GRIHA V.2019

Volume 1

Introduction to National Rating System - GRIHA
An evaluation tool to help design, build, operate, and maintain a resource-efficient built environment

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GRIHA Council
Core 1B, 3rd Floor
India Habitat Centre, Lodhi Road
New Delhi – 110003

Tel: (+91 11) 46444500/24339606-08)
Email id: info@grihaindia.org
Website: www.grihaindia.org

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Tel. 2468 2100 or 4150 4900
Fax 2468 2144 or 2468 2145
India +91 • Delhi (0) 11
Email id: teripress@teri.res.in
Website: www.teriin.org

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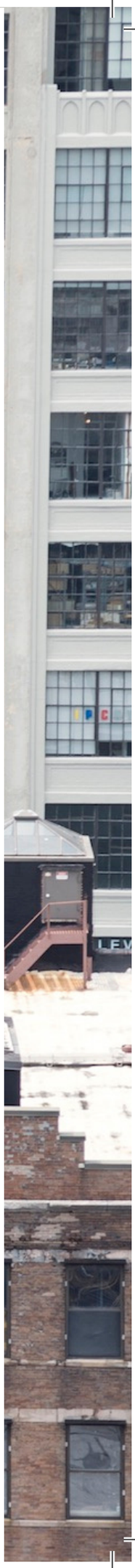

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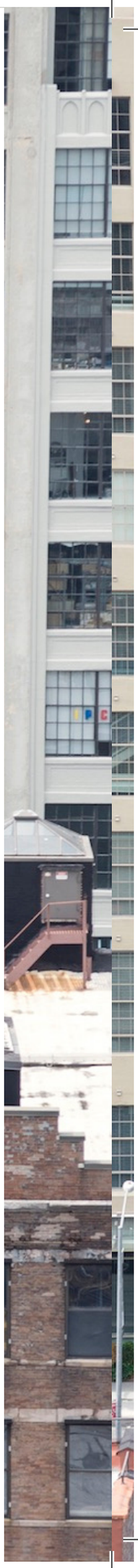

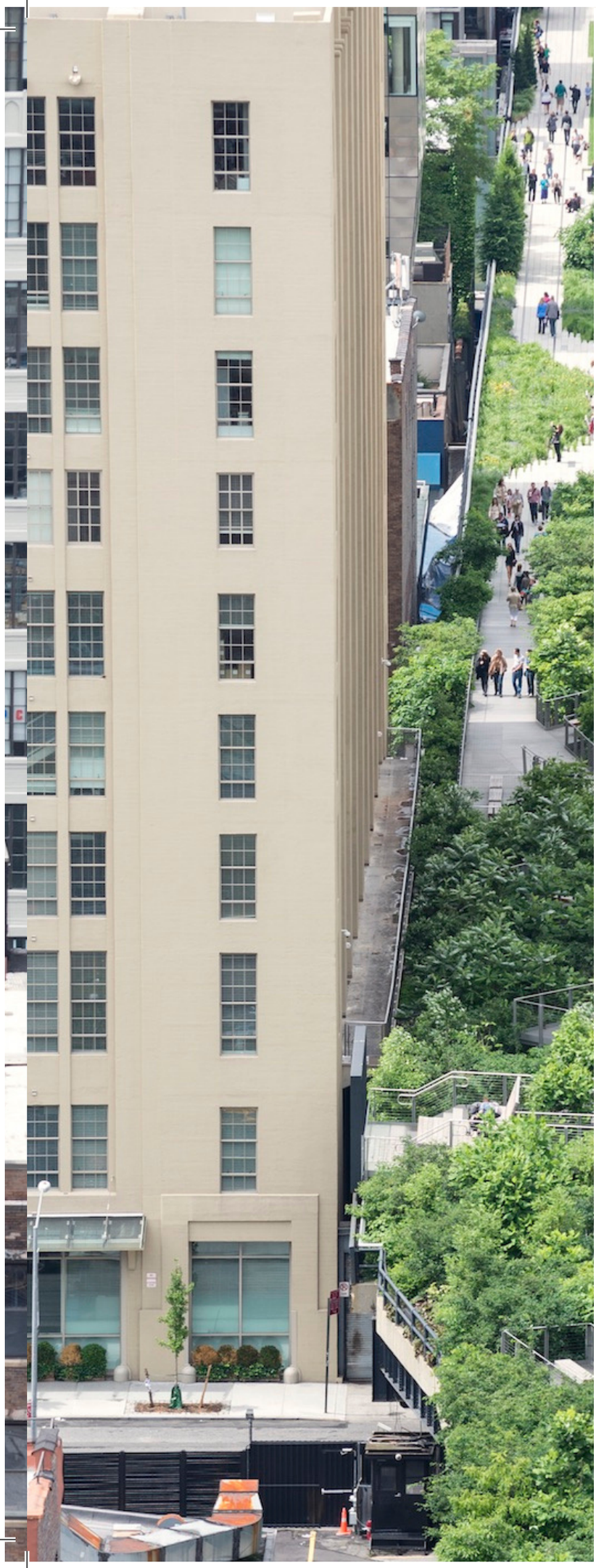

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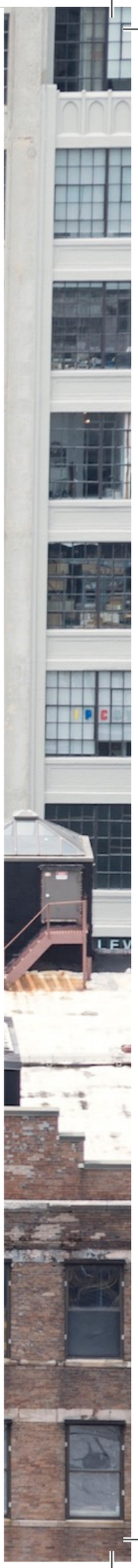


MESSAGE
PRESIDENT GRIHA COUNCIL

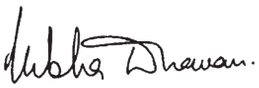
The recently released report "Climate Change 2021: The Physical Science Basis" by the Intergovernmental Panel on Climate Change emphasises upon the urgency of the global warming crisis and attributes the cause to human activity. Since the late 19th century till date, global surface temperatures have increased by approximately 1.07°C. The building and construction industry account for about 38% of global carbon emission and to ensure at least a stabilisation of global warming at around 1.5°C, an immediate decarbonisation over the lifecycle of buildings is vital.

Green buildings especially net-zero and net-positive buildings can lead the way in combating climate change. A green building is one which is environmentally responsible and resource-efficient throughout its lifecycle. It not only has a reduced carbon footprint, but also creates a positive impact on both users and the environment. With a green building footprint exceeding 565.13 million square feet, GRIHA Council is synonymous with sustainable development in India. It is seen as an effective agent of change in addressing issues related to air quality, the protection of bio-diversity and the pressing need to reduce greenhouse gas emissions. As materials, technologies and practices evolve, GRIHA variants too have evolved to evaluate resource efficiency at the design, construction and operations stages, catering to both new buildings and the existing built environment.

In alignment with these advancements in problems and solutions alike, GRIHA Council is introducing GRIHA v.2019 with a focus on whole life and holistic sustainability. It now includes parameters of life cycle assessment and costing, an environmental performance index for water, and strategies for external site development, along with updated benchmarks in line with the revised national norms and aims to further negate the impact of the built on the environment while moving towards net positivity.

With an equal focus on design and construction strategies, materials and technologies, embodied and operational carbon, tradition knowledge and scientific evolvements; we at GRIHA Council strive every day to promote sustainability and resilience whilst helping India transition towards environment centric development.

GRIHA v2019 is the result of months of dedicated research and hard-work by my team, guided by technical advisors from across the country, each adept in their field; and to them all I extend my appreciation. With detailed manuals and a simplified user interface, this version is designed for ease of implementation to ensure that going forth; all buildings new and old across the nation are sustainable ones. I encourage each one of you to take the first step towards augmenting the green building footprint in India through large scale adoption of the GRIHA v.2019 and in turn benefiting the community at large.



Dr Vibha Dhawan

FOREWORD

CEO GRIHA COUNCIL

With modern buildings placing increasingly exorbitant demands on our sources of energy and water,the time has come when the possible benefits of cutting-edge green building practices can no longer be sidelined or ignored. In order to enhance sustainable practices pertaining to the built environment and reduce adverse environmental impact, the existing GRIHA v.2015 rating system has been upgraded to align with evolving global sustainability targets.

GRIHA Council is pleased to introduce the GRIHA v.2019, developed in keeping with the ongoing advancements in the Indian construction sector and to cater to buildings of varied functionalities and typologies. The rating continues to be in alignment with national standards and guidelines such as the National Building Code 2016 and the Energy Conservation Building Code 2017, together with other relevant regulations pertaining to specific topics such as waste management. GRIHA v.2019 has been structured to introduce relatively newer concepts in the design and construction sector – life cycle assessment and life cycle cost analysis of materials, a water performance index intended to reduce the stress on municipal supply lines, emphasis on the treatment of grey and black water, the possibilities of self-sufficiency through urban agriculture, the integration of renewable energy generation with optimized energy use and enhanced management of waste with a focus on the generator's responsibility. Additional aspects such as carbon offsets and enhanced commissioning of systems to ensure compliance with the design intent have also been explored. For the very first time, strategies and benchmarks for cold climates in the subcontinent have also been introduced.

Through the integration of user experience, market feedback, and ease of implementation, GRIHA v.2019 aims to push the market towards enhanced resource efficiency. Using improved benchmarks, this version of the rating system provides a holistic perspective on the development and operation of a green building, thereby aiding in the assessment of its economic viability. On a broader scale, it is hoped that this system will benefit the community at large through reduced emissions, a reduction in stress on natural resources and improved efficiency.

I compliment the efforts of our team at GRIHA Council in putting the "GRIHA v.2019" together.

I gratefully acknowledge the support of everyone associated with the development of this rating system and look forward to their continued guidance for its enhancement.

Sanjay Seth

ACKNOWLEDGEMENTS

Ms. Archana Khanna, founder-partner at First Principle, New Delhi, is a postgraduate in Urban Design from the School of Planning and Architecture, New Delhi. She runs a successful practice in New Delhi since 1993. As the Convenor of the Sustainability Committee of the Northern Chapter of the Indian Institute of Architects, she actively works with organizations in the field of sustainability and green building certification for taking them forward among the architectural fraternity in the region through specially curated training programs.

Prof. (Dr.) Chitrarekha Kabre earned her PhD in Architecture from the University of Queensland, Australia. She has 30 years of academic and professional experience in energy efficient and sustainable architecture. She authored the books 'Sustainable Building Design: Applications Using Climatic Data in India' by Springer, Germany and 'Synergistic Design of Sustainable Built Environment' by Taylor and Francis, USA.

Mr. Jayesh Vira is an Engineer and a Sustainability Consultant with specialization in built environment and comprehensive building commissioning. He has more than 18 years of experience in environmental consultancy and research and development in the field of sustainability. He has contributed significantly in developing the new criteria of the performance metering and monitoring section of the GRIHA v.2019.

