NATIONAL GREEN BUILDING ASSESSMENT TOOL IN INDIA

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Summary

Green building certification is globally considered an important tool in promotion of sustainable practices in the buildings sector. While there are various green building certification tools prevalent across the globe, there are cases where the tools unable to address the local resource and economic situations for individual countries. Thus there is a need for every country to have a region specific green building assessment tool which caters to its specific environmental, economic, social concerns and factors in the local building industry and construction standards.

GRIHA (Green Rating for Integrated Habitat Assessment) is the National Rating System for green buildings in India. The rating system was developed considering India's national priorities and prevalent state of the buildings sector. GRIHA addresses various concerns of green buildings through the design, construction and operations phase of any building in order to ensure minimal negative impact on the environment. This rating system has the ability to rate air-conditioned as well as non-air-conditioned buildings as green. It rates green buildings on the basis of actual energy performance.

This paper attempts to discuss how GRIHA assists in minimization of environmental impact during the various stages of design, construction and operation and address local concerns. This paper will also attempt to discuss how GRIHA as a rating tool assesses the impact of building activity on environment, economics and society. This will be done through the case study of the Centre for Environmental Science and Engineering, Indian Institute of Technology, Kanpur quantifying the impact on avoided emissions.

Keywords: Green Buildings, Assessment systems, India, National Codes

1 Introduction

1.1 Current state of construction sector in India

The construction sector in India has witnessed steady growth since the beginning of the last decade. Rate of growth of the construction sector in India has been estimated at about 10% per annum [1]. The growth in the buildings sector is fuelled by the increasing urban population. The total strength of the urban population in India was 27.7% in 2000. The urban population is projected to increase to 41.1% of the total population by 2030 [2]. Rapid growth in the expanse and populations of existing and new cities in India contribute to the ascending demand for provision of energy, water and other infrastructural facilities for the residents. Constantly expanding urban areas result in depletion of fertile agricultural land, increased demand for water and electricity, waste water treatment and solid waste management. At the current rate of construction and Business as Usual scenario, the annual energy demand for new buildings is projected to increase at a rate of 5.4 billion kWh annually [3]. The per capita consumption level of water in 1990 was 2464 m^3/capita/annum but by 2025, with the expected population of 1.4 billion, the per capita availability of water is expected to be about 1700 m^3 per annum [4]. As per CPCB assessment, Class-I and Class-II towns generated about 26254 million litres of waste water per day in 2003-04. The waste water treatment capacity developed in these two classes of urban centres is only 7044 million litres per day [5]. The CPCB has also estimated that the construction industry accounts for nearly 25% of the 48 million tonnes of solid waste generated annually [6]. This scenario compels India to construct and develop green buildings and adopt sustainable development guidelines.

1.2 Green Buildings Sector in India

Construction of green buildings in India is not a recent development. In recent years, modernization of lifestyles and construction sector have replaced practise of low-resource consumption design interventions with high resource consumption practices. With the recent advent of government policies on energy efficiency, Demand Side Management measures, stricter pollution and water quality norms, design and development of energy green buildings has regained impetus.

The green buildings sector has witnessed renewed interest amongst the building professionals and occupants in the last decade. In 2008, 1.56 million sq.m. built up area, out of the total 300 million sq.m. constructed built up area, comprised of green buildings [7]. However, inspite of various government policies and economic benefits; there exist multiple barriers to the growth of green buildings sector in the country. Lack of awareness on green building practices, policies and benefits is a major obstacle in design and construction of green buildings.

The fragmented state of the construction sector in India interrupts the design and construction of green buildings. The construction process does not follow an integrated approach towards building design and construction. In the Indian construction sector, the design consultants, builders and the building occupants have incoherent interests. Construction of green buildings increases the capital investment required in green buildings which impacts the builders. However, the major economic benefits, from reducing operation cost, are reaped by the building occupants. This reflects in the lack of interest amongst builders to design and develop green buildings.

