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Study Of Eco-Friendly Development And Green Construction In India

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Abstract—The industrial revolution and technological advancement started in the 18th century have a lot to boast for its success in many aspects of human life like reduction in infant mortality rate, human life expectancy, education, health, global food production etc. But the development and gains have many flip sides also. It is not sustainable in long run. It is undermining the ability of the environment and ecosystem, disturbing the fine balance of nature on the planet which is threatening the lives of many species on earth. The main cause of Environmental problems is excessive emission of Green House Gases (GHG) like CO2, NO2, SO2, CO etc. due to the burning of fossil fuels to meet the energy demand of human beings and reduction in forest cover. The sustainability debate started in the 1960s with the beginning of a modern environmental movement. Urbanization which is a hallmark of Industrialization creates a huge demand for modern building construction material as modern building construction techniques use processed building materials like cement, steel, tiles, aluminium, glass, and bricks etc. which are produced in the construction industry. As per estimate building and construction together consumes around 36% of global final energy. The building sector is growing at a very high rate and it is estimated that over the next 40 years, the world is expected to build 230 billion m2 in new construction. (UN, Global status report 2017) adding to the existing 235 billion m2 in 2016. This growth will push energy demand to a very high level from the construction sector itself, globally. The building and construction industry accounts for about 40% of energy rated CO2 emissions. The experts and policymakers started a debate on how to reduce the energy demand and how to reduce the adverse impact of the built environment without compromising its functionality. The experts started a discussion on methods and means of construction to reduce or eliminate adverse impacts on the environment and make the building sector more sustainable. This gave birth to the "Green Building Concept". The built environment should be planned, designed and constructed in such a way that its adverse impact and influence on natural eco-cycles are minimal.

Key Words:- Eco-friendly, Green Building, Industrial revolution, Eco-Cycle

I. Introduction

Green Buildings and Sustainable Development: A Focus on India's Progress and Challenges.The concept of green buildings, which minimize energy, water, and resource consumption while reducing waste and greenhouse gas (GHG) emissions, has emerged as a critical response to global environmental challenges. Traditional buildings account for 35–40% of global energy use during construction and operation, 36% of CO_2 emissions, and significant depletion of natural resources. Climate change impacts, such as rising sea levels threatening India's Sundarbans and Himalayan glacier melt endangering the Ganges, underscore the urgency for sustainable practices Sustainability and Global Frameworks The 1992 Rio Earth Summit established sustainable development (SD) as development that meets present needs without compromising future generations. Agenda 21 and the 2015 UN Sustainable Development Goals (SDGs), particularly Goals 6 (water), 7 (energy), 11 (sustainable cities), 13 (climate action), and 15 (ecosystems), emphasize reducing the built environment's ecological footprint. Buildings, consuming 36% of global energy and contributing 40% of energy-related CO_2 emissions, are central to this agenda. The construction sector's reliance on fossil fuels exacerbates GHG emissions, necessitating decarbonization through renewable energy and efficient design. Green buildings integrate resource efficiency, renewable energy, waste reduction, and ecosystem conservation. Rating systems like BREEAM (UK), LEED (USA), and GRIHA (India) promote these principles. These systems prioritize minimizing non-renewable resource demand, enhancing material efficiency, and leveraging solar, wind, and tidal energy. Unlike linear, waste-intensive conventional construction, green buildings emulate natural ecosystems' cyclical processes, fostering resilience and sustainability. India's Green Building Landscape India introduced green building initiatives in 2001 with LEED India, administered by the Indian Green Building Council (IGBC), certifying 4,981 projects by 2018. The indigenous GRIHA system, launched in 2005, has registered over 1,200 projects. Despite progress, challenges persist in scaling sustainable practices across India's 330 million households, particularly in rapidly urbanizing areas where cities contribute 80% of GHG emissions.

India's federal structure complicates policy implementation, as urban development is state-regulated. The Model Building Byelaws (MBBL 2016) by the Ministry of Housing and Urban Affairs (MOHUA) aim to standardize sustainable practices but lack enforceability, leading to uneven adoption. Strengthening institutional frameworks and aligning state bylaws with national guidelines are crucial for mainstreaming green construction.

Introduction to Green Buildings

A green building minimizes energy, water, and natural resource consumption while reducing waste, greenhouse gas (GHG) emissions, and promoting occupant health. Unlike conventional structures, green buildings harmonize with local ecosystems, prioritize renewable materials, and slash energy and water demands by 80–100 watts per square meter. Traditional architecture often inherently embraced these principles, but modern practices, influenced by global trends, have drifted toward resource-heavy methods. Buildings consume 70% of electricity, 39% of primary energy, 25% of water, and generate 35% of solid waste, 36% of CO_2, and 46% of SO_2 emissions underscoring the urgent need for sustainable alternatives.

