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# Green Energy and Indoor Technology for Smart Building.

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**Abstract:** *The beginning of the twenty-first century has ushered in the era of green buildings. Normal buildings use energy inefficiently, generate large amounts of waste in their construction and operation and emit large quantities of pollutants and greenhouse gases. In contrast to conventional buildings, green buildings seek to use land and energy efficiently conserve water and other resources impure indoor and outdoor air quality- and increase the use of recycled and renewable materials While green buildings still constitute a tiny subset of existing buildings their numbers are increasing rapidly. Green building (also known as green construction or sustainable building)refers io a structure and the application or processes that are environmentally responsible and resource efficient throughout a building's life cycle: from planning to design, construction, operation, renovation, and demolition.*

**Keywords:** *green buildings*.

## I. INTRODUCTION

The beginning of the twenty-first century has ushered in the era of green buildings. Normal buildings use energy inefficiently, generate large amounts of waste in their construction and operation and emit large quantities of pollutants and greenhouse gases. In contrast to conventional buildings, green buildings seek to use land and energy efficiently conserve water and other resources impure indoor and outdoor air quality- and increase the use of recycled and renewable materials While green buildings still constitute a tiny subset of existing buildings their numbers are increasing rapidly. Green building (also known as green construction or sustainable building) refers io a structure and the application or processes that are environmentally responsible and resource efficient throughout a building's life cycle: from planning to design, construction, operation, renovation, and demolition. This requires close cooperation of the contractor, the architects, the engineers and the client at all project stages_ The Green Building practice expands and complements the classical building design exonerees of economy utility durability and comfort. Green building brings together a vast array of practices, techniques and skills to reduce and eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources. using sunlight through passive solar active solar and photovoltaic equipment and using plants and trees through green roofs, rain gardens and reduction of rainwater run-off- Miny other techniques are used such as using low impact building materials or using packed permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water. While practices or technologies employed in green building are constantly evolving and may differ from region to region fundamental principles persist from which the method is derived: siting and structure design efficiency energy efficiency- water efficiency materials eminency indoor environmental quality enhancement, operations and maintenance optimization and waste and toxics reduction. The essence of green building is an optimization of one or more of these principles.

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### 1.1 Objective

The research work focuses on the following objectives

**1. Conserving the Natural Environment.**

Structures and infrastructure tend to disturb the natural environment ecosystems significantly topsoil, 'vegetation, water cycles behaviour and biodiversity in general are impacted on by the built environment. All of these systems are necessary for the healthy functioning of the planetary systems that are needed for our survival.

**2. Optimum Use of Builduing Materials**

Building materials utilize natural resources. Obtaining these materials requires timber harvesting, cultivation, mining and quarrying. Many of these activities are currently degrading the environment. Once obtained these materials need to be processed, manufactured and transported. Using local materials as far as possible is an easy Way io be greener. It is therefore imperative to specify the most sustainable building materials possible and to use them in the most efficient way.

**3. Energy Efficiency**

It is estimated that 40% of the energy used on the planet is by buildings. for the majority of energy is generated using non-renewable sources such as coal, gas and oil. Being non-renewable, these resources will get depleted and, as they become scarcer become more expensive and more difficult to extract. The process of converting these fossil fuels into energy most cases produce greenhouse gases (GEIGs) which contribute global warming.

### 1.2 Literature Survey

Green buildings have emerged as a critical response to the environmental and economic impacts of conventional construction. They aim to reduce resource consumption, improve indoor comfort, and minimize ecological footprints across the entire building life cycle—from site selection to construction, operation, and end-of-life management. Research identifies the core pillars of green design as energy efficiency, water conservation, sustainable material use, site planning, and indoor environmental quality (IEQ). These aspects work together to deliver healthier spaces and long-term operational savings while causing minimal harm to the environment.

Energy efficiency remains central in the literature, with studies showing that optimized building envelopes, daylighting, efficient HVAC systems, and on-site renewable energy significantly reduce operational loads. Simulation tools and energy modelling help designers evaluate alternatives and choose strategies that achieve the best performance-to-cost ratio.

Water management is another priority, where rainwater harvesting, greywater reuse, low-flow fixtures, and sustainable landscaping collectively reduce dependency on municipal water supplies and mitigate urban runoff.

Material selection also plays an important role, with a shift toward low-embodied-energy, recycled, regional and low-VOC options that improve indoor air quality and reduce environmental burden. Waste reduction through recycling and responsible construction practices is also widely emphasized.

Literature further highlights IEQ as a determinant of occupant health and productivity, supported by adequate ventilation, daylight penetration, thermal comfort, and low-toxicity finishes.

International and Indian green rating systems such as LEED India, IGBC, and GRIHA provide structured frameworks to measure sustainability performance. These rating systems classify buildings across categories such as energy, water, materials, site planning, and IEQ, helping designers align projects with measurable environmental goals. GRIHA, in particular, emphasizes passive design strategies tailored to Indian climatic conditions.