2 Green Rating for Integrated Habitat Assessment (GRIHA) – developing the rating system

2.1 Need for a local green building assessment tool

The detrimental impacts of buildings on the environment are diverse. The key to minimizing the environmental impact of buildings and designing green buildings lies in adoption of an integrated approach towards building design and operation. An integrated approach to building design and operation aims at promoting best practices like better site and construction management, building design optimization, energy efficiency, water efficiency, waste water and solid waste management and well being of building occupants.

The national codes in India address individual aspects of building design, operation and performance.

- The National Building Code (NBC) of India was first published in 1970. The NBC addresses aspects related to building design, best construction practices, plumbing, Heating, Ventilation and Air-conditioning; landscaping etc. The NBC has undergone several revisions, the most recent one being in 2005. The NBC underwent revision in 2005 in order to incorporate parameters to facilitate the design of energy efficient buildings in India.
- The Central Pollution Control Board (CPCB) guidelines were formulated in order to specify the maximum permissible pollution limits during various construction phases of buildings. CPCB guideline establishes benchmarks for aspects like outdoor noise pollution, water quality, waste water treatment and discharge levels etc.
- Bureau of Indian Standards (BIS) guidelines address diverse sectors in India. BIS has effective standards pertaining to various quality aspects. These are quality of water for various uses, recommended indoor noise levels, specifications for low-energy materials for use in building structure etc. amongst others.
- The Energy Conservation Building Code (ECBC) was launched by the Bureau of Energy Efficiency in 2007. ECBC lays down guidelines for energy performance requirements in buildings with a connected load of at least 500kW or demand of 600 kVA or higher. The code stipulates energy performance parameters for the building envelope, lighting systems, HVAC systems, electrical systems and water heating and pumping systems.

Individually, the aforementioned codes address different individual aspects concerned with green building design. However, neither of them provides an integrated approach towards green building design. GRIHA, as a green building rating system, was formulated to link the various standards into one system which would provide an integrated approach towards design and assessment of green buildings.

2.2 Government policies and frameworks

Realizing the importance of energy efficiency and sustainable development, the Government of India released and enacted several policies over the years to establish frameworks and guidelines in order to reduce the environmental impact of buildings.

- As a consequence of The Energy Conservation Act, released in 2001, the Bureau of Energy Efficiency (BEE) was set up in 2002. BEE came out with the Energy Conservation Building Code (ECBC) in 2007.
- The Integrated Energy Policy was released in 2006 emphasized upon the potential of Demand Side Management (DSM) measures. The Integrated Energy Policy directed the National Building Code to be revised in order to facilitate incorporation of energy efficient measures in buildings. NBC underwent this revision in 2005.
- The Ministry of Environment and Forests (MoEF), as a part of the Environment Protection Act 1986, established a mechanism to evaluate the environmental impact of projects concerned with infrastructure development, mining, power generation, industries etc. The EIA was initially mandated for 29 major polluting activities. In the amendment to the Act issued in 2004, it was deemed mandatory that construction of new townships, colonies, commercial complexes etc. would require EIA clearance if the complexes:
  - were to house 1000 or more persons; or
  - have a sewage discharge capacity of 50 kL/day or more; or
  - require an investment of Rs. 50 lakhs or more.

- The National Action Plan on Climate Change (NAPCC) was released by the Office of the Prime Minister of India in 2008. NAPCC listed out eight different missions for sustainable development. The Sustainable Habitat Mission emphasized the need for energy efficiency in buildings and listed down various financial, regulatory and delivery mechanisms for their promotion. The Solar Mission under the NAPCC emphasizes the need for generation of energy using renewable sources.

GRIHA underwent periodic revisions to streamline itself with various government policies and initiatives.

- Compliance with the mandatory clauses of ECBC has been made mandatory under GRIHA.
- The Integrated Energy Policy emphasizes on DSM measures. GRIHA addresses this aspect by mandating design of fenestration in order to minimize use of artificial lighting, design of efficient artificial lighting system and compliance with mandatory clauses of ECBC. These aspects cause a decrease in the energy requirement of the buildings.
- The Solar Mission under the NAPCC has a target of achieving 20,000 MW through the use of solar photovoltaic panels by the year 2022. GRIHA addresses this aspect by mandating the installation of solar photovoltaic panels equivalent to 1% of the total connected load of internal artificial lighting and HVAC loads.

