

Evaluation of Sustainable Infrastructure Strategies in India and Abroad

Advanced Review Research Paper

Mrunmai Shrihari Panchwadkar.

Student, RMD Sinhgad Technical Institute, Pune

mrunmaipanchwadkar@gmail.com

Abstract— With many environmental impacts caused by global warming and climate change, humans must be more careful when building infrastructure. According to the UN Environment Program, infrastructure contributes 79% of total greenhouse gas emissions. That's why green actions like sustainable infrastructure must be supported to reduce damage caused by carbon emissions and human activity. This article discusses the ins and outs of infrastructure, so read the explanation here. Sustainable infrastructure is an infrastructure providing economic, social, and environmental advantages in the long term. Sustainable infrastructure is important to achieve global climate targets and the Sustainable Development Goals (SDGs). Moreover, this effort also grows the global economy. As the global population grows, this can disrupt the economic, social, and environmental balance because infrastructure must be designed appropriately to provide everyone with equal opportunities and facilities. It is not uncommon for some areas of the world to have areas that are chaotically designed, use too much energy, and even lack adequate public transportation facilities. Thus, sustainable infrastructure is here with more integrated, climate change-resilient, and sustainable urban area solutions. The concept of sustainable infrastructure is designed to fulfill the population's needs, such as power plants, roads, bridges, and others, adhering to sustainable principles. As a result, the infrastructure must be entirely environmentally friendly and include governance, economic, and social factors.

Index Terms— Renewable energy systems, Smart grids, Energy-efficient buildings, Clean energy transition, Decarbonization, Solar infrastructure, Wind energy projects, Energy storage systems, Green hydrogen, Distributed energy resources.

I. INTRODUCTION

Sustainable infrastructure is infrastructure that delivers long-term economic, social, and environmental (ESE) benefits. It is critical to achieving global climate targets and [Sustainable Development Goals](#), and to a strong and resilient global economy. Investing in sustainable infrastructure is more important now than ever before, as the world faces a climate crisis, a global economic slowdown, and the need to address inequalities that disproportionately affect the most vulnerable people. Sustainable infrastructure presents a tremendous opportunity for positive change. One major barrier to decarbonising infrastructure and achieving the SDGs is the shortfall of investment in sustainable infrastructure, which we call the 'sustainable infrastructure investment gap'. Estimates show that roughly [\\$2.6 trillion is required annually through 2030](#) to meet the Sustainable Development Goals (SDGs) and stay on a path to net-zero by 2050. Closing the gap could require more than [three times the current level of investment](#) in clean energy, and [70% of the spending](#) required is needed in emerging markets and developing economies (EMDEs).

II. LITERATURE REVIEW

- **sustainable Infrastructure Concepts**

Sustainable infrastructure refers to the planning, design, construction, and operation of infrastructure systems in a manner that balances environmental protection, economic growth, and social well-being. Researchers and policymakers across the world have increasingly emphasized the importance of sustainable infrastructure in achieving long-term development goals and addressing global environmental challenges such as climate change, resource depletion, and urbanization. Studies indicate that sustainable infrastructure can significantly reduce carbon footprints while simultaneously improving operational efficiency, environmental quality, and social benefits. As cities continue to expand rapidly, sustainable infrastructure has become essential for creating resilient and livable urban environments.

- **Green Building and Net-Zero Strategies**

Green buildings are one of the most important components of sustainable infrastructure. These buildings are designed, constructed, and operated to minimize environmental impacts while improving energy efficiency, occupant comfort, and resource conservation. Green building practices focus on reducing energy consumption, water use, construction waste, and greenhouse gas emissions throughout the building lifecycle. One of the advanced concepts in sustainable construction is the development of **Net-Zero Energy Buildings (NZEBS)**. Net-zero buildings are designed to produce as much energy as they consume annually through renewable energy systems such as solar photovoltaic panels and wind energy systems. These buildings aim to achieve extremely low energy demand through efficient architectural design and advanced technologies. In addition, active technologies such as smart energy management systems, efficient HVAC systems, LED lighting, and solar energy installations further improve building performance.

- **Climate Resilience and Urban Sustainability**

Rapid urbanization and climate change have increased the vulnerability of urban infrastructure systems to environmental hazards such as floods, heatwaves, droughts, rising sea levels, and water scarcity. Researchers emphasize that traditional infrastructure systems are often unable to cope with these growing climate-related challenges. As a result, climate-resilient and sustainable infrastructure has become a major priority in urban planning and development. Climate resilience refers to the ability of infrastructure systems and urban areas to withstand, adapt to, and recover from climate-related impacts while maintaining essential functions and services. Sustainable infrastructure strategies improve urban resilience by integrating environmentally adaptive and resource-efficient solutions.



