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Rating of a Residential Project of a Tier-II City in India to Promote Green and Sustainable Construction Practices

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Abstract

The challenges encountered within the construction industry continue to serve as a driving force for the implementation of sustainable development practices. Consequently, there is a growing inclination towards incorporating green technologies within our national framework. An esteemed entity in this domain is Green Rated Integrated Habitat Assessment (GRIHA), a prominent national body entrusted with the task of furnishing directives for green constructions in India. Despite the established efficacy of green construction, the number of GRIHA-registered projects remains relatively modest. The benefits of embracing green buildings are manifold, encompassing aspects such as energy efficiency, adequate ventilation, and water conservation. These structures play a pivotal role in curtailing carbon emissions and reducing maintenance expenses. In the long run, inhabitants of green buildings can distinctly perceive the advantages vis-à-vis those residing in conventional residential edifices. The ongoing study delves into the evaluation of a conventional residential venture in Bhopal (M.P.), a Tier-II city, based on 34 GRIHA criteria, aiming to elucidate strategies for securing 1–5-star ratings. This scholarly endeavor is poised to illuminate developers in Tier-II cities regarding deficiencies in construction practices that hinder green certification, thereby stimulating buyer interest in eco-friendly residential properties. The evaluation of the project, in accordance with GRIHA guidelines, sheds light on imperative tasks necessary to meet mandatory criteria.

Keywords: Tier-II city, environmental sustainability, residential project, sustainable construction, Green rated project

Introduction

The global community is grappling with pressing issues like global warming and climate alterations, posing a significant peril to humanity's existence. Notably, man-made structures, particularly buildings, represent a substantial source of CO_2 emissions in urban landscapes, accounting for 40% of energy consumption [1]. Green buildings emerge as a viable solution for mitigating carbon footprints by leveraging renewable energy sources. These structures advocate for the utilization of natural resources and eco-friendly materials, thereby safeguarding the environment. By fostering the adoption of green construction practices, it is plausible to mitigate the adverse impacts of climate change [2].To advocate for green construction, a study focusing on a residential project in Bhopal, a Tier-II city in India, has been undertaken. A critical examination of non-certified traditional residential projects is imperative to ascertain their compliance with GRIHA standards, thereby facilitating the identification of areas requiring improvement to secure a minimum 1-star rating as per GRIHA guidelines. This analysis will elucidate the extent to which traditional residential projects adhere to mandatory or partially obligatory criteria.

There are certain obstructions that Tier-II cities are facing in the country to adopt the guidelines of agencies like GRIHA. A few major reasons have been indicated below.

The specific challenges Tier-II cities face when meeting GRIHA guidelines

1. Lack of support from government bodies in terms of incentives or ease of construction. All the state governments do not provide incentives in India which is a prime reason for a small number of green-rated projects. Unlike Delhi and Rajasthan, governments provide an additional 5% Floor Area Ratio (FAR), and the Maharashtra government provides relaxation in property taxes for green-rated projects.
2. The developers are not interested in bearing the additional cost of the green residential project without the support of the government for installing renewable energy systems like Solar panels, water treatment plants (WTP), etc., for reusing the available water.
3. Lack of knowledge among the stakeholders regarding the long-term benefits of green residential projects.
4. Developers are also unaware of the fact that by making a few changes and following the mandatory criterion as per GRIHA, their traditional projects can be converted to a 1-star green-rated project.

This research work has been done keeping in view certain objectives that can lead to a noble cause if fulfilled. The objectives of the research have been highlighted below.

Objectives of the Research

1) To eliminate the dependency on non-renewable resources and ultimately reutilize renewable resources in the construction industry to protect the environment from losses.
2) To optimize the use of advanced construction materials and advanced techniques by utilizing minimum energy in the project and using equipment that can satisfy the lighting, air conditioning, and other needs.
3) To best use water and wastewater treatment activities to provide safe and eco-friendly conditions.
4) Commencing government in making regulatory norms that can promote the construction of green buildings by providing subsidies and aid to the developers and customers in the state and the country.

The details of the existing subsidies in terms of additional Floor Area Ratio (FAR), Floor Space Index (FSI), and incentives in the form of property tax relaxations, etc., by different government bodies in India have been shown in Table 1 below.