Thus compliance with the GRIHA system warrants compliance with the various government codes and policies.

2.3 Origin of TERI-GRIHA-Methodology

The process of formulating the rating system began in 2003-04. A core team of TERI experts was formed. This team comprised of internal experts of TERI related to the fields of energy efficiency, renewable energy, water and waste management. The internal TERI team conducted a detailed study of various international green building rating systems like Leadership in Energy and Environmental Design (LEED), Hong Kong Building Environmental Assessment Method (HK-BEAM), Comprehensive Assessment System for Built Environment Efficiency (CASBEE), BRE Environment Assessment Method (BREEAM) etc. As an outcome of the study, a broad structure and respective criteria variables of the rating system were prepared.

The first draft of the rating system was a rating tool based on a prescriptive checklist. Post various stakeholder dialogues, the rating system was modified and converted to a performance-based assessment system.

The broad aspects to assess the environmental performance of buildings were established. Each aspect was assigned several of various criteria which analyzed building performance based on various benchmarks and parameters. The assessment parameters for individual criteria were formulated post multiple discussions and inputs from sectoral experts.

The initial rating system developed, assessed the building performance on the basis of 32 criteria and rated the environmental performance of the building on a scale of 1 to 100. Each criterion was allocated certain points based on discussion with experts in order to arrive at the total of 100 points. The rating system was named TERI-Green Rating for Integrated Habitat Assessment (TERI-GRIHA). Post conversion to GRIHA, the number of criteria was increased to 34.

