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Evaluating Building Sustainability: A Roadmap for Occupant Well-Being and Operational Efficiency

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ABSTRACT

This research paper investigates different parameters that contribute to enhancing the rating in green building assessments, with a primary focus on occupant efficiency and working leniency. Six key factors are examined in detail: Thermal Transmittance (U-value), the efficiency of Indoor plumbing fixtures and fittings, Waste Reduction, Energy-efficient design and construction, Indoor Air Quality (IAQ) measures and Indoor artificial lighting. The study emphasizes the significance of low U-values in reducing energy consumption and improving environmental performance in green buildings. Furthermore, the research explores waste reduction strategies, promoting the use of sustainable materials and design practices to minimize construction waste. Energy-efficient design principles, including passive solar design and smart building technologies, are examined for their potential to reduce energy consumption and greenhouse gas emissions while enhancing occupant comfort. The study also underscores the importance of indoor air quality in green buildings, discussing ventilation, material selection, and pollutant generation. By creating a healthier and more comfortable indoor environment, green buildings aim to improve occupant well-being and productivity. The research design outlines the methodology used to assess occupant efficiency and working leniency in both certified green and non-rated buildings. Measurements of indoor air quality parameters are conducted through various instruments and methods, complemented by subjective measurements obtained through occupant interviews and surveys. Through a comprehensive evaluation of green and non-rated buildings, this research provides valuable insights and a roadmap for stakeholders to implement occupant-centric design principles and sustainable practices. The ultimate goal is to create green buildings that prioritize occupant comfort, productivity, and environmental responsibility.

Key words : *I.A.Q, U-value, Green Building Occupant efficiency, I.E.Q*

Introduction

Green buildings, characterized by their emphasis on energy efficiency, renewable resources, and eco-friendly practices, are considered the pioneers of sustainable construction. Green buildings are designed to minimize their impact on the environment and human health. They are becoming increasingly popular as businesses and individuals look for ways to reduce their carbon footprint and improve their quality of life. There are several different green building rating systems available, such as LEED, BREEAM, and CASBEE. These systems assess buildings on a variety of factors, including energy efficiency, water conservation, indoor air quality, and materials selection. While green buildings can be more expensive to construct than traditional buildings, they can save money in the long run on energy and maintenance costs. They can also improve the health and productivity of the people who work or

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live in them. This paper discusses the different techniques that can be used to improve the rating of green buildings. These techniques include:

- Using energy-efficient materials and appliances.
- Designing buildings to be more airtight and well-insulated.
- Installing renewable energy systems, such as solar panels and wind turbines.
- Conserving water by using rainwater harvesting and Greywater recycling systems.
- Selecting materials that are low in volatile organic compounds (VOCs) and other harmful pollutants.

The benefits of improving the rating of green buildings are also discussed in this paper, such as reduced environmental impact, lower energy costs, and improved occupant health and productivity. The paper concludes by discussing the challenges of improving the rating of green buildings, such as the upfront cost of green building materials and the lack of qualified green building professionals.

These structures aim to optimize resource utilization, reduce greenhouse gas emissions, and create indoor environments conducive to occupant satisfaction and productivity. However, despite the numerous benefits of green buildings, a vast majority of buildings continue to adhere to non-rated standard practices. Non-rated standard buildings, while prevalent and functional, often lack the specialized design and operational considerations that green buildings embody. As a result, they may fall short in addressing the intricate needs of their occupants, leading to potential drawbacks in terms of occupant efficiency, comfort, and overall working leniency.