Table 1. Nature of Incentives provided by Indian States & Union Territories [3]

S. No.	Name of State or Union Territory	Year of applicability	Nature of incentive
1	Andhra Pradesh	2015	Financial (Permit fees relaxation)
2	Chandigarh	2015	Mandatory to be done (Govt.)
3	Delhi	2013	Additional FAR & Ground coverage
4	Goa	2019	Mandatory to be done (T&CP)
5	Gujarat	2015	Additional FAR & FSI/Relaxation in consulting charges
6	Haryana	2017	Additional FAR & FSI/Mandatory for government & PSU's
7	Himachal Pradesh	2017	Additional FAR & FSI
8	Jharkhand	2017	Additional FAR & FSI
9	Kerela	2011	Mandatory to be done (PWD)
10	Maharashtra	2011	Relaxation in premium & property tax
11	Odisha	2018	Incentive as per state govt.
12	Punjab	2013	Additional FAR & FSI
13	Rajasthan	2014	Additional FAR & FSI
14	Sikkim	2015	Additional FAR & FSI
15	Uttar Pradesh	2011	Additional FAR & FSI
16	Uttarakhand	2017	Additional FAR & FSI/Mandatory for govt. buildings
17	West Bengal	2015	Additional FAR & FSI

Literature Review

Utilization of Waste in Construction Activities

The issue of waste management resulting from urbanization on a global scale can be effectively addressed through the establishment of standards for sustainable development. Research has specifically focused on the potential utilization of waste materials in construction processes. Furthermore, an examination of the benefits and challenges associated with incorporating waste into construction projects has been conducted through the analysis of two case studies in India. By integrating waste materials into residential projects, both governmental and private agencies can enhance their ability to manage construction waste efficiently and develop appropriate strategies for the future [3, 4].

Use of Sustainable Construction Materials

The incorporation of sustainable building materials is a fundamental aspect of environmentally friendly construction endeavours. The utilization of sustainable materials is closely linked to considerations such as economic viability, environmental preservation, and social equity. Key elements of any sustainable residential project encompass enhancements in water and energy efficiency, reduction of waste generation at the construction site, improvement of indoor air quality, optimal HVAC system design, and meticulous site planning. The utilization of industrial waste like fly-ash, steel or iron slag, etc. can help in preventing the environment as well. Nowadays, fly-ash is being utilised in mortar and bricks, thus dumping the waste generated in infrastructures. The principles of sustainable development also entail the selection of materials with minimal adverse environmental impacts, emphasizing recyclability and reusability [5, 6].

The Concept of Sustainable Construction

In response to the energy crisis of the 1960s, extensive research efforts have been dedicated to enhancing energy efficiency and mitigating environmental degradation. The construction industry encountered similar challenges, prompting the gradual emergence of the concept of sustainable construction. To disseminate this concept globally, various rating systems have been established worldwide. Researchers have sought to define sustainable construction based on criteria adopted by different nations [7].

The progress of sustainable development hinges on external factors such as policy development, certification schemes, and economic incentives, as well as internal factors including technological advancements and user interaction with green technologies. Presently, over 48 green building standards and 18 evaluation systems have been introduced worldwide by experts. Effective implementation of green building technologies necessitates enhancements in governmental policies and incentive frameworks. Furthermore, improvements in the quality of professional assessments, technical skills of workers and staff, and engagement of relevant consultants are essential. These collective efforts will contribute to national development, formulation of sound policies, and encouragement of construction firms to overcome obstacles, paving the way for extensive research endeavours in the future [8].

Innovation in Low-Energy Green Buildings within the Construction Industry

A research framework based on Innovation Assessment and Governance Assessment tools was employed to examine low-energy green building initiatives in two cities, Delhi and Singapore. Data collection involved interviews with experts and participants. The findings of the study reveal that the governance conditions in Singapore are resilient compared to those in Delhi. The governance policies and support in Delhi are only moderately supportive of green building innovations [9, 10].

The construction sector bears equal responsibility for environmental degradation through material consumption and waste generation. The rapid urbanization observed in the nation has prompted technical officials and industry professionals to focus on sustainable construction initiatives. Consequently, urgent action is needed to address the barriers hindering the adoption of sustainable and eco-friendly construction practices within the country [11]. To delve into the underlying issues, a survey utilizing questionnaires was conducted among industry professionals and experts engaged in on-site activities. The survey responses provided by site engineers, project managers, planning engineers, supervisors, and trainee students unveiled crucial factors influencing sustainable construction. Key findings highlighted the lack of skilled labor, uninformed clients, and a general deficiency in knowledge among industry professionals concerning green construction technologies. Therefore, research consistently emphasizes that collaborative efforts from all stakeholders are essential for achieving success [12].