Mr. Jeevan Mohan is an Architect and a Sustainability Consultant specialized in built ecologies at Terra Viridis since 2010. He is responsible for research and delivering integrated sustainable design services. In this context, he pushes for different facets of sustainable projects: passive, zero-energy, high performance, daylight, water efficiency, biodiversity, GRIHA certification, etc.

Ar. Rahul Shrikhande has been working in the field of sustainability from the last ten years. Prior to starting his own practice in 2016 in Mumbai, he was working with TERI, Delhi as research associate, his area of specialisation is climate responsive buildings. He was also associated with M.Tech students of TERI School of Advanced Studies and is currently working as visiting faculty at VESCOA, Mumbai.

Dr. S Raghunath is a professor in BMS College of Engineering, Bengaluru . His researches include experimental dynamics, earthquake resistant buildings, alternative building materials and methods, energy and buildings, etc. He is also involved with Nivasa, an architectural NGO working to enable humane and dignified housing conditions for the urban and rural poor, through design.

Dr. S. Rajkumar is Head & DGM – CEFD , Buildings & Factories IC in L&T Construction. He has been working in the field of energy efficient buildings, energy audits, energy and system optimization within a building and also has an expertise in the thermal comfort analysis of air-conditioned and non-air-conditioned building for the last 18 years. He is also actively involved in energy analysis of low energy space conditioning strategies for buildings and is proficient in using building simulation tools.

Mr. Vikas Chand Sharma has been working in the field of sustainability for more than 17 years and is associated with renowned real estate organizations such as IREO, DLF, EMAAR-MGF. The work profile revolves around Corporate sustainability, green building, environment impact assessment studies, environmental audits, CSR initiatives, solid waste management, water & wastewater management, environment health and safety, training & development for green buildings. By education, he has a Masters degree in Environmental Planning and has pursued his Bachelor's in Environmental Engineering. He is a panelist for the 'Skill development and training for wastewater treatment plants' as a certified trainer recognized by the Skill Council for Green Jobs under the National Skill Development Council, Government of India.

TECHNICAL ADVISORY COMMITTEE

Mr. Sanjay Seth is CEO of GRIHA Council and spearheads the Sustainable Habitat Division in TERI. He has more than twenty eight years of experience in the power sector. Under his guidance he has overseen implementation of policies and programmes of BEE as well as the National Mission on Enhanced Energy Efficiency (NMEEE), and multiple international bilateral/multilateral cooperation programmes.

Ms. Shabnam Bassi is secretary & Area Convenor of GRIHA Council. She has multiple years of experience in building sector while working in UNDP and BEE. She has led projects related to energy efficiency in buildings sector in the country and has co-ordinated with the Central, State and Municipal bodies to facilitate ECBC integration. She has worked in close cooperation with various international agencies in developing programmes / government policies for promoting energy efficiency in buildings.

Dr. Arun Tripathi is the Director General of National Institute of Solar Energy. He is an adviser in MNRE and has over 3 decades of experience in planning, development, and implementation of various RE programmes particularly on biogas development, biomass gasification, solar rooftops, waste to energy, village energy security, solar cities, green buildings and information and public awareness in the country

Mr. Saurabh Diddi is working as Director with Bureau of Energy Efficiency (BEE), Ministry of Power. He has more than 16 years of experience in energy efficiency sector. He leads the energy efficiency agenda in building sector with focus on ECBC, Star rating of buildings in India and is spearheading EMIS implementation in building sector in India.

Ar. Vijay Garg is currently serving as the vice president of COA. The Council of Architecture (COA) has been constituted by the Government of India under the provisions of the Architects Act, 1972, enacted by the Parliament of India. The Act provides for registration of Architects, standards of education, recognized qualifications and standards of practice to be complied with by the practicing architects.

Mr. Paritosh Tyagi is the former Chairman of Central Pollution Control Board. Under his leadership various regulatory measures on pollution norms were followed throughout the nation and he was also responsible for reorganizing the head office and zonal offices of the Central Pollution Control Board. Currently he works as an adviser for integrating environmental concerns in project formulation, implementation and operation.

Mr. Richie Mittal is the National President at ISHRAE and Managing Director at Overdrive Engineering. He has been working in the field of Energy efficiency for cooling since last 35 years. He has also expertise in air quality management and building commissioning and is the flag bearer in use of renewable energy cooling technologies in India.

Mr. Harish Borah is an independent life cycle practitioner within the building industry and specializes in life cycle costing and assessment of buildings. He is primarily engaged with ADW Developments for life cycle management and has gained critical insights on the subject matter through practical application and engagement across multiple international projects in India, UK and Qatar.

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28. Srishti Gaur

Abbreviations

AAC	Autoclaved Aerated Concrete
AC	Air Conditioner
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning
ASTM	American Society for Testing and Materials
BEE	Bureau of Energy Efficiency
BoD	Basis of Design
BOQ	Bill of Quantities
BIS	Bureau of Indian Standards
BIPV	Building-Integrated Photovoltaics
BREEAM	Building Research Establishment Environmental Assessment Method
CAC	Ceiling Attenuation Class
CAD	Computer-Aided Design
CASBEE	Comprehensive Assessment System for Building Environment Efficiency
CDs	Compact Disc
C&D	Construction and Demolition
CFC	Chlorofluorocarbons
CFM	Cubic Feet per Minute
COP	Coefficient of Performance
CP	Certified Professional
CPCB	Central Pollution Control Board
CSEB	Compressed Stabilized Earth Block
CM	Construction Management
CO_2	Carbon Dioxide
CPHEEO	Central Public Health and Environmental Engineering Organisation
DA	Daylight Autonomy
DLDD	Desertification, Land Degradation and Drought
DG	Diesel Genset
ECBC	Energy Conservation Building Code
EO	Energy Optimization
EN	European Standard
ETP	Effluent Treatment Plant
EPD	Environmental Product Declaration
EPI	Energy Performance Index
FTL	Full Tank Level
GWP	Global Warming Potential
GDP	Gross Domestic Product
GHGs	Greenhouse Gases

GoI	Government of India
GRIHA	Green Rating for Integrated Habitat Assessment
GW	Gigawatts
HT	High Tension
HK-BEAM	Building Environment Assessment Method-Hong Kong
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
ICAR	Indian Council of Agricultural Research
IPLV	Integrated Part Load Value
ISO	International Organization for Standardization
ISHRAE	Indian Society of Heating Refrigerating and Air Conditioning Engineers
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
LCC	Life Cycle Costing
LED	Light Emitting Diode
LPA	Long Period Average
LPCD	Litres per Capita per Day
LT	Low Tension
LULUCF	Land Use, Land-Use Change and Forestry
MNRE	Ministry of New and Renewable Energy
MoUD	Ministry of Urban Development
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAAQS	National Ambient Air Quality Standards
NBC	National Building Code
NITI	National Institution for Transforming India
NMT	Non-motorised Transport
NRC	Noise Reduction Coefficient
OC	Occupant Comfort
ODP	Ozone Depleting Potential
OPC	Ordinary Portland Cement
OPR	Owner Project Requirement
O&M	Operation and Maintenance
OWC	Organic Waste Converter
PPC	Portland Pozzolana Cement
ppmv	Parts per Million by Volume
PMM	Performance Metering and Monitoring
PV	Photovoltaic
PRS	Pearl Rating System

PVC	Polyvinyl Chloride
RA	Recycled Aggregate
RCA	Recycled Concrete Aggregate
REC	Renewable Energy Certificate
RH	Relative Humidity
RCC	Reinforced Cement Concrete
RWA	Residents Welfare Association
SDG	Sustainable Development Goal
SHGC	Solar Heat Gain Coefficient
SOS	Save Our Soul
SP	Special Publication
SRI	Solar Reflective Index
SRR	Skylight Roof Ratio
STP	Sewage Treatment Plant
SBM	Sustainable Building Materials
SES	Socio-Economic Strategies
SSP	Sustainable Site Planning
STC	Sound Transmission Class
SWM	Solid Waste Management
TERI	The Energy and Resources Institute
TFL	Tubular Fluorescent Lamps
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
UDI	Useful Daylight Illuminance
UHIE	Urban Heat Island Effect
UN	United Nations
URDPFI	Urban and Regional Development Plans Formulation and Implementation
USAID	United States Agency for International Development
USA	United States of America
UPS	Uninterruptible Power Supply
v	Version
VLT	Visible Light Transmission
VOC	Volatile Organic Compound
VRF	Variable Refrigerant Flow
WCED	World Commission on Environment and Development
WM	Water Management
WMO	World Meteorological Organization
WTP	Water Treatment Plant
WPI	Water Performance Index
WWR	Window Wall Ratio

Introduction

Climate Change – global challenge

Earth's climate is changing and its damaging impact is preordained for the next decade and perhaps beyond. With Industrial Revolution, the global average surface temperature rose from 0.6°C to 0.9°C between 1906 and 2005, and the rate of increase in temperature has nearly doubled over the past 50 years. The global surface temperatures in 2018 were recorded as the fourth warmest since 1880, according to the independent analyzes by National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA). The satellite measurements and annotations recorded at thousands of weather observatories across the globe show Earth's shrinking ice cover, which is another evidence of climate change. The rate of global warming is equivalent in scale to the largest global change ever established in the past 65 million years of paleoclimatic records (Diffenbaugh and Field 2013). The global warming is predominantly owing to the increased emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) in the atmosphere, a result of various anthropogenic activities. Since the mid-18th century, humans have released nearly 2.5 trillion tonne of CO_2 into the atmosphere, increasing the atmospheric CO_2 concentrations from about 280 parts per million by volume (ppmv) to 367 ppmv, as depicted in Figure 1 (Houghton, Jenkins, and Ephraums 1991). In the past 61 years of observation at Mauna Loa Observatory, its highest recorded level was in May 2019, which was 414.7 ppmv as reported by NOAA. So statistically, it translates that there has been an increase of more than 2 ppmv per year, which resulted in an average day to be hotter in many locations.