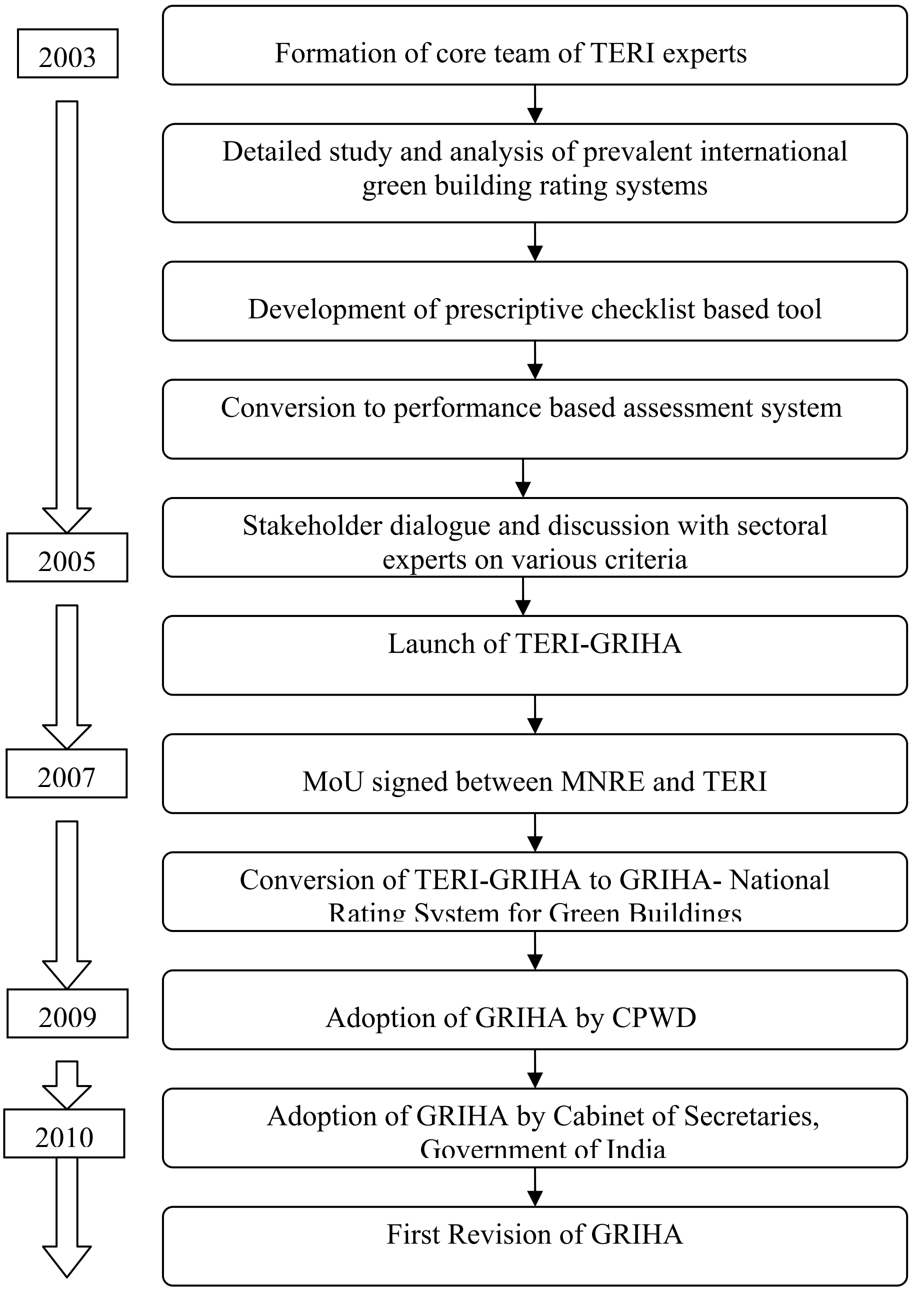

Fig. 1 Timeline of GRIHA evolution

2.4 Agencies involved in formulation and development of GRIHA

The Energy and Resources Institute (TERI) played the key role in the development of GRIHA and its various assessment parameters. The TERI team conducted extensive study and based on past audit experience, was able to establish the performance benchmarks and assessment parameters for various criteria.

The National Advisory Committee (NAC) comprising various representatives of the different government bodies was formed to supervise the implementation of GRIHA across the country and to streamline it with various government policies. The NAC includes high ranking officials from Ministry of New and Renewable Energy, Ministry of Environment and Forests, Ministry of Housing and Urban Poverty Alleviation, Central Public Works

Department, Bureau of Energy Efficiency, Bureau of Indian Standards, TERI, GRIHA Secretariat, Indian Institute of Architects, Confederation of Real Estate Developers and heads of State Nodal agencies like West Bengal Renewable Energy Development Agency, Haryana Renewable Energy Development Agency, Principal secretary, Urban Development, Govt. of Maharashtra and Municipal Commissioner of the city of Bangalore.

The Technical Advisory Committee (TAC) of GRIHA comprises of a panel of technical experts in the field of passive and low-energy architecture, construction, energy efficiency, material applications, water and waste water etc. These sectoral experts assisted in the formulation of the various criteria and assessment benchmarks listed down in GRIHA. Post conversion of the rating system as the National Rating System for Green Buildings, this panel of experts constituted the Technical Advisory Committee of GRIHA. The role of the TAC is to address modifications and revision required in various GRIHA criteria.

The NAC and TAC further assisted in dovetailing the various independent policies and guidelines of different ministries of the Government of India and incorporating them in GRIHA.

A MoU was formally signed between The Ministry of New and Renewable Energy (MNRE) and TERI in November 2007 and GRIHA was adopted as the National Rating System for Green Buildings in India. The ministry provided financial and regulatory assistance to the GRIHA Secretariat in order to promote and implement GRIHA across the country. The ministry also assisted the GRIHA Secretariat in setting up the Association for Development and Research on Sustainable Habitats (ADaRSH). ADaRSH, an independent body, addresses with the various activities concerned with sustainable habitats in India.

2.5 GRIHA as the National Rating System for Green Buildings in India

GRIHA was adopted as the National Rating System for Green Buildings in India by the MNRE, Government of India in 2007. In order to create awareness towards GRIHA and to advance the implementation, MNRE constituted the GRIHA Secretariat. The GRIHA Secretariat was assigned the task of conducting various GRIHA training programmes as well as awareness generation programmes across the country.

MNRE also announced various incentives and subsidies in order to eliminate the financial hurdles which restricted the growth of green buildings and GRIHA in the country. Under a scheme launched by the MNRE, the GRIHA registration fee for the first 100 government buildings was waived off. The ministry also announced subsidies for renewable energy technology for buildings. These incentives reduced the financial incentives towards wide-spread adoption of GRIHA and green buildings. Consequently, awareness of GRIHA amongst the building professionals has risen since 2007.