Decision-making within green building studies often uses tools such as the Analytic Hierarchy Process (AHP), which converts expert judgments into weighted criteria using pairwise comparisons, eigenvalue calculations, and consistency checks. This method supports structured evaluation of sustainability prioritie

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## II. THEORETICAL BACKGROUND

The concept of green and smart buildings is rooted in the broader theoretical framework of sustainable development, which emphasizes meeting present needs without compromising future generations. In the built environment, sustainability is achieved by reducing resource consumption, minimizing environmental degradation, and improving occupant wellbeing throughout the building's life cycle. Green building theory therefore integrates environmental science, architectural design, engineering systems, and building performance analytics to deliver energy-efficient and ecologically responsible structures.

A foundational theory supporting green building design is Building Physics, which explains how heat, air, light, and moisture move through building elements. This theory forms the basis for passive design strategies such as orientation, shading, natural ventilation, and daylighting, which reduce dependence on mechanical systems. Combined with Thermodynamic principles, building physics enables the optimization of heating, cooling, and lighting loads, thereby enhancing energy performance.

The Indoor Environmental Quality (IEQ) framework is another theoretical pillar, highlighting how air quality, lighting quality, acoustics, and thermal comfort impact human health and productivity. Theories related to human comfort, such as Fanger's Predicted Mean Vote (PMV) model and adaptive comfort standards, guide the design of occupant-centric indoor environments. These principles are essential for integrating smart sensors, automated controls, and ventilation systems that regulate indoor conditions efficiently.

The theory of Life Cycle Assessment (LCA) underpins material selection, emphasizing embodied energy, recyclability, durability, and environmental impact across extraction, manufacturing, use, and disposal. LCA supports the shift toward low-impact materials and waste-minimizing construction practices.

To evaluate and quantify sustainability, theoretical models such as multi-criteria decision-making (MCDM) are widely used. The Analytic Hierarchy Process (AHP), one of the most established MCDM tools, provides a structured method for assessing complex decisions by breaking them into hierarchies, performing pairwise comparisons, and generating weighted scores based on expert judgments. This framework is especially relevant for developing rating systems and prioritizing green building criteria.

Overall, the theoretical background combines environmental principles, engineering theories, human comfort models, and decision-making frameworks to enable the design and assessment of smart, energy-efficient, and sustainable buildings.

## III. DESIGN AND DEVELOPMENTS

The design and development of the proposed green and smart building framework focus on integrating sustainable architectural principles with intelligent indoor technologies to improve energy performance, resource efficiency, and occupant wellbeing. The process begins with identifying key sustainability parameters that align with recognized green building standards such as GRIHA, LEED India, and IGBC. These parameters include site planning, energy efficiency, water management, material selection, waste reduction, and indoor environmental quality (IEQ). Each parameter forms a core component of the overall evaluation system.

The first step in the design stage is to break down these major parameters into measurable sub-criteria. This includes factors such as building orientation, envelope design, renewable energy integration, daylighting strategies, rainwater harvesting, greywater reuse, low-VOCs materials, ventilation systems, and indoor air-quality controls. This structured breakdown establishes a clear foundation for systematic analysis.

To assign importance to each criterion, the Analytic Hierarchy Process (AHP) is employed as the central decision-making tool. Expert surveys and pairwise comparisons are used to determine the relative priorities of the criteria. Through eigenvalue calculations and consistency ratio checks, the AHP model produces normalized weights that represent the significance of each sustainability component. This ensures that the evaluation method is transparent, scientifically grounded, and responsive to expert judgment.

Smart building technologies are then integrated into the design to enhance performance across the selected criteria. This includes the incorporation of IoT-based sensors, automated lighting and HVAC systems, occupancy detection modules, air-quality monitors, and energy-management dashboards. These technologies support real-time monitoring, reduce unnecessary energy consumption, and maintain optimal indoor comfort conditions.

The final outcome of the design and development process is a structured and user-friendly model capable of guiding architects, engineers, and stakeholders in planning and assessing sustainable, energy-efficient, and technologically advanced smart buildings.

## IV. PROGRESS OF WORK

The project has progressed systematically through the key stages required for developing a green and smart building evaluation framework. The initial phase involved an extensive review of literature related to sustainable building design, green rating systems, energy-efficient technologies, and indoor environmental quality. Relevant national and international standards such as GRIHA, LEED India, and IGBC were studied to identify common assessment categories and performance indicators. This groundwork helped establish the theoretical and conceptual basis for the project.

Following the literature review, major sustainability criteria were identified and categorized under energy efficiency, water management, material sustainability, site planning, waste management, and indoor environmental quality. These categories were further broken down into measurable sub-criteria that reflect practical and technical aspects of green building performance. Parallelly, smart indoor technologies such as sensors, automated controls, and energy-monitoring systems were examined for their applicability in enhancing building performance.

### 4.1 Expected Out Come

The proposed project is expected to result in a comprehensive, structured, and practical framework for evaluating and designing green and smart buildings. The primary outcome is the development of a decision-making model based on the Analytic Hierarchy Process (AHP), which assigns scientifically validated weights to major sustainability criteria such as energy efficiency, water management, materials, site planning, and indoor environmental quality. This model will provide a clear and objective method for assessing the overall sustainability performance of a building.

Another major expected outcome is the integration of smart indoor technologies into the evaluation system. Through the identification and application of IoT-based sensors, automated lighting and HVAC controls, and indoor air-quality monitoring tools, the project will demonstrate how smart systems can significantly enhance building performance, reduce operational costs, and improve occupant comfort. This will help bridge the gap between traditional green building approaches and modern intelligent building systems.

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