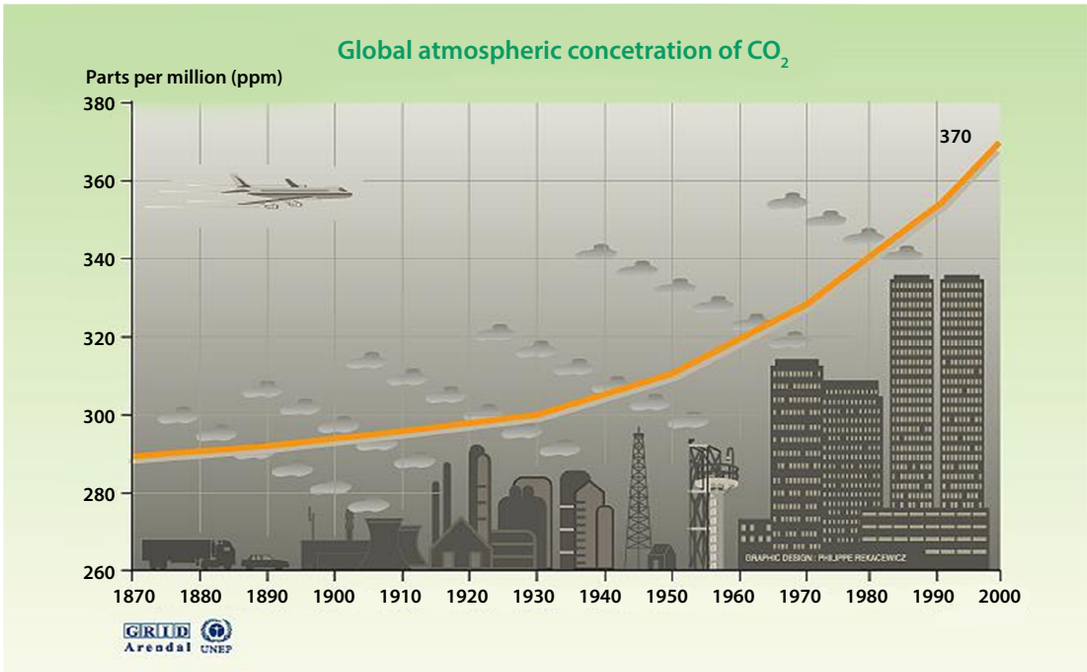

FIGURE 1: Global atmospheric concentration of CO_2

> "Climate change" means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.
>
> – United Nations Framework Convention on Climate Change (Article 1)

Linear and non-linear impacts of Climate Change on Multiple Systems

Seasonal variations in the earth's climate are a natural phenomenon. However, due to faster pace of development and inertia towards continued emissions, these variations are not merely caused by natural factors but largely by anthropogenic factors. Given the size, green cover, and tremendous heat capacity of the oceans, it takes massive amount of heat energy to raise the earth's surface temperature even to a small amount. This excess heat is impelling regional and seasonal climate extremes, such as intensified precipitation, harsh temperatures, reduction in snow cover, and so on, which drastically impact the environment and its inhabitants. A few variations have been elaborated further to contextualize the link between global climate change and local contributors.

> "Climate system" is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things. The atmospheric component of the climate system most obviously characterizes climate; climate is often defined as 'average weather'. Climate is usually described in terms of the mean and variability of temperature, precipitation and wind over a period of time, ranging from months to millions of years (the classical period is 30 years).
>
> – Fourth Assessment Report of Intergovernmental Panel on Climate Change (IPCC), 2007

Increase in global average temperatures

The global average temperature has increased at an average rate of 0.07°C per decade since 1880 and over twice that rate (+0.18°C) since 1981. According to the global climate report by NOAA-National Centers for Environmental Information, 2019 was the second warmest year in the 140-year record,

with a global land and ocean surface temperature departure from the average of +0.95°C. This value is only 0.04°C less than the record high value of +0.99°C set in 2016 and 0.02°C higher than the third highest value set in 2015 (+0.93°C). The 10 warmest years on record occurred after 1998, out of which 9 warmest years were after 2005. It is projected that the global surface temperature by 2020 will be more than 0.5°C warmer than the 1986–2005 average, regardless of the decarbonization pathway the world follows (Global Climate Report - Annual 2019 n.d.).The comprehensive surface temperature data set for India shows that there has been a multi-decadal increase (from 1950 to 2010) in the maximum surface temperatures over the country observed during the pre-monsoon months of April and May. These results are consistent with the IPCC reports that detail the warming of the global climate system which accelerated since the 1950s (Ross, Krishnamurti, Pattnaik, *et al* 2018).

The rise in earth's surface temperature is majorly attributed to the excess of GHGs present in the atmosphere. However, regionally there could be multiple factors that contribute to this apart from the GHG emissions. For example, in urban areas, rise in temperature can be ascribed to the urban heat island effect that is created owing to the excess of concrete and hard paved surfaces, including both vertical and horizontal surfaces, which re-radiate the heat back to the atmosphere. Moreover, the large open spaces that are considered as terrestrial sinks of carbon and heat under the land use, land-use change and forestry (LULUCF) are renewed for real estate or infrastructure development in cities. Such alterations disturb microclimates in the cities/regions by breaking the equilibrium in exchange of CO_2 between the biosphere and the atmosphere.

Extreme precipitation

With the increase in temperature, the process of evaporation progresses, which in turn proliferates the overall precipitation, as warmer atmosphere can hold more moisture. For every 1°C rise in temperature, the atmosphere can hold 7% more water vapour which increases the volume of precipitation by 1–2% (The Guardian 2015). Therefore, it may be deduced that a rise in temperature increases precipitation in many areas and also shift in wind patterns and ocean currents, which drive the global climate system. Nevertheless, increased precipitation does not necessarily mean an increase in the amount of water available for drinking and irrigation. According to the World Meteorological Organization (WMO), rainfall during India's monsoon season (June–September) in 2019 was 10% above the 1961–2010 average, the wettest summer monsoon season since 1994, and the first time it was above-average since 2013.

The local factors that contribute in spatial variation of rainfall over a region are land use and land cover changes that lead to deforestation and increase in the number of pockets of heat islands in the region.

Drought

Lack of precipitation observed in a season and for years, in severe cases, lead to drought-like condition. This virtually affects all climatic regions and more than a half of the earth is vulnerable to droughts every year, as per WMO. Regions with higher variability of rainfall are more susceptible to

long droughts which further leads to degradation of soil, affecting agricultural productivity, natural habitats, and social cohesion. India is the seventh largest country in the world with 328 million hectares of geographical area, out of which nearly a third (107 million hectares) is affected by drought. The area includes about 39% of the country's cultivable land and affects about 29% of the population. During the last 131 years, India experienced 22 major droughts. The severest was the 2002 drought which affected 56% of the geographical area, 150 million cattle, and 300 million people's livelihood, across 18 different states (Flood and Drought Management through Water Resources Development in India 2007).

Essentially, the interlinkage with the rising surface temperature and the precipitation pattern determines the dry period leading to drought, which can be largely associated with the usage of land mass, forest cover, and wetlands in the region.

India is vulnerable to natural disasters due to its unique geo-climatic conditions as seen in Figure 2. Floods, droughts, cyclones, seismic tremors, and landslides have been recurrent phenomena in the country. According to WMO, about 60% of the landform in India is likely to experience earthquakes of various magnitudes, over 45 million hectares is prone to floods, nearly 8% of the total area is prone to cyclones, and 68% of the area is subjected to drought. During 1990–2000, an average of about 4344 people lost their lives and 30 million were affected by disasters every year, as per the report by WMO.

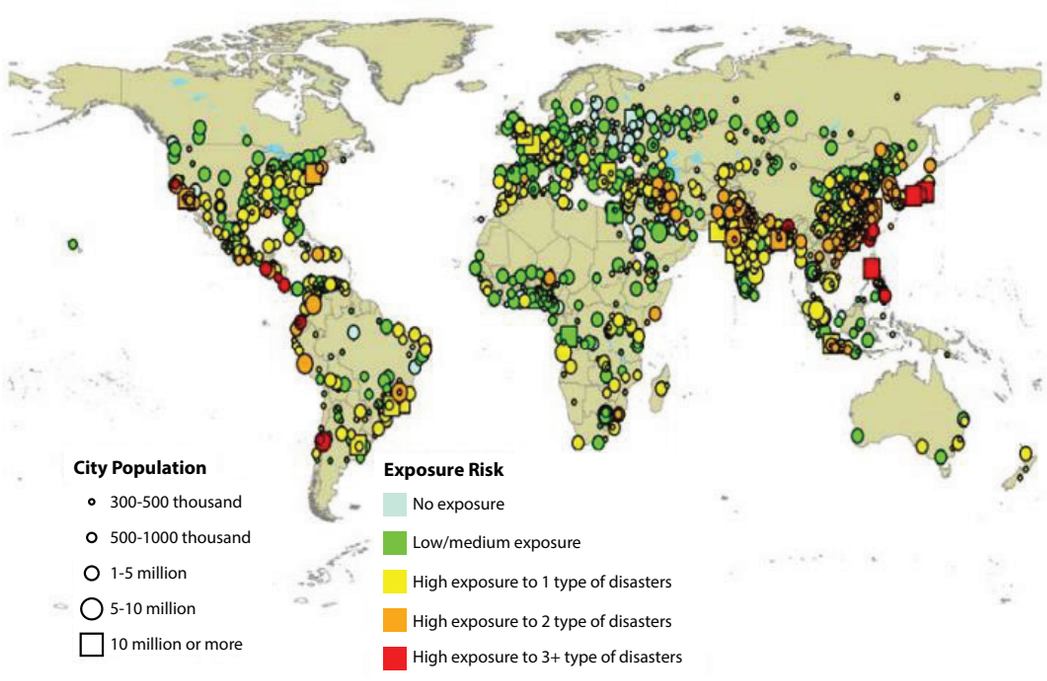

FIGURE 2: Distribution of cities by population size and risk of exposure to natural disasters

Source: Gu, Danan Gerland, Pelletier, et al. (2015)

Natural ecosystem

Dependency of mankind on the natural ecosystem for its existence and other important services is incontrovertible. But, at the same time, there is fragmentation and destruction of the ecosystem. This co-existence at different proportions emanates an imbalance, which further gets accelerated due to climate change. Colonization and utilization of energy resources, such as crude oil, coal, natural gas, and similar assets for development, significantly act as a driving force for the disruption of ecosystem. Furthermore, overuse and mismanagement of natural resources could have a nonlinear and, in some cases, an irreversible impact, such as melting of glaciers due to rise in surface temperature, which could further imperil economic activities of the nearby regions and beyond.

Food system

Conducive climatic conditions in many parts of India have led to undertake agricultural activities which support the demand chain and food supply. However, the same gets adversely disrupted during natural calamities like drought, extreme temperatures, heavy precipitation, and so on. The extent and impact of these calamities is exponentially high due to climate change, introducing more volatility in the demand management and food supply. The impact of climate change on agriculture presumably causes about 1.5% loss in India's gross domestic product (GDP) (DownToEarth 2017). The study led by the University of Exeter indicates that India is at the greatest vulnerability to food insecurity when moving from the present-day climate to 2°C global warming (Betts, Alfieri, Bradshaw, *et al*. 2018).

Physical assets and infrastructure

Physical assets such as buildings can be significantly vulnerable to climate change. The risk of collapse of buildings due to heavy downpours or tremors of high magnitude can lead to significant loss of human and capital. Alternately, the climatic hazards could paralyze the functioning of infrastructural assets leading to a decline in the services being offered or may be a rise in the cost of availing the services. This, in turn can have a knock-on effect on other sectors which are partially or fully dependent on these infrastructural assets. For instance, the breakdown of a road network in a city may affect basic food supply to the communities. Similarly, the power failure would disrupt the associated functioning of the city.

Liveability and workability

Due to hot weather conditions, the outdoor labours' productivity is expected to fall with the reduced effective number of hours to work outdoors. As per the data available for 2017, in India, heat-exposed work contributes to about 50% of the GDP, which drives about 30% of the GDP growth, and employs about 75% of the labour force which is approximately 380 million people. By 2030, the average number of daylit working hours lost in the country is anticipated to increase to the point where between 2.5% and 4.5% of the GDP could be at risk annually (Woetzel, Pinner, Samandari, *et al*. 2020) Employment (i.e., workability) being one of the important dimensions of liveability would have a direct impact on the overall liveability quotient. Figure 3 depicts the affected areas and the projected intensity of extreme heat and humidity (in 2030 and 2050), leading to a higher share of lost effective working hours than today in the country.