2. Climate Crisis and the Role of Buildings

Climate change manifests through rising temperatures, melting glaciers (threatening rivers like the Ganga), and sinking islands (e.g., Sundarbans). GHG emissions, primarily from coal-fired power plants and construction activities, drive these changes. Renewable energy— solar, wind, and tidal—offers a solution, particularly in sun-rich regions like India. The construction sector alone contributes 40% of global CO_2 emissions, with building materials (cement, steel) and operations (lighting, cooling) as major culprits. Decarbonizing this sector by 2050, through policies and technology, is critical.

3. Sustainability and Global Agendas

The 1992 Rio Earth Summit established sustainability as a global priority, culminating in Agenda 21 and the Sustainable Development Goals (SDGs). Key targets relevant to construction include:

- Goal 6: Sustainable water management.
- Goal 7: Affordable clean energy.
- Goal 11: Sustainable cities.
- Goal 13: Climate action.

- Goal 15: Ecosystem restoration.

The 2015 Paris Agreement further emphasized limiting global warming to 1.5–2°C, necessitating rapid reductions in fossil fuel dependency, especially in urbanizing regions.

4. Urbanization, Energy, and Emissions

Urbanization drives 230 billion m^2 of new construction by 2060, escalating energy demand. Buildings already consume 36% of global energy, with 82% derived from fossil fuels. This sector accounts for 40% of energy-related CO_2 emissions, split between construction (embodied energy) and operations (cooling, lighting). Transitioning to renewable energy and efficient design is non-negotiable for sustainability.

5. Green Building Principles

Resource Efficiency: Minimizing non-renewable use, maximizing recycling.
Renewable Integration: Solar, wind, and rainwater harvesting.
Ecosystem Harmony: Reducing habitat disruption and microclimatic impacts (e.g., urban heat islands).
Health Focus: Non-toxic materials and improved indoor air quality.
Global rating systems like LEED (USA), BREEAM (UK), and GRIHA (India) codify these principles, promoting certification to standardize sustainable practices.

6. Green Building Movement in India

India's green building journey began in 2001 with LEED-India, administered by the Indian Green Building Council (IGBC). By 2018, 4,981 projects were registered. The indigenous GRIH system, launched in 2005, has certified1,200+ projects. Despite progress, challenges persist: **Policy Fragmentation:** Building bylaws vary across states, hindering uniform adoption.
Awareness Gaps: Limited knowledge among developers and consumers.
Cost Myths: Perceived high upfront costs deter adoption, despite long-term savings.
The federal structure complicates enforcement, though the 2016 Model Building Bylaws aim to unify standards. Urban areas, housing 33% of India's population, contribute disproportionately to emissions, necessitating urgent institutional and regulatory support.

II. Methodology

Methodology Summary: Assessing Green Building Progress in India This research employs a mixed-methods approach to analyze India's green building movement, focusing on its alignment with sustainable development goals. The methodology is structured into three core components:

1. Tracing the Evolution of Sustainability

The study reviews historical and contemporary literature, UN reports (e.g., Brundtland Commission, Rio Summit, SDGs), and global frameworks to contextualize sustainability's origins and its integration into built-environment policies. Emphasis is placed on India's traditional ecological practices and post-1992 institutional responses to climate challenges.

2. Urbanization and Environmental Impact Analysis

Urbanization trends (1961–2018) are examined using data from UN agencies (UNEP, WHO), the World Bank, and India's Census Bureau. Key metrics include urban population growth, migration patterns, and resource consumption. A flow chart (Fig. 3.1) illustrates urbanization's linear contribution to CO_2 emissions and resource depletion, particularly through construction activities reliant on fossil fuels. The study highlights India's unique challenges, such as rapid urban expansion amidst limited resources and federal governance complexities.

3. Green Building Systems and Policy Evaluation

The research evaluates India's adoption of green building practices through Rating Systems Comparative analysis of LEED- India and GRIHA, including certification processes, costs, and credit-point structures. Data from IGBC and GRIHA annual reports (2004–2018) quantify project registrations and geographic distribution. Policy Frameworks Review of India's Model Building Byelaws (MBBL 2004/2016) and state-level amendments to assess regulatory alignment with sustainability goals. State gazettes and

notifications are analysed to gauge policy implementation efficacy.

4. Data Sources and Analysis

Primary data derive from UN databases, Indian Census reports, TERI publications, and certification bodies (IGBC/GRIHA). Secondary data include urban water demand projections and state-by-state policy adoption rates. Analytical methods involve:

Quantitative: Graphical representation of urban growth rates (global/India), megacity expansion (1950–2030), and green project registrations. **Qualitative Assessment** of institutional symbiosis between voluntary green certifications (e.g., LEED) and regulatory frameworks (e.g., MBBL).