An Examination of Sustainable Buildings in India

Sustainable buildings play a pivotal role in mitigating environmental harm by reducing reliance on fossil fuels during development. Furthermore, they enhance residents' quality of life through eco-friendly initiatives. Despite the limited research conducted in this area, it can be inferred that there is notable progress in the field. Scholars have endeavored to conclude by analyzing data from cities such as Delhi, the national capital. By categorizing the outcomes based on factors like age, gender, income, and education level, researchers can obtain precise insights into the increasing utilization of sustainable infrastructures. It has been demonstrated that knowledge and awareness among stakeholders serve as primary drivers in advancing sustainable buildings across India [13, 14].

Methodology

To better understand the lacuna in traditional residential projects, it is essential to have an intensive study of this kind of project. The shortcomings of these projects will help to overcome them in the upcoming projects. Hence, in the current research, a case study has been done on a traditional project of a Tier-II city (Bhopal) in India. The selected project SAGE Golden Spring (SGS) is located on Ayodhya Bypass Road, Bhopal, and comprises 3, 4, and 5 BHK Bungalows, 2 and 3 BHK luxurious flats with various modern facilities such as a rainwater harvesting system, swimming pools, jogging tracks, club house, Jain temple, and landscaped gardens. Some of the important statistics related to the project are shown in Table 2, which depicts the details of the area that the bungalows possess.

Table 2. Area statement of bungalows

Unit Type	Accommodation	Plot Size (in ft.)	Plot Area (sq. ft.)	Built Up Area (sq.ft.)
B	5 BHK	22*60	1320	3560
C	4 BHK	22*50	1100	3000
D	3 BHK	18*50	900	2210

Table 3 highlights the area covered by flats on the selected site.

Table 3. Area statement of flats

Unit Type	Accommodation	Carpet Area (in Ft.)	Built Up Area (sq. ft.)	Super Built Up Area (sq.ft.)
C1	3 BHK	1080	1184	1515
C2	3 BHK	1080	1184	1515
C3	2 BHK	900	973	1275

The figure 1 (a) to (f) shown below demonstrates the different construction phases of the project SGS highlighting the quality of work being done.

Figure 1. Images of selected site for evaluation(a) entrance of Site SGS,(b) foundation level work,(c) superstructure work on site, (d) constructed bungalows on site,(e) construction phase of site, and (f) Isometric view of site

The project has been evaluated, and the shortcomings of each criterion have been listed below. The marks have been awarded as per the compliance given in the GRIHA manual.

The rating system of residential projects as per GRIHA is shown in Table 4.

Table 4: Evaluation system of GRIHA (GRIHA Manual 2019)

S. No.	Points scored	Rating
1	50-60	One star
2	61-70	Two stars
3	71-80	Three stars
4	81-90	Four stars
5	91-100	Five stars

The major drawbacks and the remedial measures have been highlighted.

The details of the different criteria of GRIHA have been highlighted in Table 5, which explains the requirements of a residential project to achieve star ratings.

Table 5. Specifications based on GRIHA as per the different phases of the building life cycle

Criterion No.	Clause	Work requirements under criterion as per GRIHA
1	Site Planning phase (Partly Mandatory)	Site selection should comply with the provisions of eco-sensitive zone regulations, coastal zone regulations, and heritage areas (identified in the master plan).
2	Site Planning phase (Partly Mandatory)	To preserve existing vegetation using non-disturbance or damage to trees and other forms of vegetation during construction.
3	Site preservation phase	To lay the topsoil properly, including soil stabilization and maintenance of adequate fertility of the soil supporting vegetative growth.
4	Site preservation phase	Minimizing the disruption of the natural ecosystem and designing to harness the maximum benefits of the prevailing micro-climate.
5	Landscape feature for green rating (Partly Mandatory)	Net paved area of site under parking, roads, paths, or any other use not to exceed 25% of site area.
6	Renewable energy-based systems phase	To meet minimum allowable luminous efficacy (as per lamp type) and make progressive use of a renewable-energy-based lighting system.
7	Site preservation phase	Minimizing road and pedestrian walkway length by appropriate planning and shading of pedestrian roads
8	Construction phase (Mandatory)	Ensuring cleanliness of the workplace for the disposal of waste and effluent, providing clean drinking water and latrines and urinals to workers.
9	Construction phase (Mandatory)	Ensuring proper screening, covering brick and loads of dusty materials, wheel washing facility, and water spraying facility on site.
10	Landscape feature for green rating	Reducing the water requirement for landscaping purposes by 30% or more.
11	Water management phase	Reducing building water use by applying low-flow fixtures and other tools by 25% or more. Using smart water meters can also help in water management.
12	Construction phase	Use materials such as pre-mixed concrete to prevent loss during mixing. Use recycled treated water and control the waste of curing water.
13	Planning and building design phase (Mandatory)	Planning appropriately to reflect climate responsiveness, including adequate daylighting as well as efficient artificial lighting.
14	Planning and building design phase (Partly Mandatory)	Ensure that the building complies with the mandatory compliance requirement of the Energy Conservation and Building Code (ECBC) 2007 and meets thermal comfort conditions as per the National Building Code (NBC) 2005.
15	Material selection phase	Using fly-ash, a minimum of 15% replacement of Portland cement with fly-ash, a minimum of 40% usage of fly-ash (by volume of materials used), and a minimum of 30% replacement of Portland cement with fly-ash (by weight of cement used) in plastering work.