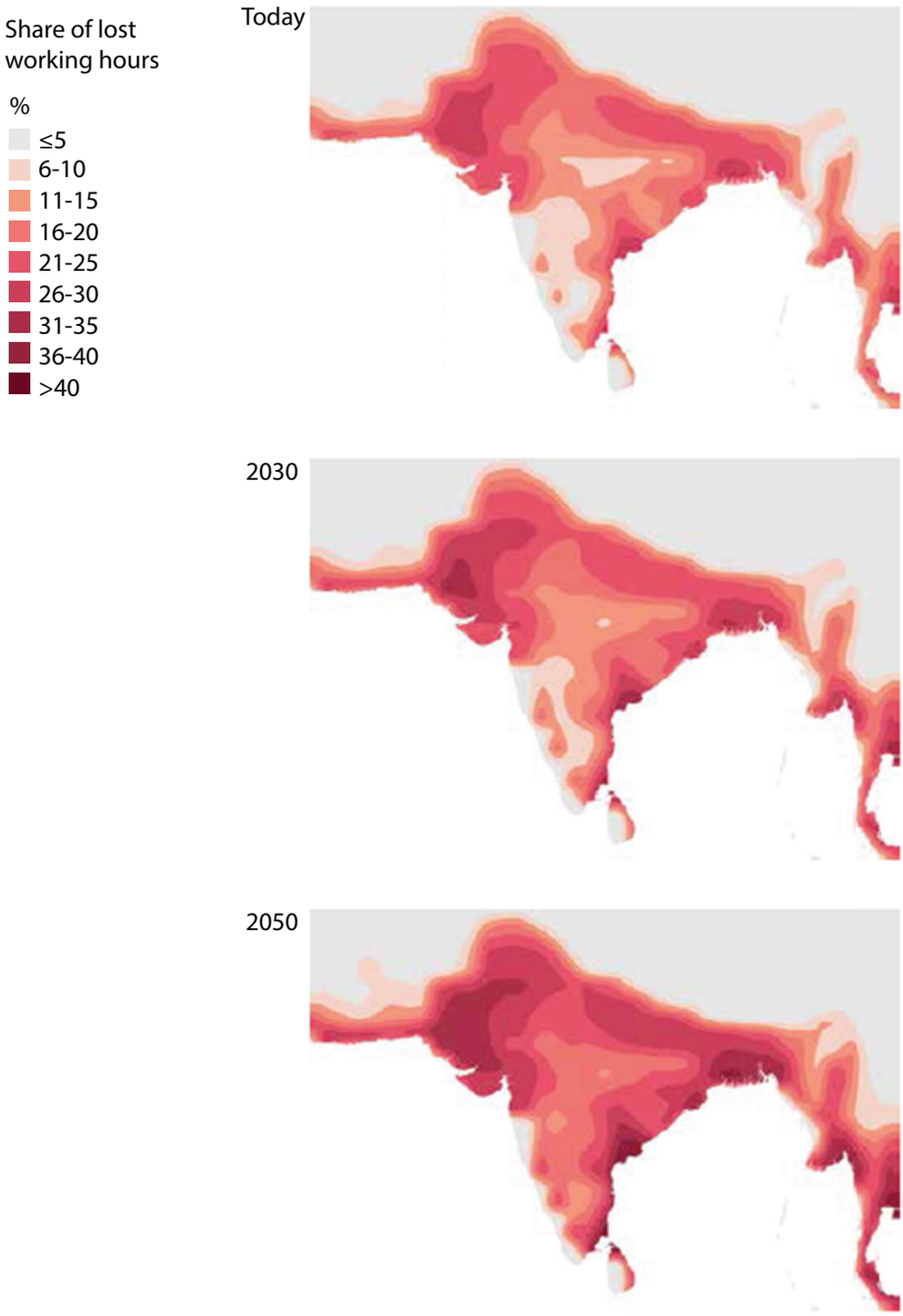

FIGURE 3: Affected areas and share of lost working hours

Source: Woetzel, Pinner, Samandari, et al. (2020)

Resource – Challenges and Opportunities

The endeavour to overcome the global challenge of climate change is still unsettled, as there is an increasing gap between the available resources and their demand and management. The building construction industry, which is one of the major contributors to climate change, is growing at a remarkable pace in India. The built-up area is expected to be increased, as 70% of the buildings that will exist by the end of this decade are yet to be built. The construction market in the country will grow almost twice as fast as China by 2030, providing a new engine of global growth in the emerging markets (Global Construction Perspectives and Oxford Economics n.d.). This strong agglomeration force, which includes a few others such as urban amenities, wage premiums, and so on, would add pressure on the undersupply of housing and resources, and will have a cascading impact on multiple sectors and systems and eventually on the climate goals.

Land

Land is a finite and vital resource for food, fibre, and fuel production and key ecosystem services such as natural management of water systems, wetlands, biodiversity, and forests. However, it is shrinking and deteriorating due to contending pressure from urbanization coupled with climate change, which has become a global challenge. Desertification and loss of biodiversity were identified as the greatest concerns to sustainable development during the 1992 Rio Earth Summit. The United Nations Convention to Combat Desertification (UNCCD) is one of the three Rio Conventions that focuses upon Desertification, Land Degradation and Drought (DLDD).

In 2014-2015, India's GDP suffered a loss of 2.5% due to land degradation. In a study conducted on the economics of DLDD in India, it was estimated that the annual cost of land degradation will surpass the total costs of reclamation in 2030 (Sethi, Datt, Datta, *et al.* 2018). Thus, land management is crucial as the important functions of land and soil underpin the nexus of food, energy, and water security.

Energy

According to the World Resources Institute's Climate Analysis Indicators Tool, in 2014, in India 68.7% of the GHG emissions were attributable to the energy sector, followed by the agriculture sector (19.6%), industrial processes (6%), land-use change and forestry (3.8%), and waste (1.9%). Further, within the energy sector, electricity and heat generation contributed around 49% of emissions, followed by 24% from manufacturing and construction. The electricity use in buildings has increased by more than 500% since 2010 (UN Environment and International Energy Agency 2017). Having said this, India is moving towards clean energy sources. As of October 2019, the installed-generation capacity of renewable energy in India was 83.38 gigawatts (GW), which included 31.69 GW from solar, 37.09 GW from wind, 9.95 GW from bio-power, and 4.65 GW from hydropower. The percentage of renewable energy in India's energy mix has risen steadily to almost 9% compared with the 2014–2015 levels (Mishra 2019). Moreover, India is the world's largest light-emitting diode (LED) market and under the domestic efficient lighting programme, more than 250 million LEDs were distributed till 2017 (UN Environment and International Energy Agency 2017). The future of this growth is promising as India has committed in the Intended Nationally Determined Contribution (INDC) to achieve 40% of the electric power from non-fossil fuel-based energy resources by 2030, along with creating an additional carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent by developing and enhancing the forest and tree cover (USAID 2019).

Water

Water is the essential natural resource that cuts across all the criteria for basic survival of humankind and economic development. In urban areas, the service-level benchmark issued by the Ministry of Urban Development, Government of India (MoUD, GoI) for water supply is 135 litres per capita per day (lpcd). Conversely, as per Central Public Health and Environmental Engineering Organisation (CPHEEO), the average water supply in urban local bodies is 69.25 lpcd. This indicates that there is a huge gap between demand and supply of water in urban areas in the country. Further, this translates that 163 million people are deprived of access to safe drinking water and more than 100 million people are exposed to poor quality water in urban areas (Ali, and Dkhar 2018). With the change in climate, the availability of water and its quality issues further exacerbates. However, rainwater harvesting is an optimistic method of water conservation. It can be done either by storing rainwater in receptacles or recharging the groundwater aquifers. There is also a severe lack of infrastructure to treat wastewater which could potentially be used to offset the secondary water demand. The present installed capacity can treat only about 30% of the waste generated in India, and rest is directly released into the rivers and lakes. Cities like Mumbai and Delhi have less than half of the required number of waste treatment plants (Delawala 2017). However, the situation has improved and since 2014, the country has been investing in wastewater treatment. Under the Swachh Bharat Abhiyan, the urban and rural sanitation coverage has significantly increased and so has the participation of the private corporations. The World Bank estimates that India's total water and sanitation sector is worth $420 million, with an annual growth rate of 18% (Dutta 2017).

Materials

India is the fourth largest construction market in the world after the USA, China, and Japan and is expected to become the third largest by 2025 with a size of $1 trillion (FE Bureau 2016). The absolute material consumption between 1997-2007 grew by more than 1 billion tonnes. If this pattern continues, the construction sector will surpass the agricultural sector by 2020 and become the highest material consuming sector in the country (Sekhar, Varsha, and Nagrath 2015). The predominant materials used in the construction sector are sand, stones (as aggregates), soil (for bricks), and cement. The per capita consumption of cement is comparatively low by at least 200 kg per person to that of the developed countries, but seeing the current growth trend, Indian cement production may increase four to seven times by 2050 (Satpathy, Malik, Arora, *et al.* 2016). India is currently the second largest producer of cement in the world with 502 million tonnes installed capacity, which is 8% of the global installed capacity (Cement Manufacturers Association n.d.). Nonetheless, the cement industry is one of the largest emitters of CO_2 and accounts for approximately 7% of the country's total CO_2 emissions. Although India has considerable limestone reserves, they may run out by 2060 considering the current growth rates. These forecasts indicate that the Indian construction industry is likely to face serious material supply issues.

Given that the material cost accounts for roughly two-third of the total project cost, it makes the construction sector vulnerable to price shocks due to supply bottlenecks (Satpathy, Malik, Arora, *et al.* 2016). Thus, it provides immense opportunity for decoupling critical resources from environmental impact and economic point of view, while laying emphasis on resource efficiency and use of secondary and alternate materials as seen in Figure 4.

Resource Decoupling promotes using less materials for the same economics output thus seeking to alleviate the problem of scarcity by reducing the rate of physical resource depletion, while simultaneously helping to reduce costs by raising resource productivity. Impact decoupling looks at raising economic output while reducing negative environmental impacts that arise from the extraction of required resources.

