Analyzing and comparing building energy rating systems and well health safety rating in Indian context.

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Abstract*—Building energy rating systems like GRIHA, IGBC, and LEED are some energy rating systems that support and promote sustainable construction. focusing on parameters like energy efficiency, and water conservation, and includes factors like indoor environmental quality, lighting, fitness, and mental health the main goal or aim of this is to improve occupant well-being and make a sustainable future. The main objective of this review paper is to present a comparative analysis of IGBC, GRIHA, and LEED to identify their pros and cons in the Indian context It also explores the integration WELL Health-Safety Rating into existing green building frameworks. The study mainly aims to establish an Indian context approach to sustainable design and operations that enhances environmental performance while prioritizing occupant comfort, health, and safety. The review also provides insights into this energy rating system as well as the health rating systems literature study forming a plinth for developing the proposed integrated framework.

***Index Terms*- GRIHA, LEED, IGBC, Energy Rating System, health rating system, sustainable construction, sustainable architecture.**

I. INTRODUCTION

The increasing emphasis on sustainability, energy efficiency and human health in modern architecture has propelled the exploration of innovative design approaches and construction techniques which promotes energy rating systems like GRIHA, LEED, and IGBC which promotes sustainable construction and architecture by implementing energy efficiency, water conservation, and a better indoor environment. while NIEHS WELL Health and Safety rating system emphasizes features like air quality, Fitness, lighting, and mental health. These energy rating systems not only help reduce harmful environmental impacts but also improve occupant well-being.

The solution to eliminate all the shortcomings and to find a singular approach that aims for both an energy rating system and human health and safety is to formulate a combined integrated framework. applying this combined approach can provide a more superior and effective strategy for sustainable design and operations, enhancing environmental performance as well as human comfort healthy, and safety also it will have a universal recognition which will have all the regional and international aspects to it.

II. LITERATURE STUDY

A. GRIHA:(Green Rating for Integrated Habitat Assessment)

About- GRIHA is India's official framework for encouraging sustainable construction practices is the Green Rating for Integrated Habitat Assessment, or GRIHA, system. It was developed by TERI and approved by MNRE in 2007. It is developed to reduce the environmental impact of buildings right from its construction phase through its lifetime. GRIHA strongly promotes and emphasizes sustainable materials, waste management, water conservation, energy efficiency, and occupant comfort. It is formulated and incorporate national standards like ECBC and NBC and is made focused to India's varied climatic zones and regions. It also offers a strong base for lowering carbon footprints and encouraging resource efficiency in the built environment, which matches the global goals of sustainability.

1. *Criterion*

I. *Sustainable Site Planning*: The category emphasis on site planning and designing in way to sustain the natural environment of the site. The strategy aims to preserve biodiversity, incorporating natural features into design and ensures compliance with local plans. UHIE is addressed by promoting use of vegetation reflective materials, and green roof. (GRIHA, 2019)

II. *Construction Management*- The category aims to carry out construction activities with minimal harm to the environment. It includes various

measures like dust control, noise, and water pollution at the site and also includes managing construction waste effectively. Topsoil is also conserved in these criteria ensuring reuse of the soil in landscape. To reduce the ecological footprint use of treated water is also managed in construction activities (GRIHA, 2019).

III. *Energy Optimization*- This criterion pushes measures to reduce energy consumption by means of building insulation, efficient equipment, and design strategies that maximize natural ventilation and lighting. To cutdown the dependence and use of fossil fuels renewable source of energy is also promoted through use of solar panels To ensure climate- friendly design low environmental impact materials and substances such as those free from ozone-depleting substances are selected. (GRIHA, 2019)

IV. *Occupant comfort*- Buildings must serve the people who live or work in them, in addition to being sustainable. This area focuses on making spaces comfortable and healthy. Good natural light, combined with effective artificial lighting, boosts productivity and well-being. Thermal insulation and acoustic treatments make a comfortable place to live or work, while preserving excellent indoor air quality with correct ventilation and low-emission materials protects health (GRIHA, 2019).

V. *Water Management*- Given the growing worry over water scarcity, this category encourages efficient water use and conservation. It recommends utilizing low-flow fixtures to reduce consumption and promotes water recycling through effective treatment systems. Harvesting rainwater for non-potable u3se, such as irrigation, further reduces demand on municipal water resources. The emphasis on delivering clean and safe water emphasizes the value of both conservation and quality in sustainable water policies (GRIHA, 2019).