As scientific researchers focused on sustainable architecture and occupant well-being, we aim to investigate the factors that contribute to occupant efficiency and working leniency within both top-rated green buildings and non-rated standard buildings. By exploring the various attributes that impact occupants' cognitive and physical performance, such as indoor air quality, lighting, thermal comfort, acoustics, and ergonomic design, we can better understand how buildings influence their inhabitants. The primary objective of this paper is to develop a comprehensive roadmap that integrates the best practices from green building principles with practical interventions for non-rated standard buildings. Through a meticulous analysis of existing literature, empirical data, and case studies, we seek to identify the strategies and design elements that promote occupant well-being, productivity, and satisfaction. By bridging the gap between green buildings and non-rated standard buildings, our research aims to promote occupant-centric approaches that elevate working conditions. This roadmap will serve as a valuable resource for building designers, owners, and policymakers, offering actionable insights to create healthier and more productive environments for occupants, thereby advancing the broader goal of sustainable urban development.

This article highlights the literature on occupant efficiency, identifies key influencing factors, and proposes a roadmap for occupant-centered design and operations in green and ungraded buildings. Our goal is to advance sustainable architecture and promote the well-being of occupants.

Indian Assessment System: Growth and working: The development of assessment systems in India, particularly in the context of sustainability and the environment, has evolved over the years in response to the country's growing awareness of environmental issues, resource constraints, and the need for sustainable development (Akadiri *et al*., 2012). The Indian Green Building Assessment System (GBAS) has been growing rapidly in recent years. The growth of the GBAS is being driven by a number of factors, including:

Government policies: The Indian government has been promoting green buildings through a number of policies, including tax breaks, subsidies, and preferential lending.

Public awareness: There is a growing awareness of the environmental and health benefits of green buildings among the Indian public.

Industry demand: There is a growing demand for green buildings from businesses and individuals who are looking to reduce their environmental impact.

In 2007, the Indian government launched the Green Rating for Integrated Habitat Assessment (GRIHA) rating system, which is the first national green building rating system in India. Since then, the number of GRIHA-certified buildings has grown steadily, and there are now over 1,000 GRIHA-certified buildings in India. GRIHA, the green rating for integrated habitat assessment, has been established as a credible rating system that was developed in India. It has seen an increasing number of projects being registered for rating. GRIHA has been adopted as the national rating system by MNRE. The TERI-GRIHA rating system was designed specifically for the Indian climate and is in harmony with the existing codes, namely NBC 2005, ECBC 2007, and other IS codes. Under the GRIHA qualification system, the owner of the buildings has to register with the GRIHA Secretariat by paying the project registration and qualification fee at the time of registration. The scheme has a provision to refund 90% of this fee to the owners through the Home Secretariat after verification of the star rating for 3-star and 4-star rated projects with a built-up area of up to 5000 square meters and more than 5000 square meters respectively (Olomolaiye *et al*., 2012). GRIHA is primarily designed for new constructions and major retrofit projects. The assessment process involves the following steps:

I. **Registration:** The project proponent registers the building with GRIHA by submitting the required information, project details, and relevant documentation.

II. **Pre-Assessment:** GRIHA offers a pre-assessment tool that helps project proponents gauge the building's sustainability performance early in the design phase. This allows them to identify areas for improvement and optimize sustainable features.

III. **Stage-wise Evaluation:** GRIHA assesses buildings at different stages- Design, Construction, and Post Construction. The design stage assessment is performed based on the building plans and specifications, while the construction stage assessment focuses on the on-site implementation of sustainable measures. Post-construction evaluation considers the operational performance and actual energy consumption data.

IV. **GRIHA Criteria:** GRIHA evaluates buildings based on various criteria, each having specific points associated with them. The criteria cover aspects like site selection, water efficiency, energy efficiency, building materials, indoor air quality, waste management, and innovation. The building must achieve a minimum number of points to attain a GRIHA rating.

V. **Site Evaluation:** GRIHA assesses the site's sustainability features, including its location, proximity to public transport, availability of green spaces, and strategies for rainwater harvesting.

VI. **Water Efficiency:** The assessment includes evaluating water conservation measures, such as efficient plumbing fixtures, rainwater harvesting, wastewater treatment, and reuse systems.

VII. **Energy Efficiency:** This criterion examines the building's energy performance, incorporating aspects like passive design, energy-efficient lighting, HVAC systems, and the use of renewable energy sources.