5. Key Findings and Implications

The methodology reveals fragmented policy adoption across states, underscoring challenges in India's federal structure. Despite robust institutional frameworks (e.g., Swachh Bharat Mission), the study identifies gaps in inter-agency collaboration. The Indira Parya varan Bhawan case validates green buildings' efficacy, achieving 40–50% energy savings and 55% water reduction.

Methodology: Analysing Green Building Growth and Challenges in India

6. Evolution of Sustainability

The study traces sustainability's origins to the 1960s environmental movement, accelerated by UN initiatives like the Brundtland Report (1987) and Rio Earth Summit (1992). Key sources include:

Global reports: UNEP, IPCC, and WHO publications on climate change and urbanization.

Policy milestones: Agenda 21 (1992), SDGs (2015), and Paris Agreement (2015).

Academic literature: Works by Meadows et al. (1972) on ecological limits and modern critiques of industrialization.

7. Urbanization: Data Collection

Urbanization drives 70% of global CO_2 emissions, with India's urban population projected to reach 600 million by 2030*. Data sources include:

Global datasets: UN World Urbanization Prospects (2018), World Bank urban growth statistics (1961–2018).

Indian data: Census of India (1901–2011), Ministry of Housing and Urban Affairs (MOHUA) reports, and TERI studies on urban water/energy demand.

Energy demand: Buildings consume 36% of global energy, with India's construction sector heavily reliant on fossil fuels.

Environmental impact: Urbanization disrupts ecosystems, intensifies heat islands, and strains water resources.

8. Green Building Concept and Rating Systems

The study evaluates India's green building movement through:

1. LEED-India (launched 2001): Managed by the Indian Green Building Council (IGBC), with 4,981 projects registered by 2018.
2. GRIH (2005): Government-backed system certifying1,200+ projects by 2017.
3. Policy analysis: Adoption of Model Building Byelaws (MBBL 2004/2016) promoting sustainability.

9. Data Source

Global urbanization: World Bank, UN population databases.

Indian context: Census data, MOHUA reports, TERI publications.

Green building metrics: IGBC/GRIHA annual reports, certification guidelines.

Policy compliance: State government gazettes on building byelaw amendments.

10. Data Analysis

1.**Urbanization Trends:** India's urban population grew from 17% (1951) to 34% (2011), mirroring global trends. Megacities (e.g., Mumbai, Delhi) face acute resource stress, contributing to 40% of national CO_2 emissions.

2.Green Building Growth:
LEED-India projects surged post-2010, led by Karnataka, Maharashtra, and Tamil Nadu. GRIHA adoption remains limited to government and institutional projects.

11. Policy Implementation:
Only 8 states (e.g., Gujarat, Maharashtra) revised building bylaws per MBBL 2004 guidelines. Lack of enforcement and awareness hinders nationwide adoption.

12. Water and Energy Savings
Green buildings save 30–40% water via efficient fixtures and recycling. Solar integration reduces grid dependence by 25–50% in certified projects.

III. Results and Discussion

India adopted the green building concept in 2001, aligning with global sustainability efforts. This research paper explores the evolution of sustainability, the green building concept as a subset of sustainability, and the development of green rating systems both globally and in India. Early concerns about environmental degradation led to sustainability gaining policy relevance in the 1990s. Buildings contribute significantly to CO_2 emissions, and rapid urbanisation has increased the strain on natural resources.
To measure sustainability in construction, green rating systems were introduced, such as BREEAM (UK, 1990), LEED (USA, 1998), and India's LEED India (2001). India later developed its own system, GRIHA (2005), supported by the Ministry of New & Renewable Energy. The Indian Green Building Council has promoted these systems nationwide. A detailed qualitative and quantitative analysis of LEED India and GRIHA is part of the study, including the case study of Indira Paryavaran Bhawan, a 5-star GRIHA-rated net-zero energy building.

IV Future Research Areas

1. Material Labeling: Develop policies for eco-labeling construction materials to promote transparency and sustainability.
2. Rural-Urban Outreach: Expand green building adoption to smaller towns via subsidies and awareness campaigns.
3. Vastu Shastra Integration: Study synergies between ancient Indian architecture (e.g., natural ventilation, solar orientation) and modern green principles.
4. Policy Frameworks: Strengthen state-level enforcement of MBBL and incentivize green certifications.

India's green building movement has made strides in institutionalizing sustainability, yet challenges like policy fragmentation and cost barriers persist. Leveraging traditional wisdom (e.g., Vastu Shastra) and scaling successful models (e.g., Indira Parya varan Bhawan) can accelerate progress. Future efforts must prioritize interdisciplinary research, affordable certification, and inclusive policies to achieve the SDGs and climate targets.

IV. Conclusion

While India has made strides in green building adoption, achieving SDGs requires overcoming fragmented governance, resource constraints, and technological gaps. Aligning construction practices with ecological principles, enhancing stakeholder collaboration, and fostering policy coherence can position India as a global leader in sustainable development, ensuring resilience against climate change while meeting urbanization demands.

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