VI. *Solid Waste Management*- A sustainable lifestyle requires effective trash management. This criterion promotes recycling wherever feasible, separating garbage at the source, and turning organic waste into energy or compost. Environmental impact can be decreased by encouraging waste-to-resource technology and reducing dependency on landfills. To ensure long-term sustainability, post-construction projects are encouraged to incorporate waste management systems that inhabitants or occupants may readily follow (GRIHA, 2019).

VII. *Sustainable Building materials*- It has a great impact on the project's environmental impact. it promotes and emphasizes use of eco-friendly alternatives and techniques, such as use of recycled material or materials which have low embodied energy levels. materials such as fly ash bricks, bamboo are preferred over resource-intensive solutions. life cycle evaluations is also considered in selection of materials to evaluate the harm in a period of time. the main aim is to be independent of nonrenewable resources (GRIHA, 2019).

VIII. *Life Cycle Costing*- Consideration of long-term financial effects is another aspect of sustainability. In addition to the initial cost of construction, life cycle costing accounts for the costs of building maintenance and operation. With this method, decisions taken at the design stage, such installing energy-efficient technologies, are guaranteed to result in savings during the building's lifetime. It is a win-win approach for developers and residents alike since it balances environmental responsibility with economic viability (GRIHA, 2019).

IX. *Socio-Economic* Strategies-Sustainability is more than just the environment; it also encompasses humans. The category strives to make a positive social impact by providing construction workers with safe working conditions and necessities such as clean drinking water and basic sanitation, as well as promoting ease of circulation for the disabled through universal design principles, for an overall more inclusive and eco-friendlier environment areas for service workers and interest of stakeholders is equally considered and ensured (GRIHA, 2019).

X. *Performance Metering and Monitoring*- This parameter focuses on monitoring systems to guarantee buildings operate as intended. It tracks Real-time energy and water usage tracking, 7and it is made possible by devices like smart meters, which allows for increase in efficiency. Commissioning procedures confirm that all

systems, including lighting and HVAC, operate as planned. The building is sustainable throughout its life, not just when it is finished, if the right maintenance procedures are followed (GRIHA, 2019)

XI. *Innovation*- This category if for those ideas, solutions and innovations which are unique and which goes beyond the standards and rules & regulation. some of these technologies includes net positive energy systems, advanced water recycling technologies and real time air quality monitoring systems. These innovations show creativity and development which also encourages stakeholders to adopt unique strategies which helps in enhancing resource efficiency, occupant health and environmental impact. through these innovations and projects, it drives and encourages stakeholders to implement new cutting-edge green practices and also showcases that these technologies can be applied to real world scenarios and also can be replicated and scaled according to the requirements (GRIHA, 2019).

This is a Table showcasing all Section and Criterion:

Manual Volume	Section	Criterion No.	Criterion Name	Maximum Points	Appraisal Type
I.	Introduction, Process, Criteria (Intent, Appraisal, Compliance)				
II.	1. Sustainable Site Planning	1	Green Infrastructure	5	Partly Mandatory
		2	Low Impact Design Strategies	5	Optional
		3	Design to Mitigate UHIE	2	Optional
	2. Construction Management	4	Air and Soil Pollution Control	1	Partly Mandatory
		5	Topsoil Preservation	1	Optional
		6	Construction Management Practices	2	Partly Mandatory
III.	3. Energy Optimization	7	Energy Optimization	12	Partly Mandatory
		8	Renewable Energy Utilization	5	Partly Mandatory
		9	Low ODP and GWP Materials	1	Partly Mandatory
	4. Occupant Comfort	10	Visual Comfort	4	Partly Mandatory
		11	Thermal and Acoustic Comfort	2	Partly Mandatory
		12	Indoor Air Quality	6	Partly Mandatory
IV.	5. Water Management	13	Water Demand Reduction	4	Partly Mandatory
		14	Wastewater Treatment	2	Optional
		15	Rainwater Management	5	Optional
		16	Water Quality and Self-Sufficiency	5	Partly Mandatory
	6. Solid Waste Management	17	Waste Management – Post Occupancy	4	Partly Mandatory
		18	Organic Waste Treatment	2	Optional
V.	7. Sustainable Building Materials	19	Utilization of Alternative Materials in Building	5	Optional
		20	Reduction in Global Warming Potential through Life Cycle Assessment	5	Optional
		21	Alternative Materials for External Site Development	2	Optional
	8. Life Cycle Costing	22	Life Cycle Cost Analysis	5	Optional
VI.	9. Socio-Economic Strategies	23	Safety and Sanitation for Construction Workers	1	Partly Mandatory
		24	Universal Accessibility	2	Optional
		25	Dedicated Facilities for Service Staff	2	Optional
		26	Positive Social Impact	3	Partly Mandatory
	10. Performance Metering and Monitoring	27	Project Commissioning	0	Mandatory
		28	Smart Metering and Monitoring	7	Partly Mandatory
		29	Operation and Maintenance Protocol	0	Mandatory
			Total Points	**100**	
	11. Innovation	30	Innovation	5	Optional