GRIHA was adopted by the Central Public Works Department (CPWD) in May 2009. CPWD resolved to train its professionals in GRIHA and to design and construct GRIHA complaint buildings. The Cabinet of Secretaries, Government of India, comprising of Secretaries of various ministries of the government also passed a resolution asserting that all future central government buildings in India will be GRIHA compliant. As an outcome of these various initiatives, awareness of GRIHA as the National Rating System for green buildings in India and its implementation has increased.

3 GRIHA – the rating system

GRIHA can be classified as a performance based green building assessment system. GRIHA analyses the environmental performance of a building during the construction, design and the operation phase. GRIHA is a star-based rating system which rates residential, commercial as well as institutional buildings. There are 34 criteria in GRIHA totalling to a 100 (+4 bonus) points. In order to be GRIHA certified, a building must achieve a minimum tally of 50 points. Buildings with points tally of 51-60 attain the lowest level of certification of a One-star GRIHA rating and buildings with points tally of 91-100 attain the highest level of certification of a Five-star GRIHA rated building.

Tab. 1 GRIHA rating bandwidth

Points achieved	Star Rating
51-60	1 star
61-70	2 star
71-80	3 star
81-90	4 star
91-100	5 star

Certification under GRIHA is administered in two stages. The first stage is termed as 'Pre-certification' and the second stage is termed as 'Final certification'. A building is Pre-certified under GRIHA upon successful evaluation of the intent documentation for the project. The building then has to conduct a mandatory energy audit after one year of building occupancy for verification of building performance. Once the building performance is verified and conforms to the documentation, the building receives the Final certification which is valid for a period of 5 years.

3.1 Distinguishing characteristics of GRIHA

- Non-applicability

  This clause assesses the relevance of a criterion with respect to the selected site/building size. This is a provision provided to the clients to opt out of criteria which did not apply to a given project due to natural constraints or do not have a significant environment impact. In such cases, the performance of the buildings is evaluated as a percentile.
- Absolute performance benchmarks for energy consumption

  GRIHA examines the reduction in energy consumption in buildings with respect to pre-established Energy Performance Indices (EPI). EPI varies for various building uses, climatic conditions and space conditioning strategy. Since the EPI is a constant benchmark value, it serves as a common platform for comparative analysis of energy efficiency of various buildings.
- EPI benchmarks for non-air-conditioned spaces

  Majority of new buildings constructed in India are non-air-conditioned. GRIHA has established EPI benchmarks for non-air-conditioned spaces as well.
- Post occupancy audit

  The intention of Post-occupancy audit is to monitor the actual building performance vis-à-vis the predicted building performance.

3.2 Assessment Parameters

GRIHA identifies five broad categories for assessing the environmental performance of buildings. These are: Site Planning; Energy Efficiency; Water, wastewater and Solid Waste Management; Health and Well Being; and Sustainable Construction Materials. Each aspect has been assigned several criteria which evaluate the environmental performance.

Points allocated to each aspect respect their importance in with respect to national concerns. As a result, Energy efficiency was allocated the maximum points.

Tab. 2 lists the various criteria under each aspect.