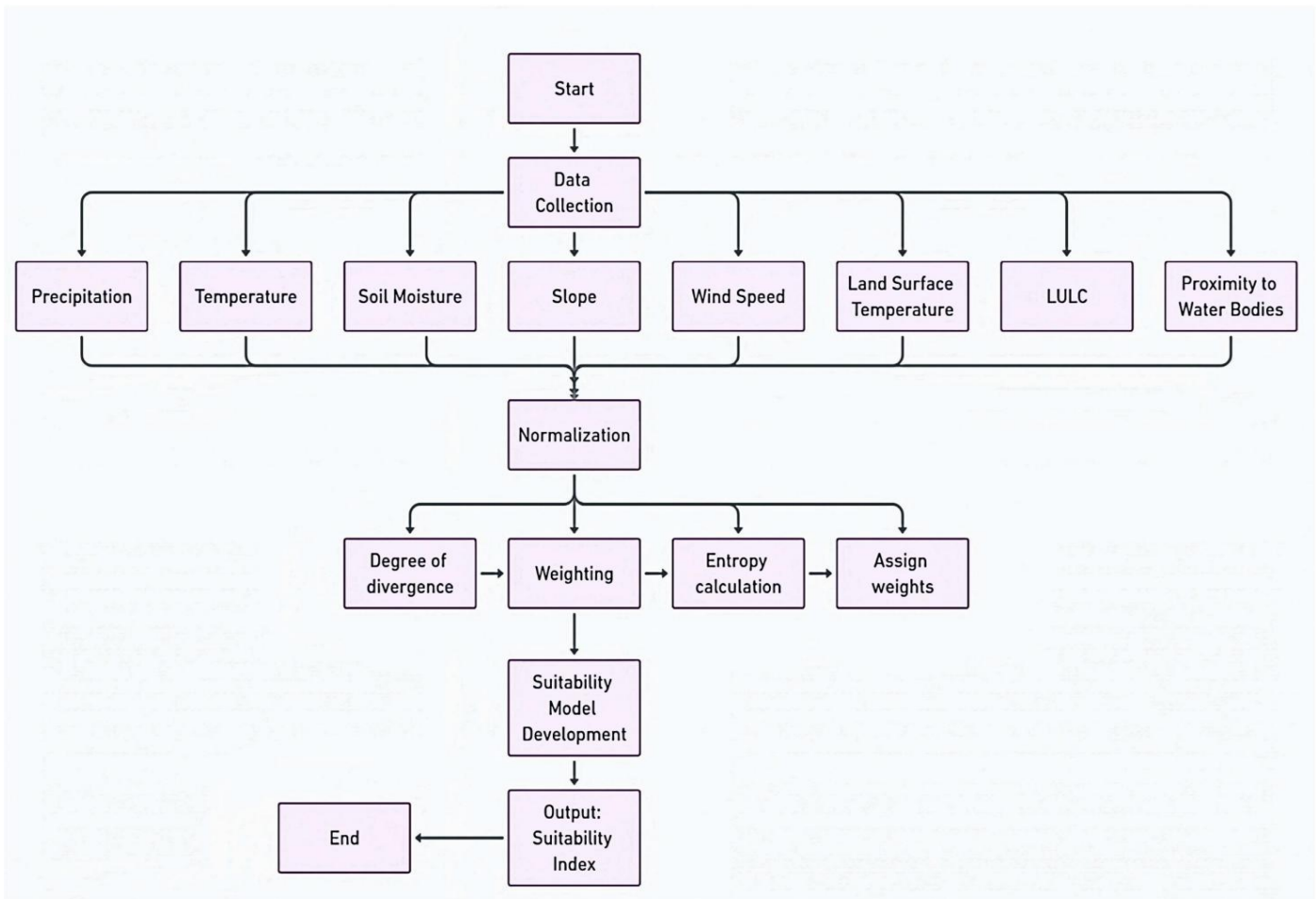
Fig. 1 Sustainable infrastructure

IV. RESEARCH METHODOLOGY

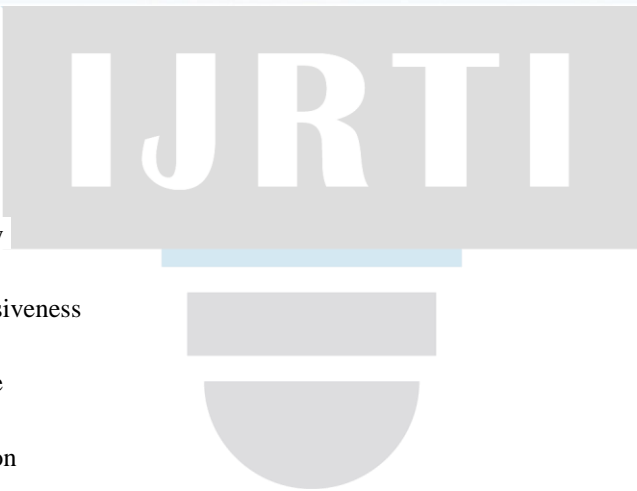
Description of methodology

Sustainable infrastructure is based on four major dimensions:

- Environmental Dimension :
 - Reduction of greenhouse gas emissions
 - Renewable energy utilization
 - Resource conservation



- Waste reduction
- Biodiversity protection
- Social Dimension
- Public health and safety
- Accessibility and inclusiveness
- Improved quality of life
- Community participation
- Social equity
- Economic Dimension
- Cost-effectiveness
- Long-term economic benefits
- Job creation
- Efficient resource utilization



- Lifecycle cost reduction
- Governance Dimension
- Governance includes:
 - Transparent decision-making
 - Stakeholder involvement
 - Institutional accountability

CASE STUDY

CASE STUDY 1- INDIRA PARYAVARAN BHAVAN, NEW DELHI

India's First Net-Zero Energy Building Indira Paryavaran Bhavan- This is a project of the ministry of environment and forests for the construction of new office buildings at Aliganj, Jor Bagh Road, New Delhi. The project has been designed to make the net-zero energy building. First in government sector targeted for both ratings of green building (STAR GRIHA LEED India Platinum) The building has won awards such as the Adarsh/GRIHA of MNRE for ideal illustration of Integration of Renewable Energy Technologies. This new office building has been constructed in a composite zone. This building sets revolutionary change into conventional building design. The building has been designed by CPWD by using an integrated design approach with the help of multi-disciplinary fields experts like Architect, Electric Consultant, HVAC Consultant, Plumbing Consultant, Green Building Consultant, Commissioning Authority, Landscape Consultant, Structure Consultant, and other project team members. The project team emphasized on the energy conservation measure at every step of building design and construction for reducing energy demand by using passive design strategies by providing windows with shadings which again provide adequate natural light with that landscape