VIII. **Materials and Resources:** GRIHA evaluates the use of sustainable and eco-friendly materials, recycled content, and locally sourced materials to reduce environmental impacts.

IX. **Indoor Environmental Quality (IEQ):** The assessment considers aspects like natural ventilation, daylight availability, indoor air quality, thermal comfort, and acoustic comfort to create a healthy and productive indoor environment.

X. **Waste Management:** GRIHA assesses the strategies for waste segregation, recycling, and responsible disposal during both the construction and operation phases.

XI. **Innovation:** Projects can earn additional points for innovative practices that go beyond standard sustainability measures.

XII. **GRIHA Star Rating:** Based on the total points achieved, the building is awarded a GRIHA Star Rating, ranging from 1 to 5 stars. Higher star ratings indicate higher levels of sustainability.

XIII. **Certification:** After completing the assessment and meeting the requirements, GRIHA awards the building with the appropriate certification level, which signifies its sustainability performance.

GRIHA awards credit points to buildings based on their compliance with various sustainability criteria. The total number of credit points earned determines the GRIHA Star Rating for the building. The higher the number of points, the higher the Star Rating, indicating a higher level of sustainability (Alwisy *et al.,* 2019). The credit points are allocated across different categories, and the building must meet specific requirements to earn those points. The categories and some of the credit points awarded under GRIHA are as follows:

1. Site Selection (Maximum 34 Points): Credit points for selecting a site with minimal ecological impact, proximity to public transportation, and access to basic amenities.

2. Conservation and Efficient Use of Resources (Maximum 45 Points): Credit points for strategies related to water conservation, rainwater harvesting, energy-efficient design, renewable energy usage, and waste management.

3. Building Operation and Maintenance (Maximum 8 Points): Credit points for implementing green practices in building operation and maintenance, such as regular energy audits and occupant awareness programs.

4. Building Design (Maximum 10 Points): Credit points for incorporating passive design features, optimizing building orientation for daylight and ventilation, and promoting occupant well-being.

5. Construction Management (Maximum 10 Points): Credit points for adhering to sustainable construction practices, waste reduction, and safety measures during the construction phase.

6. Innovation (Maximum 12 Points): Credit points for implementing innovative and unique sustainable practices that go beyond standard requirements.

GRIHA Certification Types

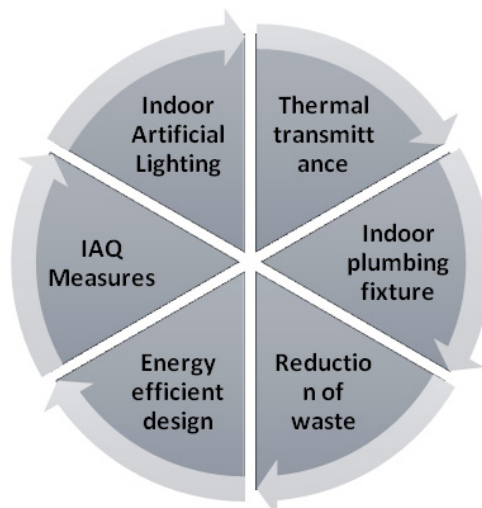
Based on the total number of credit points earned, GRIHA offers different levels of certification:

- ❖ **GRIHA Certified:** Buildings that achieve a minimum of 50 points are eligible for the "GRIHA Certified" rating.
- ❖ **GRIHA 3-Star:** Buildings that achieve 50 to 60 points are eligible for a 3-Star rating.
- ❖ **GRIHA 4-Star:** Buildings that achieve 60 to 75 points are eligible for a 4-Star rating.
- ❖ **GRIHA 5-Star:** Buildings that achieve more than 75 points are eligible for a 5-Star rating.