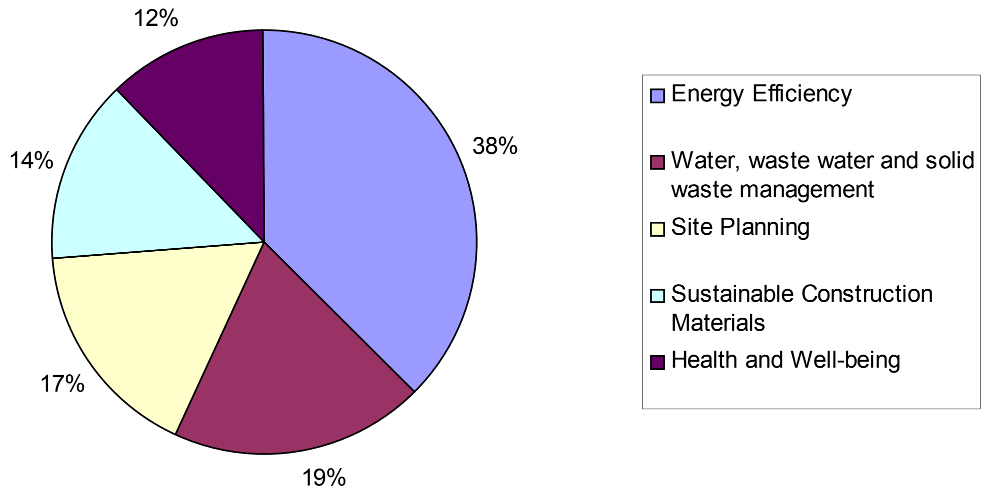

Fig. 2 GRIHA point allocation

Tab. 2 GRIHA assessment criteria

Green Building Aspects	**Assessment Criterion**
Site Planning	▪ Site selection ▪ Preserve and protect landscape during construction ▪ Top soil preservation ▪ Design to include to existing site features ▪ Reduce hard paving on site ▪ Plan utilities efficiently and optimize on-site circulation efficiency
Energy Efficiency	▪ Optimize building design to reduce conventional energy demand ▪ Optimize energy performance of building within specified comfort limits ▪ Enhance outdoor lighting system efficiency ▪ Renewable Energy Utilization ▪ Renewable energy based hot-water system ▪ Operation and Maintenance ▪ Energy audit and validation
Water Efficiency, Waste Water and Solid Waste Management	▪ Reduce landscape water requirement ▪ Reduce building water use ▪ Efficient water use during construction ▪ Waste water treatment ▪ Water recycle and reuse (including rainwater) ▪ Reduction in waste during construction ▪ Efficient waste segregation ▪ Storage and disposal of wastes ▪ Resource recovery from waste
Health and Well-being	▪ Minimum level of health and sanitation for construction workers ▪ Reduction of air pollution during construction ▪ Use of low-VOC paints, adhesives and sealants ▪ Minimization of Ozone depleting substances ▪ Acceptable outdoor and indoor noise levels ▪ Tobacco and Smoke control ▪ Universal Accessibility
Sustainable Construction Materials	▪ Utilization of industrial wastes ▪ Low-energy construction ▪ Low-energy material application in interiors

3.3 Response to local context

GRIHA as a rating system promotes adoption of traditional knowledge and principles in construction practices through its assessment criteria. For example, assessment criteria concerned with site planning and building design promotes passive design. Reduction in landscape water demand promotes the plantation of native tree species. The EPI benchmarks are classified based on the five climatic zones of the country. As majority of the construction consists of non-air-conditioned spaces, GRIHA provides EPI benchmarks for non-AC spaces as well.

The mandatory criteria make certain that, as an outcome of compliance with GRIHA, buildings respond to the national concerns. The criteria mandating the compliance of building fenestrations with the SHGC requirements of ECBC and daylighting requirements of NBC (2005) ensure adoption of traditional and passive design principles.

In India, construction workers work in dilapidated conditions, often with no safety measures put in place. GRIHA mandates the provision of appropriate sanitation facilities, drinking water and safety measures for construction workers. Another important issue is addressed by the criterion mandating the compliance with the BIS standard for water quality. The water supplied to buildings for various uses, is often unable to meet the water quality standards set by BIS. Thus mandating compliance with BIS ensures that building occupants use water which meets the required quality standards.

4 Case Study – Centre for Environmental Science and Engineering, Indian Institute of Technology, Kanpur

Fig. 3 Centre for Environmental Science and Engineering, IIT Kanpur [8]

4.1 Building Description

The IIT Kanpur Centre for Environmental Sciences and Engineering (CESE) building is the first GRIHA rated building in India and achieved the highest rating of 5-stars. The building houses laboratories, seminar rooms, classrooms etc. The building comprises of 1912 sq.m of air-conditioned spaces and 2328 sq.m of non-air-conditioned spaces. Low-energy design and climate responsive site planning assisted the CESE building in achieving 41.3% reduction in EPI from the GRIHA benchmark.