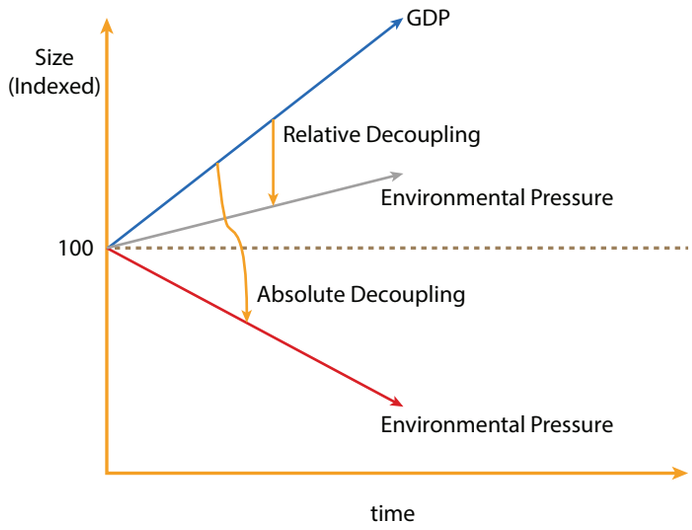

FIGURE 4: Decoupling for resource efficiency

Source: Hennicke, Khosla, Dewan, et al. (2014)

Waste – as a resource

By 2050, global waste production is expected to be approximately 27 billion tonnes per year, out of which one-third is expected from Asia, with major contributors being China and India. In India, the municipal solid waste generation per capita ranges from approximately 0.17 kg per person per day in small towns to approximately 0.62 kg per person per day in cities. More than 90% of the waste in the country is dumped in an unsatisfactory manner, instead of being scientifically disposed of in an engineered landfill (Kumar, Smith, Fowler, *et al.* 2017). The adverse effects of poor waste management have been well documented with increased incidents of health issues, such as anaemia, asthma, bacterial infections, and environmental challenges. Hence, engineered landfills are recommended for safe disposal of waste on land, while preventing ground and surface water pollution, fire hazards, odour, wind-blown litter, and largely reducing GHG emissions. Public participation is another major issue associated with waste management as there is generally lack of responsibility towards waste at the community level. Hence, there is a need to create awareness at all levels in the society to develop sustainable waste management systems that ensure maximum resource recovery, safe disposal of residual waste, and waste-to-energy facilities. The material/resource recovery from waste (such as producing biogas and manure) can significantly reduce the load on the landfill sites. Furthermore, given that the Indian construction industry is likely to face serious material supply issues, resource recovery from waste provides dual benefit. Industries also generate a lot of waste which can be transformed into resources. One such example is utilization of fly ash (which is a waste product of a coal-based thermal power plant), in cement industries as a pozzolanic material for manufacturing Portland Pozzolana cement. Fly ash is also used in road and pavement construction, light weight aggregate, mortar, paint industry, and so on. Thus, it partially or completely substitutes the requirement of a virgin material.

Sustainable Development and Green Buildings – As a Solution

In an effort to link the issues of economic development and environmental stability, the Brundtland report, also known as 'Our Common Future' published in 1987 by the World Commission on Environment and Development (WCED), introduced the concept of sustainable development. This report discussed many issues such as international economy, food security, species and ecosystems, energy, and many others. However, it is most often cited for its definition of sustainable development, which is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The concept of sustainable development aims at maintaining economic progression while protecting the environmental values through policy instruments and long-term development strategies. However, there have been arguments that there need not be a trade-off between environmental sustainability and economic development. Having said that, sustainable development is the practice of creating structures, systems, and processes that have low environmental impact and safeguards resource efficiency throughout the life cycle to minimize the briefly enlisted effects in Table 1.

TABLE 1: Effects on the environment

Aspects of Built Environment	Consumption	Environmental Effects	Ultimate Effects
Siting	Natural resources	Waste	Harm to humans
Design	Energy	Air pollution	Environment degradation
Construction	Water	Water pollution	Loss of resources
Operation	Materials	Indoor pollution	
Maintenance		Heat islands	
Renovation		Storm-water runoff	
Deconstruction		Noise pollution	

Source: Environmental Protection Agency (2016)

What are green buildings?

Buildings have major environmental impacts over their entire life cycle. However, the impact is mostly dominated by the use phase, that is, energy and water demand during their operation. Resource-intensive materials provide structure to a building, landscaping adds beauty to it, and water and pesticides are required to maintain it. Energy-consuming systems for lighting, air conditioning, and water heating provide comfort to its occupants. Hi-tech controls add intelligence to 'inanimate' buildings so that they can respond to varying conditions and intelligently monitor and control resource use, security, and usage of firefighting and other systems in the building. Water is a vital resource for the occupants; it is continuously consumed during construction and operation phases of a building. Several building processes and occupant functions generate large amounts of waste which can be recycled for use or can be reused directly. Thus, buildings and its occupants affect the urban air quality and contribute to climate change. Hence, the need to design a green building arises with an aim to address all these issues in an integrated and scientific manner. It may cost a little

more to design and construct a green building compared to conventional buildings. However, it is also a proven fact that it costs less to maintain a green building that has tremendous environmental benefits and provides a better place for the occupants to reside or work.

A green building utilizes minimum natural resources during its construction and operation. The aim of a green building design is to minimize the use of non-renewable resources and instead encourage on the usage of renewable resources, maximize on utilization efficiency, reuse, and recycling of these resources. A green building design emphasizes on the use of efficient building materials and construction practices; optimizes the use of on-site sources and sinks by bioclimatic architectural practices; focuses on minimal energy to power itself; uses efficient equipment to meet its lighting, air conditioning, and other needs; maximizes the use of renewable sources of energy; prioritizes efficient waste and water management practices; and provides comfortable and hygienic indoor working conditions. It is evolved through a design process that requires inputs from all concerned parties – architect, landscape designer, air conditioning, electrical, plumbing, and energy consultants to work as a team to address all the aspects of a building such as system planning, designing, construction, and operation. They critically evaluate the impact of each design decision and arrive at viable design solutions to minimize the negative effects and enhance the positive impact on the environment. In totality, the following aspects of a green building design are looked upon in an integrated way:

» Site planning

» Building envelope design

» Building system design and management (heating ventilation and air conditioning [HVAC], lighting, electrical, and water heating)

» Integration of renewable energy sources to generate energy on-site

» Water and waste management

FIGURE 5: Schematic diagram highlighting green building features

» Selection of ecologically sustainable materials (with high recycled content, rapidly renewable resources with low emission potential, and so on)

» Indoor environmental quality (maintain indoor thermal and visual comfort and air quality)

Benefits of green buildings

A green building has lower resource consumption as compared to conventional buildings, while enhancing the overall health and well-being of the users. There are a number of tangible and non-tangible benefits offered by green buildings; however, a few noteworthy are enlisted further with the rationale:

» Green buildings consume 40% to 60% (depending on the range of measures adopted) lesser electricity as compared to conventional buildings. This is primarily because they rely on passive architectural interventions in the building design, with highly efficient materials and technologies in the engineering design.

» For meeting the energy needs, they attempt to work towards on-site energy generation through renewable energy utilization. For instance, solar thermal systems can help generate hot water and replace the conventional electrical geyser in the buildings. Solar PV (photovoltaic) panels or Building-Integrated Photovoltaics (BIPV) can help generate electricity which can reduce the buildings dependence on grid power.

» Green buildings consume 40% to 80% (depending on the range of measures adopted) lesser water as compared to conventional buildings. By utilizing ultra-low-flow fixtures, dual plumbing systems, waste water recycling systems, and rainwater harvesting, these buildings not only reduce their demand for water but also consider on-site supply options to cater to their internal and external (landscape) water demands. Green buildings also ensure minimal use of potable water during construction stage through adoption of strategies, such as curing of reinforced cement concrete (RCC) columns with wet hessian cloth, ponding technique for curing RCC slabs, use of treated or harvested water for cleaning of equipment, toilets and other secondary applications.

» Green buildings generate lesser waste by employing waste management strategies on-site. They may also employ waste-to-energy or waste-to-resource (such as manure or compost) strategies on-site to minimize their burden on municipal waste management facilities and landfills.

» Green buildings generate lesser air, water, and soil pollution both during construction and operation. Through best practices, such as proper storage of construction materials, barricading of the site to prevent air and noise pollution during construction, proper storage and disposal of waste during construction and operation, and so on, these buildings ensure reduced impact on the surrounding environment.

» Green buildings ensure proper safety, health, and sanitation facilities for the construction workers (during construction) and the occupants (while in use).

» Green buildings restrict the use of high Ozone Depleting Potential (ODP) substances in their systems as well as in the interior finishes.

» The return on investment in green buildings is fast, by virtue of lower maintenance and energy costs as compared to the conventional buildings.

» Green buildings offer branding opportunity and an edge over others in the market.

Global perspective

Countries across the globe are waking up to the urgency of keeping the built environment carbon low/neutral in order to mitigate climate change. The existing built forms and new constructions are targeted either through voluntary systems or environmental regulations, which require them to be green and resource efficient. 'Advancing Net Zero' is a worldwide initiative launched by the World Green Building Council, to promote and speed up the growth of net-zero carbon buildings to 100% by 2050. While this is an ambitious target, but it is definitely motivating building owners to re-evaluate how their buildings are intended to operate *viz-a-viz* the existing scenario. Thus, the green building activities continue to grow with a dramatic hike. The driving forces across the globe in the sequence of its persuading factor, are enlisted further:

» Client demand

» Environmental regulations and bye-laws

» Healthier and safer buildings

» Market demand

» Lower operational cost

» Market transformation

» Higher property value

» Branding and image building

A building rating/certification system acts as an effective and popular tool to quantify and confirm the green credentials. Most of the rating systems are applicable across a range of building typologies and can be applied to both, new and existing buildings. A few rating or certification systems practiced have been enlisted in Table 2.

TABLE 2: Building rating or certification system

S. No.	Country	Rating System/ Programme	Focus Area	Performance Parameters
1	United States	Leadership in Energy and Environmental Design (LEED)	» New construction » Existing buildings, operations and maintenance » Commercial interiors » Core and shell » Schools » Retail » Healthcare » Homes » Neighbourhood development	» Sustainable sites » Water efficiency » Energy and atmosphere » Materials and resources » Indoor environmental quality » Locations and linkages » Awareness and education » Innovation in design » Regional priority through a set of prerequisites and credits
2	Australia	Green Star	» Office » Retail » Multi-unit residential	» Management » Indoor environmental quality » Energy » Transport » Water » Materials » Land use and ecology » Emissions » Innovation
3	United Kingdom	Building Research Environment Assessment Method Consultancy (BREEAM)	» New construction » In-use » Refurbishment and fit out » Communities	» Energy » Health and well-being » Transport » Water » Materials » Waste » Land use and ecology » Management » Pollution

contd...

TABLE 2: Building rating or certification system (contd...)