16	Structural systems phase	Replace a part of the energy-intensive materials with less energy-intensive materials and/or utilize regionally available materials, which use low-energy/energy-efficient technologies.
17	Material selection phase	Minimum 70% in each of the three categories of interiors (internal partitions, paneling/false ceiling/interior wood finishes/in-built furniture door/window frames, flooring) from low-energy materials/finishes to minimize the usage of wood.
18	Renewable energy-based systems phase (Partly Mandatory)	Rated capacity of the proposed renewable energy system of internal lighting and space conditioning connected loads, or its equivalent in the building, ranging from 1 to 30%.
19	Renewable energy-based systems phase	Meet 20% or more of the annual energy required for heating water through renewable energy-based water-heating systems for projects that have a hot water demand (minimum) of more than 500 litres per day.
20	Water management phase	Provide necessary treatment of water for achieving the desired concentration of effluents, to meet the disposal/reuse application standards.
21	Water management phase	Providing on-site wastewater treatment for achieving prescribed concentration, rainwater harvesting, and reuse of treated wastewater and rainwater for meeting the building's water and irrigation demands.
22	Construction phase	Ensure maximum resource recovery and safe disposal of wastes generated during construction, and reduce the burden on landfill by recycling and safe disposal of segregated wastes.
23	Operation and Maintenance phase	Provision of multi-colored bins for waste segregation at source.
24	Operation and Maintenance phase	Allocate separate space for the collected waste before transferring it to the recycling/disposal stations if solid waste generation on site is more than 100 kg/day.
25	Landscape feature for green rating	Make arrangements for the recycling of waste through local dealers and zero-waste generation through appropriate resource recovery measures.
26	Material selection phase	Zero/low-VOC paints: Zero/low-VOC paints for 100% of all paint used in the interior of the building, and adhesives used are water-based rather than solvent-oil based/low in oil solvent content.
27	Planning and building design phase (Mandatory)	All the insulation used in the building is Chlorofluorocarbon (CFCs) and Hydrochlorofluorocarbons (HCFCs) free, and all the Heating Ventilation Air Conditioning (HVAC) and refrigeration equipment are CFCs free. The fire suppression systems and fire extinguishers installed in the building are free of halon.
28	Operation and Maintenance phase (Mandatory)	Ensuring water from all sources (such as groundwater, municipal water, and treated wastewater) meets the water quality norms as prescribed in the Indian Standards for various applications [IS 10500-1991].
29	Planning and building design phase	The outdoor noise levels are within the acceptable limits as set in the Central Pollution Control Board (CPCB), and the indoor noise levels are within the acceptable limits as set in NBC 2005.
30	Planning and building design phase (Mandatory)	The company policy for ban/prohibition of smoking within the building premises and zero exposure to tobacco smoke for non-smokers.

31	Planning and building design phase	To ensure accessibility and usability of the building and its facilities by employees, visitors, and clients with disabilities.
32	Operation and Maintenance phase (Mandatory)	Energy audit report to be prepared by approved auditors of the Bureau of Energy Efficiency (BEE), Government of India
33	Operation and Maintenance phase (Mandatory)	Validate and maintain 'green' performance levels/adopt and propagate green practices and concepts for all electrical and mechanical systems to be maintained by the owner, supplier, or operator.
34	Innovation phase	Four innovation points are available alternative transportation, environmental education, company policy on green supply chain, life cycle cost analysis or any other criteria proposed by applicant.