4.2 Environmental best practices incorporated in the building

The building layout was planned ensuring that the longest facades of the building are oriented towards north and south. The building layout was modified to impact minimum disruption of natural condition and trees. The Window-Wall-Ratio was kept at optimum levels as recommended in the ECBC. The design of shading devices ensured minimum direct penetration of sunlight and heat gain. The daylight levels in the living areas met the

NBC 2005 recommended Illuminance levels. The building envelope was designed to be complaint with the ECBC.

Various low-energy strategies were adopted to affect reduction in absolute energy consumption of the building. The fresh air being utilized in the building is pre-cooled using an earth-air tunnel system. The protected and newly planted trees provide shade to the building during the harsh summers. Each such measure supplements the overall energy efficiency.

The building has been fitted with Solar Water heating systems and Solar Photo Voltaic which assist in generation of electricity from renewable sources. Use of low-flow fixtures resulted in over 60% reduction in water demand. High efficiency irrigation systems and native flora effected reduction of water demand for landscape purposes by about 50%. The water output from the packaged waste water treatment plant, installed for waste water treatment, meets the BIS water quality parameters.

4.3 Reduction in energy consumption and CO_2 emissions

Adoption of integrated approach towards design of CESE building at IIT Kanpur impacted a reduction of almost 60% in EPI of air-conditioned spaces as compared to a conventional building. The impact of each intervention has been specified in Tab. 3.

Tab. 3 Reduction in EPI of Air-conditioned spaces due to various interventions.

Stage	**Intervention**	**Reduction in EPI** (kWh/m^2/annum)	**EPI** (kWh/m^2/annum)
Conventional case			240
Building Envelope Optimization	Use of roof and wall insulation, reflective roof tiles and low-e double glass,	32	208
Lighting Optimization	Energy efficient T5 and CFL fixtures	40	168
HVAC Optimization	High efficiency chillers	35	133
Controls	Building controls in HVAC and artificial lighting systems	25	108
Earth Air Tunnel	Utilization of Earth Air Tunnel in HVAC system.	10	98
Final Design Case			98

The air-conditioned spaces witnessed an EPI reduction of about 38.4% below benchmark EPI of 140. The non-air-conditioned spaces witnessed an EPI reduction of about 52.4% below benchmark EPI of 25. The weighted average demonstrates an overall EPI reduction of 41.3% from GRIHA benchmark. As a result, the CESE building caused a reduction in the emission of CO_2 equivalent to 106.54 tonnes/annum [9] (Tab.4).

Tab. 4 Reduction in CO2 emissions for CESE Building, IIT Kanpur

Total area of AC spaces	1912 sq.m.
Total area of non-AC spaces	2328 sq.m.
Base Case:	
EPI for AC spaces	140 kWh/sq.m./annum
EPI for non-AC spaces	25 kWh/sq.m./annum
Total annual energy consumption in Base Case	325.88 MWh (325880 kWh)
Design Case	
EPI for AC spaces	86.3 kWh/sq.m./annum
EPI for non-AC spaces	11.9 kWh/sq.m./annum
Total annual energy consumption	192.7 MWh (192708.8 kWh)
Reduction in annual energy consumption in Design Case	133.17 MWh
Reduciton in annual CO2 emissions	106.54 tonnes

5 Conclusions

Green building assessment systems provide the requisite framework for assessment and implementation of various environmental design features in buildings. An integrated approach is crucial for design and assessment of green buildings. Green building assessment systems judge the environmental performance of buildings on various aspects. All green building rating systems address common aspects like site planning, energy efficiency, water efficiency etc. However, the benchmarks for the various parameters and their individual weightage within the each rating system should be determined based on national priorities and concerns.

GRIHA is a performance based green building assessment system. GRIHA streamlines the various national codes concerned with environmental performance in to one single code. As the National Rating System for green buildings, its benchmarks and parameters suit the national issues, resources, industry conditions and geographic conditions. GRIHA dovetails the parameters of various national codes like ECBC, NBC, CPCB, BIS etc. and streamlines them into a single code.

A successful green building rating system assesses the environmental performance of green buildings on various parameters while simultaneously providing guidance towards design of green buildings.

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