This chart depicts the distribution of criterions in terms of percentage-

2. *Rating System*-

GRIHA has a 100-point percentile-based rating system. On the submission of the required documents and upon final assessment and evaluation, the project is awarded/denied points for all the applicable appraisals. Total applicable points become the denominator while points which are not applicable (as confirmed through documentation assessment) to the project are deducted from both denominator and numerator. Points awarded represent the numerator. Points awarded under the innovation section are added only in the numerator which make them the bonus points. (GRIHA, 2019)

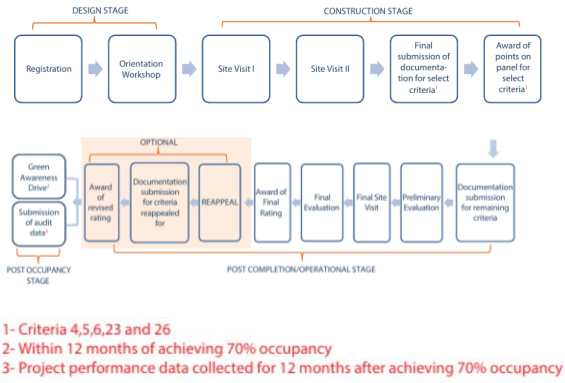
Percentile Threshold	Achievable Star Rating
25–40	★
41–55	★★
56–70	★★★
71–85	★★★★
86 and more	★★★★★

3. Rating Process

Structures in this stage of design are authorized for certification under the GRIHA rating system. Industrial buildings that are used as manufacturing units and warehouses are excluded from the rating system; however, office buildings in the industrial complexes, which are essentially habitable spaces, are eligible for certification. (GRIHA, 2019).

4. Registration-

To be eligible for a GRIHA rating, a project must complete an online registration form found on the GRIHA website (www.grihaindia.org). The beginning of the project is the ideal moment to register for GRIHA rating. This would guarantee the smooth integration of low-energy material and efficient system procurement with sustainable design and construction techniques. Given below is the table which shows step by step procedure: (GRIHA, 2019)



1- Criteria 4,5,6,23 and 26
2- Within 12 months of achieving 70% occupancy
3- Project performance data collected for 12 months after achieving 70% occupancy

B. IGBC (Green New Buildings Rating System) Introduction

IGBC Green New Buildings Rating System, the Indian Green Building Council (IGBC), which was founded by the Confederation of Indian Industry (CII) is made to address and promote environmentally viable building and construction technique. It has changed and revolutionized the building industry by promoting eco-friendly and sustainable solutions which has helped to develop and certified millions of square meters of land of green spaces by making a framework which covers all parameter like energy efficiency, waste management and water conservation which has strengthened the economic and environmental performance by helping builders and the designers.

1. IGBC Criteria's

IGBC Green New Buildings Rating System Checklist		Points Available	
		Owner-occupied Buildings	Tenant-occupied Buildings
Modules		**100**	**100**
Sustainable Architecture and Design		**5**	**5**
SA Credit 1	Integrated Design Approach	1	1
SA Credit 2	Site Preservation	2	2
SA Credit 3	Passive Architecture	2	2
Site Selection and Planning		**14**	**14**
SSP Mandatory Requirement 1	Local Building Regulations	Required	Required
SSP Mandatory Requirement 2	Soil Erosion Control	Required	Required
SSP Credit 1	Basic Amenities	1	1
SSP Credit 2	Proximity to Public Transport	1	1
SSP Credit 3	Low-emitting Vehicles	1	1
SSP Credit 4	Natural Topography or Vegetation	2	2
SSP Credit 5	Preservation or Transplantation of Trees	1	1
SSP Credit 6	Heat Island Reduction, Non-roof	2	2
SSP Credit 7	Heat Island Reduction, Roof	2	2
SSP Credit 8	Outdoor Light Pollution Reduction	1	1
SSP Credit 9	Universal Design	1	1
SSP Credit 10	Basic Facilities for Construction Workforce	1	1
SSP Credit 11	Green Building Guidelines	1	1
Water Conservation		**18**	**19**
WC Mandatory Requirement 1	Rainwater Harvesting, Roof & Non-roof	Required	Required
WC Mandatory Requirement 2	Water Efficient Plumbing Fixtures	Required	Required
WC Credit 1	Landscape Design	2	2
WC Credit 2	Management of Irrigation Systems	1	1
WC Credit 3	Rainwater Harvesting, Roof & Non-roof	4	4
WC Credit 4	Water Efficient Plumbing Fixtures	5	5
WC Credit 5	Wastewater Treatment and Reuse	5	5
WC Credit 6	Water Metering	1	2