S. No.	Country	Rating System/ programme	Focus Area	Performance Parameters
4	Hong Kong	Building Environment Assessment Method-Hong Kong (HK-BEAM)	All building types, including mixed use complexes, both new and existing	» Site aspects » Material aspects » Water use » Energy use » Indoor environmental quality » Innovations and additions
5	Japan	Comprehensive Assessment System for Building Environment Efficiency (CASBEE)	» Pre-design » New construction » Existing building and » Renovation	» Energy efficiency » Resource efficiency » Local environment » Indoor environment
6	United Arab Emirates	Pearl Rating System (PRS) Estidama	» Community » Buildings » Villas » Temporary villas and buildings	» Integrated development process » Natural systems » Liveable communities » Precious water » Resourceful energy » Stewarding materials » Innovating practice

Source: Vierra 2019

Indian Perspective

India is expected to witness a surge in the green building sector with nearly 55% of all the projects likely pursuing green by 2021, according to the Dodge Data and Analytics World Green Building Trends 2018, Smart Market Report. The most significant driving factor that reinforces the importance of green buildings in the country is the environmental regulations, as seen in Figure 6, rather than the demand of the market. Whereas, the top most challenge encountered in enhancing the green footprint in India is the lack of public awareness. However, the green building rating systems have been looked upon for the following reasons:

» To create a better performing building

» To provide marketing and competitive advantages

» To provide a third-party verification and assessment

» To avail the incentives offered by urban local bodies (in some parts of the country)

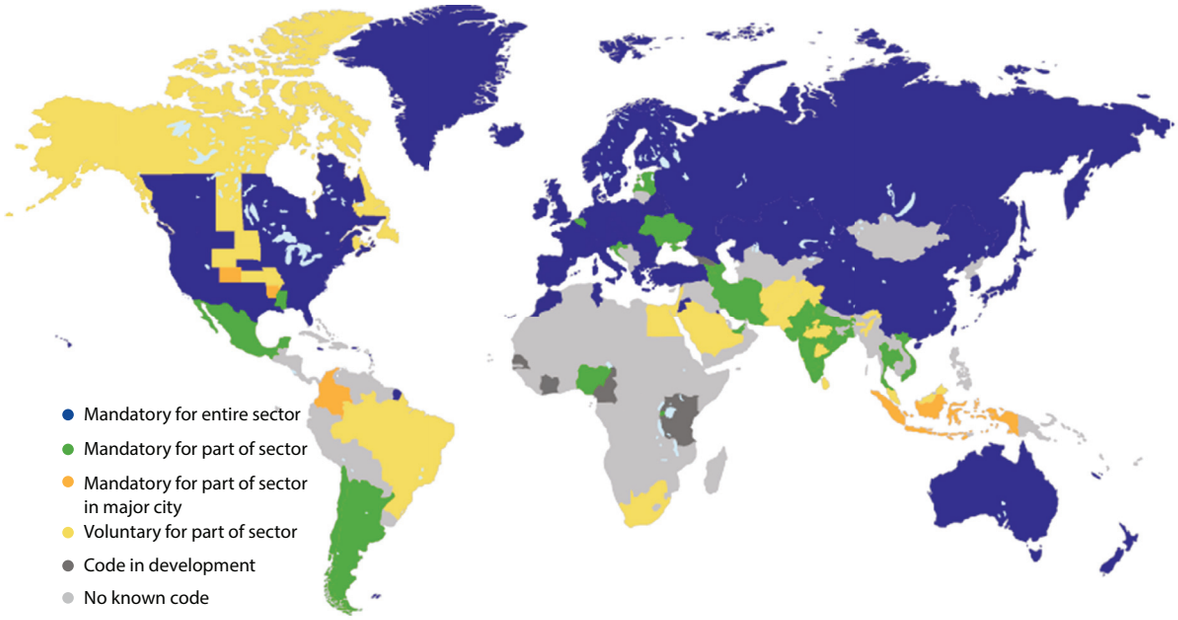

FIGURE 6: Building energy codes by jurisdiction, 2017-2018

Source: IEA (2021)

Sustainable Development Goals and GRIHA

Talking about reinforcement of the environmental regulations, India is one of the countries that has pledged to attain Sustainable Development Goals (SDGs)[1] by 2030. India is also the only country to publicly rank its sub-national governments on SDGs. This annual exercise is carried out by the National Institution for Transforming India (NITI) Aayog in the form of the SDG India Index – Baseline Report, first released in 2018. The report comprehensively documents the progress made by Indian states and union territories towards implementing the 2030 SDG targets and depicts the same on national indicators that reflect the outcomes of the interventions and schemes of the Government of India.

India's commitment to the SDGs is strongly reflected in its national development agenda that encompasses various government schemes such as Poshan Abhiyaan (National Nutrition Mission), Aayushman Bharat (National Health Protection Scheme), Swacch Bharat Abhiyaan (Clean India Mission), Beti Bachao Beti Padhao (Care for the Girl Child), Ujjwala Yojana (Clean energy) and the Pradhan Mantri Aawas Yojana (Affordable Housing). The country's commitment to 'leave no one

[1] Sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It calls for collective efforts towards building an inclusive, sustainable and resilient future for the people and the planet. To ensure the same, the Sustainable Development Goals (SDGs) were created by the United Nations and adopted by all member states in 2015. The SDGs are a set of 17 targets that integrate economic, social and environmental dimensions of development, in a holistic manner focusing on equity and inclusiveness of all. They are a universal call to action in the following critically important areas: poverty, hunger, education, health and well-being, education, gender equality, water and sanitation, energy, work and economy, infrastructure, industry and innovation, reducing inequalities, sustainable cities, consumption and production, climate action, ecosystems, peace and justice, and partnership, to be achieved by 2030.

behind' and its endorsement of regional and global partnerships is a strong step towards meeting the SDG targets.

GRIHA's aim is in line with the attainment of the SDGs especially those that pertain to the sphere of influence of sustainable building development. The detailed criteria outlined by GRIHA engage with the SDGs that fall under their purview, such as clean water and sanitation, affordable and clean energy, sustainable cities, responsible consumption and production, and climate action and through its manual, GRIHA addresses these SDGs at every step of research, formulation and appraisal.

To elaborate, the following table describes the predominant aims of each SDG and the incorporation of the same within the GRIHA criteria.

TABLE 3: Linkage of the SDGs with GRIHA criteria

SDG	Aim	About/Description	GRIHA and the SDGs
SDG 1	No Poverty	It is a multidimensional approach to poverty that aims for complete eradication of extreme poverty in all manifestations from everywhere which includes economic, social, gender-based and all other types of deprivation in income, education, nutrition, health, and access to water and sanitation, basic services and resources.	Access to required quality and quantity of water, provision of basic services, resources and sanitation for all is a chief parameter of sustainable development and in GRIHA criteria. Emphasis is also laid on providing these basic services and creche facilities for the children of the construction workers.
SDG 2	Zero Hunger	It focuses on ending hunger by achieving food security, improving nutrition, doubling agricultural productivity and ensuring sustainable food production systems.	With new technologies like hydroponics and vertical farming, growing produce in small urban spaces has been made possible. Live food gardens are embracing organic methods at household and community levels making produce healthy and pollution free. Improved food security through sustainable systems of urban farming is encouraged by GRIHA under its innovation section.

contd...

TABLE 3: Linkage of the SDGs with GRIHA criteria (contd...)

SDG	Aim	About/Description	GRIHA and the SDGs
SDG 3	Good Health and Wellbeing	It is a step to improve public health and wellbeing, with a renewed focus on mental health as well as ancillaries such as risk protection and access to quality health care services and medicines for all.	The social section caters to the provision of a healthy living environment by promoting tobacco smoke control and universal accessibility within projects. This ensures that occupants and visitors of any project can live in a healthier environment. The occupant comfort section aims to address health and well-being by ensuring visual, thermal and acoustic comfort conditions and enhanced indoor air quality.
SDG 4	Quality Education	It intends to provide inclusive, equitable and quality education for all to propagate economic growth by enhancing skills and an improved literacy rate.	The GRIHA criteria encourage the use of local workforce in building construction and thereby promote development of local artisan and labour skills.
SDG 5	Gender Equality	It aims to achieve this fundamental right by ending all forms of discrimination, violence and harmful practices against women while promoting empowerment through equal opportunities for women.	Designing gender neutral toilets is a step made by GRIHA towards gender equality, while provision of dedicated facilities for the labour force such as rest rooms and child care is included in the social section to empower the female workforce by creating easier work opportunities.
SDG 6	Clean Water and Sanitation	It ensures access to safe water sources and hygienic living conditions by reducing pollution, increasing water use efficiency and providing for community participation in water and sanitation management.	The social section aims to provide construction workers with clean drinking water along with hygienic working and living conditions inside the project. The water management section, specifically the criterion- "Water Demand Reduction and Water Quality" aims to reduce potable water demand by using highly efficient water plumbing fixtures and provide clean and hygienic quality water to the building occupants by installing appropriate treatment systems.

contd...

TABLE 3: Linkage of the SDGs with GRIHA criteria (contd...)

SDG	Aim	About/Description	GRIHA and the SDGs
SDG 7	Affordable and Clean Energy	It enables supply of reliable, sustainable and affordable energy to all, by investing in renewable energy research, infrastructure and technology.	The energy optimization section, specifically the criterion on "Renewable Energy Utilization", promotes the use of renewable energy in the projects and, thereby, intends to reduce the project's dependency on fuels derived from conventional sources.
SDG 8	Decent Work and Economic Growth	It aims for sustained and inclusive economic progress by enabling global job creation; secure working environment, protection of labour rights and promotion of technology, innovation and entrepreneurship.	The nationally widespread footprint of GRIHA has facilitated the creation of jobs in the sector of green development and its ancillaries, in turn boosting innovation in technologies, entrepreneurship and the economy.
SDG 9	Industry, Innovation and Infrastructure	To secure sustained growth, it intends for investments in resilient infrastructure, sustainable industrial development and technological progress, increased resource efficiency and incentivizes innovation.	The innovation section, conceived in line with SDG 9, emphasizes that innovation breeds development and encourages projects to adopt new or improved strategies that utilize scientific and technological advancements amongst others, for better resilience and improved sustainability.
SDG 10	Reduced Inequalities	It is a stand against inequalities of all natures that aims to provide equal opportunities and promote social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, religion or other status relevant within a society.	The social section addresses the various inequalities present within a society and ensures that they are tackled by incorporating measures such as making projects universally accessible, provision of gender neutral toilets, etc. This ensures that equal opportunities are provided irrespective of age,sex, disability, race, ethnicity, religion or any other status relevant within the society.

contd...

TABLE 3: Linkage of the SDGs with GRIHA criteria (contd...)

SDG	Aim	About/Description	GRIHA and the SDGs
SDG 11	Sustainable Cities and Communities	It aims for inclusive, sustainable and distributed urbanization by providing affordable housing, green areas, basic services and infrastructure to all, through improved urban planning and management.	The sustainable site planning section is aimed at improving urban infrastructure; enhancing urban greenery; providing access to basic amenities, as well as mitigating the UHI phenomenon in dense urban centers. This section ensures compliance to local bye- laws and clearances and incentivizes tree plantation on site. It further awards access to basic amenities in close proximity of a project to reduce dependence on motorized transport and providing equitable access for all. This section also rewards strategies to mitigate UHIE which can potentially aggravate the effects of climate change especially in tropical countries like India.
SDG 12	Responsible Consumption and Production	It is a step towards reducing degradation, pollution, and minimizing waste by prioritizing efficient use of food and other resources and sustainable consumption and production patterns.	The section on sustainable building materials addresses the impact of urban growth and increasing material demand. It establishes the need to curb wasteful usage and switch to alternatives such as recycled/ naturally occurring or rapidly renewable materials that have a smaller impact on the environment, promote responsible consumption patterns, and together with a life cycle assessment can pave the way for a circular economy. The section on solid waste management addresses the need for waste minimization along with proper segregation, collection and management. The section reiterates the hierarchy of waste managementand promotes the 6R's (Reduce, Reuse and Recycle, Refurbish, Redesign and Remanufacture). The criteria ensure that the concept of reduction and reuse of resources is adopted in projects so that the generation of waste is minimized and resources are managed responsibly.

contd...

