some of the biggest in the private sector (Apple Inc., 2022). Almost $500 million from the company's 2019 Green Bond funding has been invested in clean energy projects (Apple Inc., 2022). One standout example is the world's largest onshore wind turbines that power Apple's data centre in Viborg, Denmark (Apple Inc., 2022). Any extra energy generated there is sent back into the Danish power grid, helping to support the wider community's clean energy needs (Apple Inc., 2022).

Tesla Inc.: EV and sustainable driving: A Tesla car will save about 51 metric tons of CO2e after 17 years of operation (Tesla Inc., 2023). As electricity generation improves over time, charging EVs becomes more environmentally friendly. In contrast, the annual carbon footprint of internal combustion engine (ICE) cars stays constant (Tesla Inc., 2023).. EVs can be fully decarbonized, offering better environmental impacts than fossil fuels throughout their lifecycle (Tesla Inc., 2023).

Comparative Analysis of India, Japan, and the USA

This study compares the progress of three countries—India, Japan, and the United States—by looking at how policies, institutions, tools, and innovation have helped drive "green finance and sustainable development" in each nation.

Regulatory framework and Instruments:

India: In the Union Budget for 2022–2023, India announced plans to issue Sovereign Green Bonds to help reduce the country's carbon footprint (Department of Economic Affairs, 2022).. These bonds will raise money specifically for green infrastructure projects. The funds collected will support public sector efforts aimed at lowering the economy's overall carbon intensity, making it a key part of India's move toward a cleaner, more sustainable future (Department of Economic Affairs, 2022). There are around 22 Green debt securities issuers such as L&T Infrastructure, Tata Cleantech

Capital, Indian Renewable Energy Development Agency Limited, Ghaziabad Nagar Nigam, etc (SEBI, 2025).

Japan: There are over 100 issuers of Green bonds in Japan such as Hankyu Hanshin Holdings, Inc., Tasei Corporation, Kyoto City, Organization for Promoting Urban Development, Sumitomo Corporation, etc. under various categories such as Transportation, Real estate, Finance, Local government, Energy, Wholesale and retail trade, etc. and their end uses are approved for "clean transportation," "renewable energy," "energy efficiency," "adaptation to climate change," "sustainable management of biological and natural resources and land use," and so forth (Ministry of the Environment, 2025).

USA: The most important climate law in American history, the Inflation Reduction Act of 2022, will probably lead to a large-scale deployment of new clean electricity resources and provide incentives, programs, and funding to hasten the shift to a clean energy economy (US EPA, 2022). Bank of America issued eleven $14.93 billion Sustainable corporate bonds between 2013 and 2023. In compliance with the Sustainable Development Goals of the UN, it was the first bank in the United States to issue a corporate social bond (Bank of America, 2024). Alphabet issued $5.75 billion in sustainability bonds in August 2020, with the revenues going to sustainable energy, green buildings, energy efficiency, clean transportation, and other areas (Alphabet, 2022).

Conclusion

To sum up, green finance removes the financial barriers, and better regulation sustains the supported investments required for meeting national climate obligations. Therefore, it is imperative for India's low-carbon economy transition. Sustainable development, however, requires a cooperation module to work in harmony with technology and funding.

The US, Japan as well as India are the countries that are involved in making great progress in the area of “sustainable development” and “green financing”. India has a goal of reaching 450 GW of renewable energy capacity by the year 2030 (Koundal, 2025), and it is keen on drawing international investment in sectors of clean technology. On the other hand, Japan has promoted “sustainable finance” through its financial products such as “green digital bonds” and healthy government support. Meanwhile, the US has introduced strong policies like the Inflation Reduction Act to support its changes towards clean energy. These efforts show the country’s serious commitment to reaching its net-zero emissions goals. All three nations display a focus on collaboration between the private and public sectors, working towards environmental sustainability and achieving net-zero emissions. An increase in investments and advancing opportunities in these sectors will enable us to tackle climate change while enhancing economic growth.

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