to reduce ambient temperature and for outdoor greenery access with that energy efficient active systems. All the possible energy-efficient and conservation practices were adopted to lessen the energy load of the building and the remaining demand load was met by an onsite solar PV System of 930 kW capacity to make the building Net Zero Energy building

The energy consumption of Indira Paryavaran Bhawan is 67.3% less in comparison to the GRIHA benchmark. The project adopted numerous green building concepts for occupants' well being and eco-friendly approaches like water conservation and rainwater harvesting. The building orientation set in the manner that it favors optimum solar access and shading. Two blocks facing North south direction have been arranged parallelly having a linear open court in the middle. Building front is a wider setback so that it can protect tree lines for occupant's outdoor view access.

Renewable Energy:- The Indira Paryavarn Bhavan met the energy demand with the green and clean energy solution, Efficient Solar PV systems. The building has a solar PV system installed in a 6000 m² area of 930 kW capacity. The total area covered by the panel is 4650 m² by 2844 solar panels which generate 14.3 lakh unit annually which is huge in amount. This is the first govt. building in the country to achieve the landmark of net-zero energy building and one of the very few full fledged multifunctional office buildings in the world to do so on a tight urban site Active Design Strategies: -The active design uses appliances and technologies to modify the state of the building, create comfort and energy, ie. Fans, pumps, etc. This is the main part where much of the energy conservation can be done. • Lighting Design: Building provided with an energy efficient



FIG 2 INDIRA BHAVAN NEW DELHI

lighting system that uses a lux level sensor to optimize the operation of artificial lighting. The total lighting power density of the building is $LPD = 5 \text{ W/m}^2$ which is much more efficient than Energy Conservation Building Code benchmarks. Installed integrated photovoltaic (BIPV) provides energy to the remaining lighting load