TABLE 3: Linkage of the SDGs with GRIHA criteria (contd...)

SDG	Aim	About/Description	GRIHA and the SDGs
SDG 13	Climate Action	It is centered on planning and promoting mechanisms and policies, and mobilizing resources and investments for raising capacity for effective climate change management.	Energy efficiency is a strong greenhouse gas emission reduction tool. With the world facing an increasing rate of climate change risks, energy efficiency can potentially help mitigate those impacts. Not only this, but use of conventional fuels to generate energy leads to large GHG emissions. Hence, moving towards cleaner sources of energy would help mitigate the negative effects of climate change. The energy optimization section ensures that the project incorporates energy efficiency measures and makes use of renewable energy. It also encourages projects to move towards materials with low ODP and GWP values.
SDG 14	Life below Water	It commits countries to conserve and sustainably use oceans, seas and marine resources, prevent marine pollution, protect water-based ecosystems and research to restore marine health.	The water management section, specifically the criterion on rainwater management promotes to recharge or harvest rainwater filtered through appropriate filtration media to save groundwater. It also regulates discharge of wastewater thereby preventing water pollution, water depletion and protecting life below water.
SDG 15	Life on Land	To preserve land-based ecosystems and their biodiversity, its goal is to sustainably manage forests, combat desertification, halt and reverse land degradation, and protect flora and fauna.	The sustainable site planning criteria addresses the challenges of rapid urbanization and rampant construction by mandating conformity to various building regulations and bye-laws in an attempt to curb haphazard development and land use patterns. Adherence to GRIHA norms also ensures that urban biodiversity and microclimates are maintained. Replantation, compensatory plantation and new plantation within the thresholds will ensure survivability, enhance urban biodiversity, reduce surface runoff, help preserve top-soil as well as regulate temperature for both environmental preservation and human comfort.

contd...

TABLE 3: Linkage of the SDGs with GRIHA criteria (contd...)

SDG	Aim	About/Description	GRIHA and the SDGs
SDG 16	Peace, Justice and Strong Institutions	To encourage collaborative efforts and implement lasting solutions to reduced violence, deliver justice, combat corruption, increase accountability, increase transparency and ensure inclusive participation always.	GRIHA provides a transparent and accountable system of assessment and rating which includes multiple participants and stakeholders and lays the foundation for a strong institution in green development.
SDG 17	Partnerships for the Goal	To reinforce the need, for global ownership of the goals and for all universal cooperation to fulfill the same.	GRIHA recognizes that building construction is participational process and advocates for multilateral collaboration to attain our shared vision of sustainable development.

GRIHA – The National Green Building Rating System

With the rise in green building trends, it was vital to understand the right approach towards constructing such structures that would minimize the detrimental impacts of construction on the planet, while creating a healthy and comfortable living/working environment with zero or minimal incremental cost.

India is a land with varied climate typologies, categorized under five predominant zones as per the Energy Conservation Building Code (ECBC) 2017: hot–dry, warm–humid, composite, temperate, and cold. Therefore, the indoor thermal comfort conditions required in different parts of the country vary, and so does the energy demand of buildings in different regions. An indigenous rating system tailored to meet the requirements of each climate zone was needed which could provide definitive sustainable solutions to the rising energy stress and diminishing natural resources. With the vision to promote sustainable architecture, The Energy and Resources Institute (TERI) developed the TERI-GRIHA (Green Rating for Integrated Habitat Assessment) green building rating system in 2005 that could benefit the community at large by reducing the GHG emissions from the building sector. After a thorough study of the internationally accepted green building rating systems and prevailing building practices in India, the rating system was developed as a tool to strike a balance between the established field practices and emerging technological concepts. The resultant built form aims at creating an environmentally responsible structure that also provides healthy indoor environment for the occupants.

In 2007, the Ministry of New and Renewable Energy (MNRE) endorsed GRIHA as the National Rating System of India. This move focused on encouraging the construction of 'green habitats and energy-efficient solar buildings' in the country that suit the tropical climatic conditions.

In 2015, a document – 'India's Intended Nationally Determined Contribution: Working Towards Climate Justice' was submitted to the United Nations Framework Convention on Climate Change (UNFCCC), wherein the government highlighted GRIHA as India's 'own building energy-rating system' to stimulate large-scale replication of energy-efficient buildings.

GRIHA is designed to evaluate the environmental performance of all habitable spaces which may be air conditioned, non-air conditioned, and hybrid, for their energy and water consumption along with resource utilization and waste management over their entire life cycle. The rating applies to new building stocks. It has been formulated in terms of 'appraisals' which while acting as guidelines for the construction of 'green' buildings, also have certain points allocated to them. The project team should comply with these appraisals to achieve the desired rating and to thereby construct sustainable buildings.

The rating system considers the regional climatic conditions and provides indigenous solutions while accounting the site constraints. Moreover, GRIHA rating emphasizes on laying the foundation of construction processes with passive design strategies that contribute towards developing cost-effective and resource-efficient projects. GRIHA integrates various relevant Indian codes for construction, energy, water, materials, and waste management and thus, acts as a tool to facilitate implementation of the same.

Aim

The rating system has been developed with the aim to achieve the following goals:

» Minimize the detrimental impact of construction and built structures on the environment while ensuring comfort for users.

» Preserve the ecosystem to the extent possible.

» Assess the performance of 'green' buildings.

» Objectives

» To study the impact of the life cycle of a built structure(s) on the environment

» To increase the demand for green buildings and products among the various stakeholders

» To create recognition for buildings that considered sustainable design and construction strategies

GRIHA Council

GRIHA Council (registered under the Societies Registration Act, 1860) is an independent society for the interaction on scientific and administrative issues related to sustainable habitats in the Indian subcontinent. It was founded by TERI with support from MNRE along with experts in sustainability of built environment from across the country.

In 2009, GRIHA Council was established with the aim to promote the construction of environmentally responsible and resource-efficient buildings through GRIHA. The Council works towards streamlining the rating process to facilitate the adoption of sustainable practices in the field of built environment.

Activities

The GRIHA Council is responsible to undertake the following activities:

» **Award of rating certification:** All activities related to the issuance of GRIHA rating and all its variants are carried out by GRIHA Council.

» **Technical development:** A dedicated team at the Council constantly updates and revises the GRIHA rating system to go hand in hand with the present market conditions and to create new benchmarks for pushing the market further.

» Other variants of GRIHA that focus on small- and large-scale developments, existing building stock, and affordable building segment have also been developed to add/increase the sustainability quotient of projects of varying scales and segments.

» **Training and capacity building:** The Council conducts capacity building programmes with a commitment to educate different segments of the society regarding green building practices and the rising threat to the planet owing to unsustainable construction practices. The programmes are conducted at multilevels as follows:

- Project team: Awareness workshops are conducted on green buildings and GRIHA rating system for all the registered project teams. The online certification tool at www.grihaindia.org further helps the project teams to educate themselves on their specific roles in developing project-specific documentation.
- Field professionals: For the design and development of the green infrastructure a large pool of qualified professionals is required in all parts of the country. To enable the active dissemination of knowledge and skills necessary for designing new green buildings, GRIHA Council organizes a series of workshops across the country. These workshops are aimed at practicing professionals such as architects, engineers, developers, policymakers, and sustainability analysts who have been working in the field of green building and sustainability and are interested in GRIHA certification. Exams are conducted to certify professionals who have attended the workshops and proved to be well-equipped to further take up similar programmes in their regions. Professionals with considerable experience in green buildings are encouraged to become GRIHA evaluators and certified professionals.
- Sustainability enthusiasts: Training programmes are organized for teachers and students working/studying on the subjects related to building science and construction. Further, sustainability awards were introduced by the Council to motivate students to design sustainable structures.
- Residents Welfare Association (RWA): One day programmes are conducted for residents of housing societies to raise awareness regarding conservation and optimal utilization of natural resources and also waste management practices.

» **Advisory:** The role of policymakers is imperative in transforming the society towards sustainability. GRIHA Council works with policymakers (from different fraternities) to form frameworks for the adoption of sustainable practices for resource and construction

management at different levels of the society. The aim is to lay foundation for clean energy economy and healthy communities.

» **Advocacy:**

- National Conference: The annual event organized by GRIHA Council in association with key stakeholders in the construction industry is a platform to discuss and deliberate on furtherance of green habitat development in India. The event brings together national as well as international experts from different industries in the field of construction and sustainability to develop and drive new initiatives, provide insights, and showcase sustainable products and green business opportunities. It is, further, aimed to facilitate sharing of international best practices from all over the world to elicit practical applications that are most relevant in the Indian context.
- Media Outreach: Professionals from GRIHA Council and TERI are frequently requested by the print and electronic media for expert articles and updates on the green building front. These engagements ensure that GRIHA Council is in continuous touch with the end users either directly through its own efforts or through the media.

» **Facilitating market transformation:**

The Council has created an online catalogue of products and materials which have lower environmental impact as compared to the conventional materials available in the market.

The catalogue, known as GRIHA Product Catalogue, was launched by GRIHA Council in association with TERI, and was developed to provide green building designers and clients with all the necessary information on green building products which can be used in order to make buildings GRIHA compliant. In recent times, the market of green building products has grown manifold. On the one hand, this has helped in increasing the availability of green building products, but on the other hand, the ever-increasing range of products has made the building professionals unsure about whether a certain product meets the GRIHA parameters or not. In such situations, the catalogue provides information to the architects, engineers, builders and other building professionals about products which meet GRIHA parameters for use in their GRIHA-registered buildings.

» **Stewardship and monitoring:**

The Council conducts one day orientation workshops for the entire team of the projects registered with GRIHA. During the workshop, a detailed presentation on GRIHA rating by the Council officials is done, followed by a rigorous exercise of target setting through a checklist. The workshop serves the dual purpose of awareness of the GRIHA system for all involved and identification and evaluation of the optional criteria and applicability check to enhance the rating of the project. The outcome of the workshop is a roadmap for the GRIHA rating process along with identification of responsibilities within the project team for various GRIHA criteria. The targeted level of rating is identified for all in the team to design the project and implement accordingly.

In addition, interim site visits become a crucial part of the rating process that are included to guide the project team and monitor the project site.

GRIHA V.2019

The GRIHA rating is in its fifteenth year since its inception. Its consistent uphill movement in the performance graph is reflective from the wide market acceptance of the concepts of sustainability and green building practices. As of December 2020, over 2000 projects are registered with GRIHA Council having a footprint of 5,25,02,869 m^2, leading to have an estimated cumulative annual energy saving of 9,29,30,484 MWh and installation of 3043 MWp of renewable energy system. The water savings are estimated to be 33,20,80,780 kL per annum. Additionally, the trees planted are around 7,37,848 and proposed to be planted are over 64, 000. The effectiveness of these implemented and proposed to be implemented strategies shall lead to 3,10,49,743 tons of CO_2 reduction per annum.