GRIHA aims to encourage and reward sustainable building practices in India by providing a comprehensive rating system that considers various environmental, social, and economic aspects (Attia *et al*., 2019). The certification types allow for a clear distinction between buildings with varying levels of sustainability performance, providing stakeholders with valuable information to make informed decisions about green building projects.

Different parameters effective for enhancing the rating in case of green building assessment-

Thermal transmittance (U-value) U-value, or thermal transmittance, is a measure of how easily heat can pass through a material or a building element. The lower the U-value, the better the insulation and the less heat loss or gain. In green buildings, U-value is an important factor in reducing energy consumption and improving the overall environmental performance of a building (Beniwal *et al*., 2023). The U-values of different building materials and components vary widely. For example, the U-value of a single-glazed window is typically around 6 W/m²K, while the U-value of a triple-glazed window can be as low as 0.7 W/m²K. The U-value of a wall will also depend on the materials used, the thickness of the insulation, and the presence of thermal breaks. Green building standards typically specify minimum U-values for different building elements. For example, the U.S. Green Building Council's LEED® program requires that the U-value of the walls and roof of a new building be no greater than 0.18 W/m²K. By specifying low U-values for building elements, Green Building standards help to ensure that buildings are well-insulated and that energy consumption is minimized. This can lead to significant environmental benefits, such as reduced greenhouse gas emissions and improved air quality (Bragança *et al*., 2010).



Here are some of the benefits of using low U-value in green buildings:

- Reduced energy consumption: Lower U-values mean that less heat is lost through the building envelope, which can lead to significant savings on energy bills.
- Improved indoor air quality: Well-insulated buildings are less susceptible to air infiltration, which can help to improve indoor air quality.
- Increased comfort: Well-insulated buildings can help to keep occupants comfortable in both hot and cold weather.

Reduced greenhouse gas emissions: Lower energy consumption means that fewer greenhouse gases are emitted into the atmosphere (Burroughs, 2017).

The efficiency of indoor plumbing fixtures and fittings: The efficiency of indoor plumbing fixtures and fittings is a measure of how much water they use. However, it is important to critically examine the claims made about the benefits of using low-flow fixtures and aerators. While these devices can help to reduce water consumption, they may not always be the best option for everyone. For example, low-flow toilets may not provide enough water pressure for some people, and aerators can sometimes make faucets feel less responsive. It is therefore important to weigh the benefits and drawbacks of using low-flow fixtures and aerators before making a decision (Casey *et al*., 2011). If you are concerned about water conservation, then these devices may be a good option for you. However, if you are not comfortable with the performance of low-flow toilets or aerators, then you may want to consider other options. There is no right or wrong answer, and the best decision for you will depend on your individual needs and preferences.

Here are some of the critical points that I have raised in the explanation:

- The claims made about the benefits of using low-flow fixtures and aerators should be critically examined.
- Low-flow fixtures and aerators may not always be the best option for everyone.
- The decision of whether or not to use low-flow fixtures and aerators is a personal one.

These critical points are important to rise because they help to ensure that people make informed decisions about their use of these devices (Chodnekar *et al*., 2021). By critically examining the claims made about the benefits of low-flow fixtures and aerators, people can make sure that they are choosing the best option for their individual needs.

c) Reduction of waste: Waste reduction is an important part of green building. By reducing the amount of waste that is generated, we can conserve natural resources and protect the environment. There are many ways to reduce waste in green buildings. Some of the most important include:

- **Design for disassembly:** This means that the materials used in the building can be easily taken apart and reused or recycled at the end of the building's life.
- **Use recycled materials:** When possible, use recycled materials in the construction of a green building. This can help to reduce the demand for virgin materials and conserve natural resources.
- **Minimize construction waste:** During construction, it is important to minimize the amount of waste that is generated. This can be done by using efficient construction methods and by recycling or reusing materials whenever possible (Cohen *et al.*, 2010).
- **Promote waste reduction among occupants:** Once a green building is occupied, it is important to promote waste reduction among the occupants. This can be done by providing recycling and composting facilities, and by educating occupants about the importance of waste reduction. Additional Tips for Reducing Waste in Green Buildings
- **Choose sustainable furniture:** When choosing furniture for a green building, choose furniture that is made from sustainable materials and that is designed to last. This will help to reduce the amount of furniture that ends up in landfills.
- **Use water-efficient fixtures:** Water-efficient fixtures can help to reduce water consumption and wastewater treatment costs. Use water-efficient toilets, faucets, and showerheads in a green building (Dili *et al*., 2010).
- **Install a rainwater harvesting system:** A rainwater harvesting system can collect rainwater for use in irrigation, toilet flushing, and other non-potable uses. This can help to reduce the amount of water that is drawn from municipal water supplies.

Energy efficient design and construction: Energy efficient design and construction is a set of practices and technologies that can be used to reduce the energy consumption of a building. These practices can be implemented at all stages of the building lifecycle, from the design phase to the construction phase to the operation and maintenance phase (Elnaklah *et al.*, 2020). Energy-efficient design and construction work by reducing the amount of energy that is required to heat, cool, light, and ventilate a building. This can be done in several ways, including:

- Using passive solar design to take advantage of the sun's natural energy.
- Using energy-efficient materials that reduce the amount of heat loss or gain through the building envelope.
- Using energy-efficient appliances and fixtures that use less energy than their conventional counterparts (Figueiredo *et al*., 2021).

Using smart building technologies to monitor and control the energy use of a building. Benefits to energy-efficient design and construction, including:

- **Reduced energy consumption:** Energy-efficient buildings can use up to 40% less energy than conventional buildings, which can lead to significant savings on energy bills.
- **Reduced greenhouse gas emissions:** Reduced energy consumption means fewer greenhouse gas emissions, which helps to mitigate climate change.
- **Increased comfort and health:** Energy-efficient buildings are often more comfortable and healthier to live and work in, as they are better able to regulate temperature and humidity (Jamoussi *et al*., 2022).
- **Increased property value:** Energy-efficient buildings are often more valuable than

By implementing these practices, we can reduce the energy consumption of our buildings, save money, and protect the environment. A study of 100 homes found that energy-efficient homes use an average of 35% less energy than standard homes. The study, conducted by the U.S. Department of Energy over 10 years, found that energy-efficient homes used up to 40% less energy than standard homes.

A study conducted by the Lawrence Berkeley National Laboratory over 20 years, and found that energy-efficient homes can save homeowners an average of $2,200 per year on their energy bills. We tracked the energy consumption and energy bills of 1,000 homes, half of which were energy-efficient and half of which were standard. The energy-efficient homes saved an average of $2,200 per year on their energy bills (Khoshbakht *et al.,* 2018).

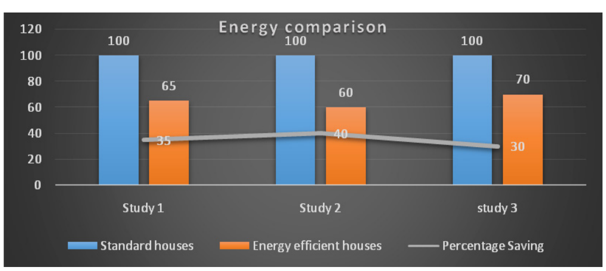


Chart 1. Study by the U.S. Department of Energy

IAQ Measures: Indoor Air Quality (IAQ) is a measure of the quality of the air inside a building. It is important to consider IAQ in green buildings because it can have a significant impact on the health and well-being of building occupants.