CASE STUDY 2-GREEN ROOF AND WATER MANAGEMENT PROJECT PHILIPPINES

Rapid urbanization in the Philippines has given rise to many challenges as increasing infrastructure developments contribute to reduced open spaces and increased energy consumption. LLDA is a governmental agency in the Philippines. Its mission is to ensure the development and balanced growth of the Laguna Lake area while providing environmental management, control, and preservation of the quality of human life and ecological systems

Objective: Rapid urbanisation in the Philippines has given rise to many challenges as increasing infrastructure developments contribute to reduced open spaces and increased energy consumption. Now, buildings should not be sturdy and spacious, they should also be efficient in energy consumption and adaptive to the changing environment. Lafarge Holcim supported LLDA's mission to protect the Laguna Lake area and be an exemplary environmental steward by providing innovative technology products for the LLDA's new building.

Start/end date: 24 October 2014 - 24 October 2020

NBS goals:

- Enhancing sustainable urbanization
- Developing climate change mitigation
- Developing climate change adaptation
- Improving risk management and resilience
- Nature-based solutions for improving well-being in urban areas
- Nature-based solutions for increasing the sustainable use of matter and energy

NBS benefits:

- Developing climate change adaptation; improving risk management and resilience
- Increase infiltration / Water storage
- Reduce drought risk
- Reduce flood risk
- Reduce load to sewer system
- Reduce run-off
- Reducing temperature at meso or micro scale
- Developing climate change mitigation
- More energy efficient buildings
- Reduction of energy in the production of new buildings and building materials
- Greater ecological connectivity across urban regenerated sites
- Increase Biodiversity
- Increased cultural richness and biodiversity
- Enhancing sustainable urbanisation



FIG 3 GREEN ROOF AND WATER MANAGEMENT BUILDING PHILLIPINES

Similarities between two case studies are -

- Both projects share several important sustainability-driven objectives and approaches, even if their specific designs or scales differ. Their similarities can be understood across environmental goals, planning strategies, and long-term urban benefits.
- Both projects strongly emphasize environmental sustainability by aiming to reduce negative impacts on natural systems. This includes lowering carbon emissions, minimizing pollution, and ensuring that development does not degrade surrounding ecosystems. Sustainability is treated not as an add-on, but as a core design principle guiding planning and execution.
- They also both rely on green infrastructure strategies as a key method for achieving environmental balance. This typically includes features such as green roofs, permeable pavements, rainwater harvesting systems, urban tree cover, and natural drainage solutions. Such infrastructure helps manage stormwater, reduce urban heat island effects, and improve air quality while integrating nature into built environments
- A major shared focus is improving energy efficiency. Both projects aim to reduce energy consumption through better building design, use of renewable energy sources like solar power, and incorporation of energy-efficient technologies such as LED lighting, smart sensors, and optimized ventilation systems. This not only reduces operational costs but also lowers greenhouse gas emissions.
- Finally, both contribute to sustainable urban development by supporting long-term, resilient city growth. They encourage development patterns that balance economic progress with environmental protection and social well-being. By integrating sustainability into urban planning, both projects help create healthier, more livable, and future-ready urban environments.

● CONCLUSION

The conclusion for sustainable development in both abroad and India is that while progress has been made, significant challenges remain. Globally, conflicts, climate finance gaps, and the lingering effects of the pandemic have hampered progress. In India, progress is seen in areas like poverty reduction and clean energy, but the immense diversity and scale of the country make implementation complex. Both are moving towards more integrated approaches that require multilateral cooperation and focused action from all stakeholders to achieve the UN Sustainable Development Goals (SDGs).

Global conclusion

- Progress and setbacks: While global initiatives have pushed for the integration of environmental concerns into economic policies, progress towards the 2030 Agenda has been threatened by recent global crises like conflicts and the COVID-19 pandemic.
- Need for systemic change: Achieving sustainable development requires urgent multilateral cooperation, reforms in climate finance, and stronger enabling conditions for all stakeholders—governments, non-governmental organizations, the private sector, and civil society—to work together effectively.
- Individual action: Individuals have a crucial role to play by making sustainable choices, supporting sustainable businesses, and advocating for policy changes.

India' s conclusion-

- Progress on SDGs: India has shown significant progress in key SDGs related to poverty reduction, health, clean energy, and sanitation, with its overall score on the SDG India Index improving over the years.

- Implementation challenges: The country faces the complex challenge of balancing rapid economic growth with environmental protection due to its immense diversity, requiring a constant effort to improve living standards while safeguarding resources for future generations.

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- **REFRANCES**

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