(IGBC Green New Buildings Rating System, 2016)

Modules		Points Available	
		Owner-occupied Buildings	Tenant-occupied Buildings
Energy Efficiency		**28**	**30**
EE Mandatory Requirement 1	Ozone Depleting Substances	Required	Required
EE Mandatory Requirement 2	Minimum Energy Efficiency	Required	Required
EE Mandatory Requirement 3	Commissioning Plan for Building Equipment & Systems	Required	Required
EE Credit 1	Eco-friendly Refrigerants	1	1
EE Credit 2	Enhanced Energy Efficiency	15	15
EE Credit 3	On-site Renewable Energy	6	8
EE Credit 4	Off-site Renewable Energy	2	2
EE Credit 5	Commissioning, Post-installation of Equipment & Systems	2	2
EE Credit 6	Energy Metering and Management	2	2
Building Materials and Resources		**16**	**16**
BMR Mandatory Requirement 1	Segregation of Waste, Post-occupancy	Required	Required
BMR Credit 1	Sustainable Building Materials	8	8
BMR Credit 2	Organic Waste Management, Post-occupancy	2	2
BMR Credit 3	Handling of Waste Materials, During Construction	1	1
BMR Credit 4	Use of Certified Green Building Materials, Products & Equipment	5	5
Indoor Environmental Quality		**12**	**9**
IEQ Mandatory Requirement 1	Minimum Fresh Air Ventilation	Required	Required
IEQ Mandatory Requirement 2	Tobacco Smoke Control	Required	Required
IEQ Credit 1	CO_2 Monitoring	1	1
IEQ Credit 2	Daylighting	2	2
IEQ Credit 3	Outdoor Views	1	1

(IGBC Green New Buildings Rating System, 2016)

Modules		Points Available	
		Owner-occupied Buildings	Tenant-occupied Buildings
IEQ Credit 4	Minimise Indoor and Outdoor Pollutants	1	1
IEQ Credit 5	Low-emitting Materials	3	3
IEQ Credit 6	Occupant Well-being Facilities	1	-
IEQ Credit 7	Indoor Air Quality Testing, After Construction and Before Occupancy	2	-
IEQ Credit 8	Indoor Air Quality Management, During Construction	1	1
Innovation and Development		**7**	**7**
ID Credit 1	Innovation in Design Process	4	4
ID Credit 2	Optimisation in Structural Design	1	1
ID Credit 3	Waste Water Reuse, During Construction	1	1
ID Credit 4	IGBC Accredited Professional	1	1

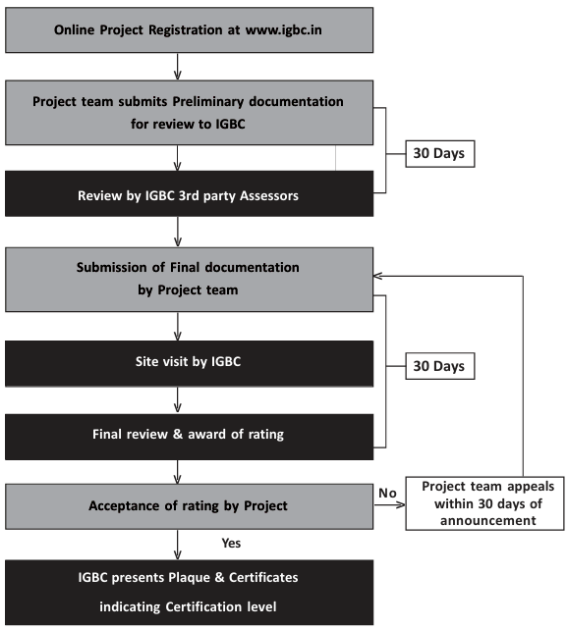
(IGBC Green New Buildings Rating System, 2016)