The selected project falls short of a 1-star rating by 7 marks, which can be recovered by taking suitable measures as specified by GRIHA. The graphical representation of the marks gained by the traditional project is shown in Figures S1 to S7 in the Supporting Information.

Figure S1 shows the marks gained from Criteria 1 to 5, Figure S2 shows the marked gained by project from criteria 6 to 10, Figure S3 shows the marked gained by project from criteria 11 to 15, Figure S4 shows the marked gained by project from criteria 16 to 20, Figure S5 shows the marked gained by project from criteria 21 to 25, Figure S6 shows the marked gained by project from criteria 26 to 30, and Figure S7 shows the marked gained by project from criteria 31 to 34.

Figure 2 below shows the overall marks gained by the project SGS and a comparative analysis of the same as per the star ratings from 1 to 5 by GRIHA.

Figure 2. Comparative analysis of marks gained by SGH as per GRIHA star ratings

Results

The traditional residential projects need certain changes during their development phases so as to be converted for at least a 1-star rating as per the National rating agencies. The details of the marks scored by the selected project (SGS) as per the guidelines of GRIHA have been illustrated in the form of Table 6. Conclusive remarks have also been provided for every criterion so that the necessary changes can be adopted while developing a residential project in the near future.

Table 6. Marks gained by project SGS as per the 34 criteria of GRIHA (GRIHA Manual)

Details of all the Criteria	Project 'Sagar Green Hills' evaluation			
	Max. Points	Applicable Points	Achieved Points	Remarks
1. Selecting the site	1	1	1	The project site selected is appropriate and as per the City's Master Plan.
2. Landscape protection during construction/compensatory depository forestation.	5	5	4	Natural vegetation was not damaged, but newer trees/plantations shall be done on site.
3. Conserving soil (post-construction)	2	2	2	Excavated soil was reutilized on the project site
4. Designing while including existing site features	4	4	2	All buildings on site shall gain maximum benefits from the prevailing micro-climate.
5. Reduction in hard pavements on site	2	2	1	The net paved area is under limits, but the shaded area shall be enhanced.
6. Uplifting external lighting system efficiency	3	3	1	Solar-based Street lights and parking lights facilities shall be provided.
7. Sustainable planning of utilities and optimizing on-site circulation efficiency	3	3	2	Arrangements for the shading of pedestrian roads are required.
8. Providing basic sanitation/safety facilities to the construction workers	2	2	1	Sanitation facilities for workers need to be improved.
9. Minimizing air pollution while constructing	2	2	1	Pollution of air during construction shall be minimized.

10. Reducing the water requirements of landscape	3	3	1	The reduction was nearly 30% only. Lawn areas can be minimized.
11. Minimizing the use of water in building	2	2	1	Better low-flow fixtures shall be installed to reduce water consumption from 25% to nearly 50%
12. Utilizing water efficiently during construction	1	1	1	Pre-mixed concrete was used to reduce water losses during mixing.
13. Designing buildings to reduce the demand for non-renewable energy	8	8	3	Adequate day lighting shall be provided on every floor of the buildings. Day lighted areas can also be increased.
14. Utilizing the building energy performance under specified limits of comfort.	16	16	4	The Energy Performance Index (EPI), i.e., annual energy consumption of a building (KWh) divided by the total built-up area, shall be reduced to 40%. Also, ECBC guidelines are to be followed.
15. Consumption of fly-ash in building structures	6	6	5	Fly ash was used in mortar and bricks, but % consumption of fly ash shall be increased in structural concrete.
16. Ways of reducing construction time by utilizing technologies like pre-cast construction, RMC, etc.)	4	4	2	The utilization of low-energy materials and lightweight concrete is to be enhanced.
17. Using material having lower energy in the interior of buildings	4	4	2	Industrial waste or recycled products shall be used in interiors (false ceiling, doors, windows, flooring, etc) to minimize wood.
18. Utilizing renewable energy in construction	5	5	0	Renewable energy systems (solar) with a rated capacity are to be installed over every building.