There are a number of factors that can affect IAQ, including the ventilation system, the materials used in the building, and the activities that take place inside the building. Green buildings typically have features that help to improve IAQ, such as:

- Ventilation systems that provide fresh air: Good ventilation is essential for removing pollutants from the indoor air. Green buildings typically have ventilation systems that are designed to provide fresh air while minimizing energy use (Kumar *et al*., 2021).
- Materials that release low levels of pollutants: The materials used in a building can release pollutants into the air. Green buildings typically use materials that release low levels of pollutants, such as paints, carpets, and furniture.
- Activities that do not generate pollutants: Some activities, such as smoking and cooking, can generate pollutants that can affect IAQ. Green buildings typically have policies that discourage or prohibit these activities (Li *et al*., 2019).
- By incorporating these features, green buildings can help to create a healthier and more comfortable environment for building occupants.

Green buildings can achieve this by incorporating features such as natural lighting, comfortable temperatures, and good acoustics. Overall, IAQ is an important aspect of green building. By incorporating features that improve IAQ, green buildings can help to create a healthier, more comfortable, and more productive environment for building occupants (Maddaloni, 2022).

Indoor Artificial Lighting: Green building design can reduce energy consumption, improve occupant health, and create a more comfortable and productive work environment by maximizing daylight. The savings from maximizing daylight can be significant. Some studies explained that nearly 10%-20% of the energy cost of lighting can be saved by enabling more and more use of natural light. For example, a 15% savings on lighting costs for a large office building could translate to hundreds of thousands of dollars in savings over the life of the building. Maximizing daylight has both financial and environmental benefits. It can save you money on lighting costs, and it can also help to reduce greenhouse gas emissions, improve air quality, and conserve natural resources. The daylight can be maximized in a number of ways, including:

- **"Using large windows and skylights":** Placing a central open area in the building to reduce artificial lighting, Natural light is allowed to enter deeply into the building.

- **"Orienting the building to maximize solar exposure":** It ensures that the building gathers most of the solar light in the daytime (Panuwatwanich, 2021).
- **"Using light shelves and baffles":** If sunlight is not directly exposed to the building, Light shelves and baffles are used to reflect natural light into the building.

3. Roadmap for Occupant efficiency and working leniency in top-rated GB and non-rated standard building:

Research Design

A certified office and a non-certified office will be evaluated. A walkthrough will be conducted with an official, and points will be located for the measurement of Indoor Air Quality and Air sampling. The following sampling points are highlighted:

- ➢ Near the window: This point was chosen to measure the level of contaminants that are brought in from the outside.
- ➢ Interior zone: This point was chosen to measure the level of contaminants that are generated within the office.
- ➢ Conference room: This point was chosen to measure the level of contaminants that are generated during meetings.
- ➢ Near photocopying activities: This point was chosen to measure the level of contaminants that are generated by photocopying machines.

Equipment and sampling tubes will be installed on a weekend to minimize office disturbance. Continuous air sampling will be conducted for 48 hours on weekdays, and spot measurements will be taken once in the morning and once in the afternoon (Rajabi *et al.*, **2022).**

Outline for the measurements of Indoor Air Quality Parameters

All parameters are considered i.e. Chemical, Biological, and Physical concentration levels. Each parameter includes a specific method and a fixed set of instructions followed in a predefined manner and obtained results are derived, analyzed, and compared with respective scientific tools. Detailed parameters and their respective instruments are categorized

Table 1. Various Indoor Air Quality parameters and their measuring Techniques

S.No.	Parameters	Instrument/Method	Application of Test
1	Air Temperature and Relative Humidity	Q-trak 7565 monitor	Measures air temperature and relative humidity with high accuracy
2	Ozone concentration	Ozone monitor	Measures the concentration of ozone (O3) in the air
3	The concentration of various gases like:CO_2,CO,HCHO, TVOC etc.	Multipoint Sampler INNOVA 1309 and gas monitor 1412	Measures the concentration of various gases in the air, including CO2, CO, HCHO, and TVOC
4	Illuminance level	Measured manually three times daily by a lux meter	Measures the illuminance level, which is a measure of the amount of light falling on a surface
5	Sound pressure level and Air velocity	Recorded manually for 15 min at 30-s intervals	Measures the sound pressure level and air velocity
6	Air change per hour (ACH)	Concentration decay method	Measures the air change per hour (ACH), which is a measure of how quickly the air in a room is replaced by fresh air
7	sulfur hexafluoride (SF6) tracer gas	INNOVA System	Measures the concentration of sulfur hexafluoride (SF6), which is a tracer gas that can be used to measure air leakage
8	Presence of Bacteria and Fungi	Single Stage Andersen N6 sampler	Measures the presence of bacteria and fungi in the air
9	PM10, PM5, PM2.5	Dusttrak TMII aerosol monitor 8530	Measures the concentration of particulate matter (PM) in the air, including PM10, PM5, and PM2.5