2. Rating System-

Certification Level	Owner-occupied Buildings	Tenant-occupied Buildings	Recognition
Certified	40 - 49	40 - 49	Best Practices
Silver	50 - 59	50 - 59	Outstanding Performance
Gold	60 - 74	60 - 74	National Excellence
Platinum	75 -100	75 - 100	Global Leadership

(IGBC Green New Buildings Rating System, 2016)

3. Registration Process-



(IGBC Green New Buildings Rating System, 2016)

C. LEED (Leadership in energy and environment design)

Introduction

Leadership in energy and environment design that promotes sustainable building practices is recognized as global certification system developed by the U.S. Green building council (USGBC). LEED has developed a framework that can be used for designing, constructing, and operating buildings that prioritize energy efficiency, resource conservation, and occupant well-being. It aims at reducing environmental impact while enhancing the functionality and liveability of spaces by addressing key aspects such as site selection, water efficiency, energy performance, materials selection and indoor environmental quality. It encourages continuous improvement and innovation in sustainable design as it is adaptable to various building types and offers multiple certification levels.

1. LEED CRITERIA'S

Below are detailed charts for the Healthcare Building Typology under each credit category from LEED BD+C, listing every credit and its associated points.

Note- The chart only mentions the credits for healthcare building typology and for BD+C

I. Integrative Process (IP)

Credit	Points	Description
Integrative Project Planning	Required	Emphasizes early-stage interdisciplinary collaboration and health mission integration
Integrative Process	1	Encourages system synergies for energy, water, and resource conservation through pre-design analyses.

(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

II. Location & Transportation (LT)

Credit	Points	Description
LEED for Neighborhood Development	5-9	Encourages locating within certified sustainable neighborhoods.
Sensitive Land Protection	1	Avoids development on environmentally sensitive lands.
High-Priority Site	1-2	Promotes development in urban,

		brownfield, or high-priority areas.
Surrounding Density & Diverse Uses	1	Develops in dense areas or near diverse land uses to reduce vehicle miles traveled.
Access to Quality Transit	1-2	Ensures proximity to robust transit options to decrease reliance on cars.
Bicycle Facilities	1	Encourages bicycle use through storage, showers, and proximity to networks.
Reduced Parking Footprint	1	Reduces parking to decrease environmental impacts of parking lots.
Green Vehicles	1	Promotes low-emission vehicles through preferred parking and EV charging stations.

(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

III. Sustainable Sites (SS)

Credit	Points	Description
Construction Activity Pollution Prevention	Required	Mandates sedimentation and erosion control during construction.
Environmental Site Assessment	Required	Identifies and remediates contaminated sites.
Site Assessment	1	Surveys site conditions (topography, hydrology, vegetation, etc.) to guide design.
Protect or Restore Habitat	1	Preserves or restores greenfield areas or provides financial support for habitat restoration.
Open Space	1	Creates accessible outdoor spaces for recreation and biodiversity.
Rainwater Management	1–2	Manages onsite runoff for specified rainfall events.
Heat Island Reduction	1	Mitigates heat gain through reflective materials or vegetation.

(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

IV. Water Efficiency (WE)

Credit	Points Description	Description
Outdoor Water Use Reduction	Required	Reduces irrigation needs through efficient landscaping.
Indoor Water Use Reduction	Required	Lowers potable water use for indoor plumbing fixtures.
Building-Level Water Metering	Required	Tracks whole-building water usage for monitoring purposes.
Outdoor Water Use Reduction	2	Further reduces irrigation demands using drought-resistant plants or captured rainwater.
Cooling Tower Water Use	2	Enhances cooling tower efficiency and minimizes potable water use.
Water Metering	1	Sub-meters water systems to monitor and optimize use.

(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

V. Energy & Atmosphere (EA)

Credit	Points	Description
Fundamental Commissioning	Required	Ensures design

		and construction meet energy-related requirements.
Minimum Energy Performance	Required	Achieves baseline energy efficiency through building systems
Building-Level Energy Metering	Required	Monitors energy use with metering systems.
Enhanced Commissioning	6	Optimizes energy system operations through advanced commissioning.
Optimize Energy Performance	18	Incentivizes significant reductions in energy use.
Demand Response	2	Promotes grid demand management through system flexibility.
Renewable Energy Production	3	Encourages onsite renewable energy installations.
Green Power and Carbon Offsets	2	Supports renewable energy certificates or carbon offset purchases.