19. Using a hot-water system based on renewable energy	3	3	0	A minimum 20% of the annual energy requirement for heating water (hot water for all needs, like washing, and bathrooms/toilets) is supplied from renewable energy sources.
20. Arrangements for treating wastewater	2	2	1	Water testing reports by govt. bodies were available, but the necessary treatment of wastewater is not being done.
21. Recycling & reusing water (even rainwater)	5	5	1	Rainwater shall be collected for future use, and providing necessary treatment of wastewater for annual water reuse up to 75% via the Water Treatment Plant (WTP) is essential.
22. Ways of minimizing construction waste	1	1	1	The construction wastage was minimal due to the reuse of the wasted mortar, etc.
23. Segregating the construction waste	1	1	0	Waste segregation was not done on-site into chemical, hazardous, and reusable categories
24. Storing and disposing of construction wastes	1	1	1	Allocation of a separate space for the excavated soil was done.
25. Ways of recovering resources from waste	2	2	0	Arrangements for resource recovery systems for biodegradable waste were not provided on-site.
26. Using paints and products with low VOC.	3	3	2	All paints used in the interior of the building were low Volatile Organic Content (VOC), but VOC adhesives and sealants shall be avoided.
27. Minimizing substances causing ozone depletion	1	1	0	CFC-free equipment for refrigeration and air conditioning shall be installed.

28. Ways of maintaining water quality	2	2	1	A certificate from the local municipal authority for water quality was available, but the water quality details before and after treatment need to be compiled.
29. Maintaining noise in the interior and exterior	2	2	0	A sound audit report conforming to the CPCB-Environmental Standards of noise at different locations inside and outside the building shall be made available.
30. Neglecting the use of Tobacco and smoke	1	1	1	The prohibition of smoking/tobacco on the building premises was strongly supported with the help of the company policy.
31. Providing accessibility for persons with disability	1	1	1	Access to facilities (like wheelchairs) and services (Ramps) by adopting appropriate site planning to eliminate barriers for disabled persons was as per the recommended standards of NBC.
32. Conducting audits of energy, waste, and water.	-	-	-	An energy audit report shall also be prepared.
33. Protocols for Operating and maintaining electrical and mechanical equipment	2	2	0	Installation of digital smart water meters shall be done at all main supply points to measure the total water consumption of the building.
34. Adopting innovative methods (beyond 100)	4	4	0	No innovative idea on the project site was implemented.
TOTAL	104	104	43	

The statistical data above illustrate that the selected residential project falls short of achieving a 1-star green rating by a margin of 7 points according to the GRIHA standards. The deficiencies in the project can be addressed through specific remedial actions to secure at least a 1-star rating. No measures were implemented to decrease air pollution and enhance air quality at the site during the process of vehicles entering or exiting. Therefore, it is imperative to ensure thorough cleaning of the wheels of such vehicles to minimize air pollution. During the loading of demolished waste or unloading of construction materials at the site, it is essential to sprinkle fresh water to mitigate air pollution and meet the requirements of criterion 9. To earn points under criterion 13 and diminish the reliance on traditional energy sources, areas of the infrastructure exposed to excessive sunlight can be shaded or covered using external structures like green facades or mechanisms. Under criterion 16, precast concrete components like precast stone blocks, pre-cast concrete blocks, pre-cast finished concrete blocks, lightweight concrete blocks over dense concrete blocks shall be used. To meet criterion 27, improved fire safety provisions should be introduced in multi-story buildings, such as an automatic sprinkler system activated by heat generation. Additionally, efforts should be made to reduce the usage of CFC-emitting equipment like air conditioning and refrigeration systems.

To comply with criterion 28, water quality testing reports should be procured from local municipal authorities to verify adherence to water quality standards outlined in the Indian Standard code 10500. Raising awareness among stakeholders about the hazards of tobacco consumption and smoking is crucial for achieving points under criterion 30. Workshops for workers and the installation of signboards across the premises indicating "Ban on Tobacco & No Smoking Zone" can aid in this effort. Addressing the shortcomings in criterion 32 can be accomplished through conducting Energy Audits, water quality Audits, and Solid waste audits on the site with the assistance of experts within two years of occupancy. Installation of smart water meters along the supply mains is necessary to curb water wastage and fulfil the requirements of criterion 33. Implementation of these recommendations and adjustments will facilitate compliance with the mandatory criteria of GRIHA, ultimately leading to the attainment of a minimum 1-star rating. Similar investigations can be conducted on conventional projects, with a comprehensive report subsequently submitted to governmental bodies to enforce green construction practices in Tier-II cities of India, thereby safeguarding against environmental degradation. Further research can be done on other traditional residential, commercial, or industrial projects to determine deficiencies and promote green and sustainable construction technologies.

Conflicts of Interest

The authors declare that there is no conflict of interest.

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