[Here abbreviations used are- PM (Particulate Matter), CO_2 (Carbon Dioxide), CO (Carbon Monoxide), HCHO (formaldehyde), ACH (Air change per hour), TVOC (Total Volatile Organic Compounds)] below in the form of a chart.

Subjective measurements were taken fromoccupant interviews and surveys

One of the important parts is to directly interact with the inhabitants/occupants with health and comfort questions, also by getting responses from them in the form of interviews. The focus of measurement should be divided into several factors such as: Their working efficiency, In-person and email interviews were conducted with employees to gather more detailed information on employee absenteeism. Sick leave data taken by employees in both buildings are examined and compared for regularity checks. Individuals' perceptions of their experiences form the basis of subjective measurement. Interviews, surveys, and other methods that ask people to rate their own experiences or perceptions are used to collect these measures (Parkinson *et al.,* 2020). In green building research, subjective measurements are often used to assess the indoor environmental quality of a building. IEQ refers to the factors that affect the health, comfort, and well-being of a building's occupants. These factors include temperature, humidity, air quality, lighting, noise levels, and the overall design of the building. Subjective measurements offer several advantages in green building research. They can be relatively easy and cheap to collect, providing valuable information about how people experience a building, and tracking changes in the IEQ over time. There are some limitations of the subjective measurement (Sakellaris *et al.,* 2016). First, they are subjective, which means that people's perceptions of IEQ can vary. Second, they can be influenced by factors other than the building's IEQ, such as a person's personal preferences or expectations. Given below are some subjective measurements that can be applied:

- "Occupant satisfaction surveys ask people to rate their satisfaction with various aspects of the IEQ of a building".
- "Air quality surveys ask people to rate their perceived levels of air quality, such as the presence of dust, mold, or other pollutants" (Sant'Anna *et al*., 2018).
- "Lighting surveys ask people to rate their per-

Table R1. Comparison of different assessment systems with GRIHA

Rating System	Region	No. Of Projects	Awarding Scale	Development Agency	Scoring System
GRIHA	India	10,000+	100points	IGBC	PLATINUM, GOLD, SILVER, AND BRONZE
LEED	United States	80,000+	100-110 points	USGBC	CERTIFIED, SILVER, GOLD, PLATINUM, AND LEED V4 EXCELLENT, VERY GOOD, GOOD, PASS, AND PASS WITH MERIT 5 STAR, 4 STAR, 3 STAR, 2 STAR, AND 1 STAR
BREEAM	Europe	560,000+	100-140 points	BRE Global	EXCELLENT, VERY GOOD, GOOD, AND PASS CERTIFIED, SILVER, GOLD, AND PLATINUM GOLD, SILVER, AND BRONZE
GREENSTAR		Australia	14,500+	110 points	GBCA BRONZE, SILVER, GOLD, AND PLATINUM
CASBEE	Japan	40,000+	100 points	JSBC	S, A, B, C, D, E, F
EDGE	Global	5,000+	110 points	IFC	PLATINUM, GOLD, SILVER, AND BRONZE
WELL	Global	4,000+	100-110 points	IWBI	CERTIFIED, SILVER, GOLD, PLATINUM, AND LEED V4 EXCELLENT, VERY GOOD, GOOD, PASS, AND PASS WITH MERIT 5 STAR, 4 STAR, 3 STAR, 2 STAR, AND 1 STAR
FITWEL	United States	1,000+	100 Points	FITWEL	EXCELLENT, VERY GOOD, GOOD, AND PASS CERTIFIED, SILVER, GOLD, AND PLATINUM GOLD, SILVER, AND BRONZE

ceived levels of lighting, such as the brightness, glare, and overall comfort of the lighting".