(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

VI. Materials & Resources (MR)

Credit	Points	Description
Storage & Collection of Recyclables	Required	Ensures access to recycling facilities for waste diversion.
Construction Waste Management Plan	Required	Manages construction waste for recycling and reduction.
Mercury Source Reduction	Required	Reduces use of mercury in lamps and medical equipment.
Life-Cycle Impact Reduction	5	Evaluates material choices for sustainability through life-cycle assessments.
Product Disclosure: Environmental Product Declarations	2	Promotes use of products with transparency in environmental impact.
Material Ingredients	2	Encourages use of materials with safer chemical compositions.
Design for Flexibility	1	Promotes adaptability in healthcare facilities to future needs.

(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

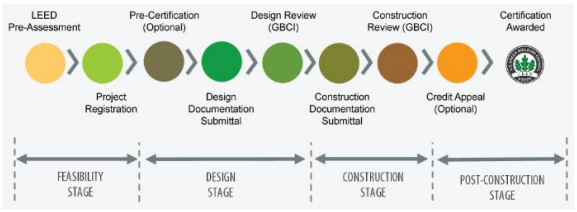
VII. Indoor Environmental Quality (EQ)

Credit	Points	Description
Minimum Indoor Air Quality	Required	Ensures basic air quality through ventilation and controls.
Environmental Tobacco Smoke Control	Required	Prohibits smoking to protect indoor air quality.
Enhanced Indoor Air Quality	2	Adds strategies for improved air quality.
Low-Emitting Materials	3	Uses products with low VOC emissions.
Construction IAQ Management Plan	1	Protects indoor air quality during construction
Indoor Air Quality Assessment	2	Tests air quality post-construction to ensure compliance.

Thermal Comfort	1	Enhances occupant comfort through improved temperature controls.
Daylighting and Views	1–2	Increases daylight access and connection to the outdoors.
Acoustic Performance	1	Optimizes spaces for reduced noise and better acoustics.

(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

2. Registration Process



(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

3. Rating System

Certification Level	Points Required	Performance Criteria
Certified	40–49	Basic achievement of sustainability measures across all credit categories.
Silver	50–59	Enhanced strategies for energy, water efficiency, and material optimization.
Gold	60–79	Significant improvements in energy performance, indoor environmental quality, and use of renewable energy.
Platinum	80+	Demonstrates leadership in sustainability with outstanding performance in all criteria.

(LEED v4 for BUILDING DESIGN AND CONSTRUCTION, 2019)

D. NIEHS WELL BUILDING HEALTH & SAFETY RATING

The WELL Building health and safety rating was developed in a response of COVID-19 pandemic, and it focuses in a human centric way and has measures of emergency plans, maintenance protocols, operation policies and engagement of stakeholders from a health perspective it has features like air and water quality management and health services, and 20 overall, evaluates 20 criteria's and has a minimum criteria of 15 by developing this framework it ensures occupant's immediate and long term wellbeing.

1. Features of WELL Health & Safety Feature guide

Feature		Status
Cleaning and Sanitization Procedures	Support Handwashing	Achieved
	Reduce Surface Contact	Achieved
	Improve Cleaning Practices	Achieved
	Select Prefered Cleaning Productss	Achieved
Emergency Preparedness Programs	Develop Emergency Preparedness Plan	Achieved
	Plan for Healthy Re-Entry	Achieved
	Provide Emergency Resources	Achieved
Health Service Resources	Provide Sick Leave	Achieved
	Provide Health Benefits	Achieved
	Support Mental Health Recovery	Achieved
	Promote Flu Vaccines	Achieved
	Promote Smoke Free Environment	Achieved
Air & Water Quality Management	Assess Ventilation	Achieved
	Assess & Maitain Air Treatment Systems	Achieved
	Develop Legionella Management Plan	Achieved
	Monitor Air & Water Quality	Achieved
	Manage Mold & Moisture	Achieved
Stakeholder Engagement & Communication	Promote Health and Wellness	Achieved
	Share Food Inspection Information	Achieved

(NIEHS WELL Health & Safety Feature Guide , 2020)

CONCLUSION

The study was to highlight the importance of the combined framework incorporating energy rating system along with WELL Health-Safety Rating. A combined framework could offer a common ground by bringing the best of both world environmental performance along with human health and wellbeing. The importance of this study was to show the adoption of regional aspects and universal recognized stability along with human comfort and safety is the way for sustainable building practice in India which will also set new standards of global sustainable architecture.

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