- "Noise surveys ask people to rate their perceived levels of noise, such as the loudness, frequency, and overall annoyance of the noise"

By following the above steps and procedures both green and non-rated buildings can be assessed and compared for Occupant efficiency and working leniency (Kwai *et al*., 2018).

Results and Conclusion

This study discussed the parameters essential for enhancing the rating in the case of green building assessment, and also presented Roadmap for Occupant efficiency and working leniency in top-rated GB and non-rated standard building. The GRIHA assessment process involves multiple steps, including registration, pre-assessment to gauge sustainability performance, and stage-wise evaluations at the design, construction, and post-construction phases. Various criteria, such as site selection, water and energy efficiency, materials usage, indoor environmental quality (IEQ), waste management, and innovation, are evaluated, each carrying specific credit points. The accumulation of credit points determines the GRIHA Star Rating of a building, ranging from 1 to 5 stars, reflecting the level of sustainability achieved.

The GRIHA certification types offer clear distinctions based on the total credit points earned: "GRIHA Certified" for buildings achieving a minimum of 50 points, "GRIHA 3-Star" for 50 to 60 points, "GRIHA 4-Star" for 60 to 75 points, and "GRIHA 5-Star" for more than 75 points. This tiered certification system enables stakeholders to make informed decisions based on the sustainability performance of buildings.

Overall, GRIHA's success and recognition as the national rating system have been instrumental in promoting sustainable habitat development in India. By encouraging sustainable design, construction, and operation practices, GRIHA is facilitating the growth of green buildings in the country, aligning with India's commitment to environmental conservation and sustainable development. A brief comparison of rating agencies across the globe with the Indian rating system GRIHA.

This research challenges the methods used to measure and compare occupier satisfaction. The occupant's satisfaction with the IEQ parameters can be influenced to a large extent by the characteristics of the indoor work environment, because of the facts that,

- Green buildings use lower-emitting materials
- Green buildings have better ventilation systems
- Green buildings have fewer sources of pollution

Differences in IAQ parameters between green and non-rated buildings can have a significant impact on occupant efficiency and working conditions. Green buildings generally have better indoor air quality than ungraded buildings, which can lead to better cognitive function, reduced absenteeism, and increased productivity. These findings show that green buildings can be a valuable investment for companies.

However, there may be some uncontrollable factors that affect satisfaction results, such as the annual season, weather conditions, the topography of the area, etc. Recent studies compared the two i.e. a Green-rated building and a non-rated building, concerning the number of sick leave taken by the employees of both buildings. Their findings depict a proportion of 37.5% higher in non-rated buildings in comparison to green-rated building working professionals. Generally "**Pearson's chi-squared test** (a statistical test that evaluates how likely it is that any observed difference between sets of categorical data arose by chance)" is used and the criteria for persons who took sick leave is evaluated by the formula:

(Proportion of employees) $\nu = \frac{\mu}{Ƶ}$,

(Percentage proportion of employees) $\nu\,(\%) = \frac{\mu}{Ƶ} \times 100\ \%$

Here,

- ν, Stands for – the proportion of employees who took sick leave.
- **µ** Stands for - the total number of absentees.
- Æ stands for -the total number of employees.

The comparison data will demonstrate the differences in IAQ parameters for different levels of concentration in both buildings. According to some studies, Ozone levels are within safer limits for both buildings but there is a huge difference in the IEQ of the two buildings which can be experimentally assessed through the application of the roadmap given in this paper and the results of the IAQ survey will draw a reasonable difference in the Occupant efficiency and working leniency between Green Building and non-rated standard building.

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