The growing awareness among the consumers in the past 15 years regarding high performing green buildings led to burgeoning demand for better systems and newer sustainable materials. Keeping pace with the rising demand, the green building industry has evolved significantly. Based on the same, the fifth version of GRIHA rating has been developed, that is, GRIHA v.2019, so as to:

» Better reflect the current market scenario

» Ensure easy adaptability by various stakeholders

» Ensure healthy indoor environment that does not get affected by the outdoor pollution, for the occupants

The new version, akin to the previous ones, was developed with the larger environmental goals of preserving the natural ecosystem by ensuring optimized utilization of resources and food security. Further, it aims to build more sustainable physical assets and infrastructure services, while enhancing the liveability and workability of the occupants.

Salient features

The following are the salient features of the new version of GRIHA rating:

» **Indigenous rating system:** The system acknowledges the diverse climatic conditions of the country which become the underlying factor for the formulation of GRIHA rating. The rating system aims at providing inherent solutions for thermal comfort within each region.

» **Adoption of holistic approach towards sustainability:** The rating system was developed with the intent to promote sustainability by not just underlining the environmental aspects but also focusing on the social and economic aspects as well.

FIGURE 7: Three pillars of sustainability

A holistic approach towards sustainability is of paramount importance in relation to construction activities. Therefore, the rating sets guidelines for creation of structures that are resource efficient, and at the same time, incorporate strategies for well-being of the individuals associated with the project before, during, and post construction.

Adoption of passive design strategies during the design stage, cost-effective strategies during the construction stage, procurement of refurbished/reused/regional products, and installation of efficient systems eventually make the project economically sustainable.

» **Process driven and performance oriented:** Every stage of construction, starting from design conception to execution, is vital to achieve sustainability. GRIHA takes into account all the stages, including design, procurement, and implementation to avoid disruption to the ecological system and construct high-performing sustainable structures.

» **Integrated team approach:** With the aim to interact with the project team and guide them through the rating process, an orientation workshop is conducted by GRIHA Council where representatives from different divisions handling the project are present to understand their role in making the project GRIHA compliant. (refer to Rating Process).

Eligibility

» **Built-up area:** All new construction projects with built-up area more than 2500 m^2 are eligible for certification under GRIHA v.2019. The following areas are excluded from the built-up area which shall not be considered for registration fees calculation:

- Parking area (Stilt/Basement)
- Non-habitable basement spaces
- Typical buildings: These are with same orientation, height, floor plan, plinth level and are constructed within a defined site boundary.
- Service rooms: These are spaces that are dedicated to building services, such as electrical room, server room, meter room, etc., with no occupancy.

» **Building typology:** All habitable buildings are eligible for GRIHA rating. The various types of buildings, based on their usability, are categorized in Table 4.

TABLE 4: Classification of buildings according to their typologies

Healthcare Facility	Hospitality	Institutional	Office	Residential	Retail	Transit Terminal
Hospitals	Hotels	Universities	Core & shell buildings	Multi-dwelling unit	Shopping complexes	Airports
Clinics	Guest houses	Schools	IT buildings/ data centres	Hostels	Banquets/ wedding halls	Heliports

contd...

TABLE 4: Classification of buildings according to their typologies (contd...)

Healthcare Facility	Hospitality	Institutional	Office	Residential	Retail	Transit Terminal
Medical colleges	Service apartments	Colleges	Owner-occupied buildings	Bungalows	Restaurants	Bus stands
Dispensaries	Community/ Visitors centre	Libraries	Co-working spaces	Villas	Food courts	Railway stations
		Institutes	Industries	Mansions	Cafeterias	Metro stations
		Sports complexes	Court	Military barracks	Multiplexes	
		Research and development buildings			Gallery/ Museum	
		Place of worship			Sports and leisure facilities	
					Auditorium/ Theatre	

» **Mixed-use development buildings:** Projects that have multiple buildings with different uses or a single building with different uses are placed under this category. In certain criteria in GRIHA rating, the assessment of spaces is based on the typology; therefore, in such cases, the evaluation is done considering applicable standards/benchmarks for individual building/space. Unique cases are discussed with GRIHA Council for the evaluation of the criteria.

» **Building operation schedule:** With the wide range of typologies being considered in the rating system, the operation schedule of a registered project is categorized into two categories,* that is, daily and weekly, as presented in Table 5.

TABLE 5: Building operation schedule

S. No.	Frequency of Operation	Operational Duration
1.	Daily	8 hours
		24 hours
2.	Weekly	5 days
		7 days

* The project which does not falling under the following operating schedule category can use their actual/ owner defined operating schedule for assessment. The base consumption calculation shall be modified for the defined operating schedule of project.

» **Climate:** GRIHA rating was designed keeping in consideration the various climate zones in India. The various climate zones as per ECBC that have been considered in GRIHA v. 2019 are: temperate, hot-dry, warm-humid, composite and cold climate.

Rating Framework

The latest version of GRIHA is structured along the lines of the previous version with an additional section on 'life cycle costing'. There is an additon of a few new criteria along with modifications in some others.

Sections and point weightages

GRIHA v. 2019 is divided into ten environmental sections, which are further split into 29 criteria, covering all the requisite parameters required to be addressed while making a 'green building'. An additional section on 'innovation' is a part of the rating system that rewards the project team for walking an extra mile to achieve environmental and social sustainability. Each criterion under these sections are explained in detail in the subsequent volumes.

TABLE 6: Rating structure for GRIHA v.2019

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

contd...

TABLE 6: Rating structure for GRIHA v.2019 (contd...)

Manual Volume	Section	Criterion No.	Criterion Name	Maximum Points	Appraisal Type
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
			Grand Total	**100 + 5**	
VII.	GRIHA Online tool and documentation guidance				

FIGURE 8: Section-wise weightage

Criterion structure

GRIHA v.2019 is a set of 29 + 1 (innovation) criteria which have been categorized into 11 sections that act as the areas of consideration while designing and constructing a green building.

Each criterion consists of the following:

» **Intent:** This defines the specific purpose behind having a particular criterion in the rating system which would help in achieving the larger goal of sustainability and reducing GHG emissions.

» **Appraisals:** These are the guidelines specified under each criterion that will help the project proponent create a sustainable built environment and achieve GRIHA rating by demonstrating compliance with them.

These appraisals classify into the following three categories:

- Mandatory: Compliance with mandatory appraisals is a must, in the absence of which the project is rendered ineligible for rating. There are no points for mandatory appraisals.
- Optional: Compliance with optional appraisals is on the discretion of the project proponent depending upon the site conditions, feasibility, and desired rating. Points have been allotted for demonstrating compliance with every optional appraisal and the same has been mentioned under the details of each criterion on provided in the manual later.

- Non-applicable: In case of specific site constraints, certain appraisals become non-applicable to the project. Points allotted under these appraisals are subtracted from the denominator during the final percentile calculation. However, the project team must submit necessary documents (as mentioned in the respective detailed criteria later in the manual) to claim non-applicability.

» **Compliance:** These are the list of documents to be provided by the project team to demonstrate compliance with the appraisals in order to achieve points.

» **Details to Appraisals:** The steps involved in fulfilling the appraisal requirement are described in the 'Details to Appraisals'. This shall include the details of concepts, calculations and strategies required to be understood to comply with the appraisals.

» **Sample documentation:** This part of the criterion shall exhibit the examples of the documents listed in the 'compliance' section.

Scores and rating

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. Based on the percentile obtained, star rating is awarded as listed in Table 7.

TABLE 7: Percentile thresholds for achieving stars

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

Rating Process

All buildings in the design stage are eligible 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. Please refer to the 'eligibility' section for the building typologies.

Step I: Registration

» A project has to be registered for GRIHA rating by filling an online registration form available on GRIHA website (www.grihaindia.org). The right time to register for GRIHA rating is during the inception of the project. This would ensure seamless integration of sustainable design and construction strategies and procurement of low energy materials and efficient systems.

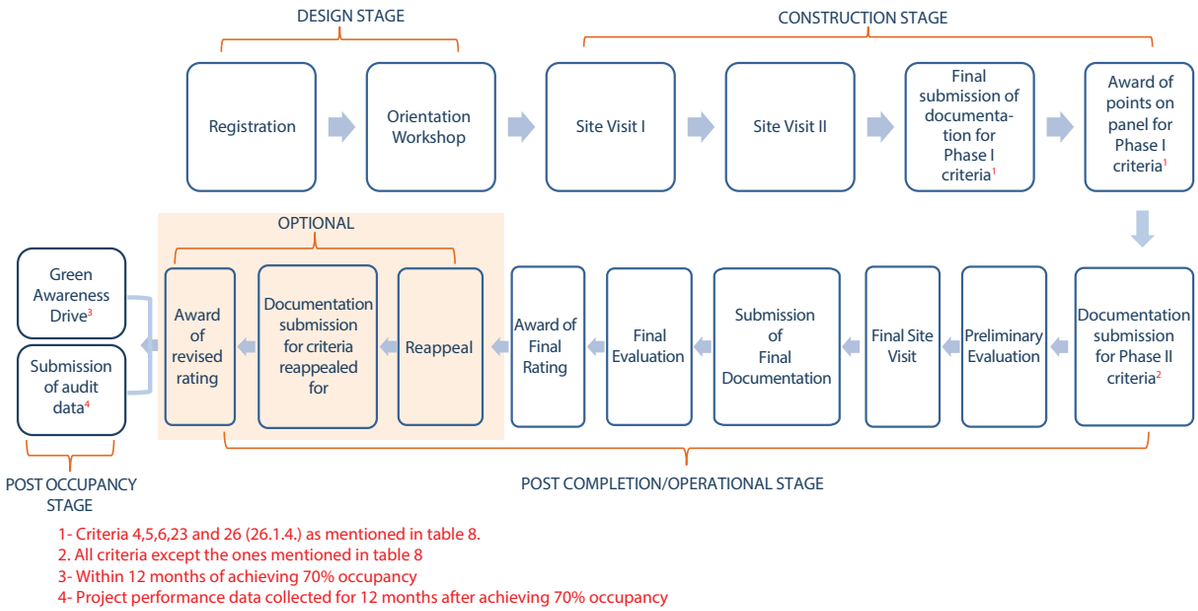

FIGURE 9: The rating process

» **Fee calculation:** The fees for GRIHA rating is calculated as per the built-up area. Please refer GRIHA website www.grihaindia.org to calculate the same.

» **Confirmation of registration and access to online panel:** Once the online form is duly submitted and registration fee is paid, the project is registered for GRIHA rating. A unique project code is generated upon registration along with the project specific username and password. These will be shared with the project team on the email ids added in the online registration form. The username and password will help the project team access the online panel where all the compliance documents will be submitted by them. In addition to this, the panel is equipped with inbuilt calculators for specific criteria which have been provided for the ease of the project team and compliance requirements. Project specific data must be added to these calculators by the project team to check criteria specific performance and fulfil submission requirements.

The online panel will be accessible to the project team for the entire course of rating. Project team can upload documents as and when convenient but submission to GRIHA Council must be done at the right stages (as explained in the steps ahead).

NOTE:

1. Virtual boundary: Projects with built-up area more than 2500 m^2 which are part of large campuses/townships but are to be registered individually should define a virtual boundary for the proposed project aspiring GRIHA rating.

   The virtual site boundary created for the proposed project should include the existing supporting services of the campus which will also serve the proposed project. If the existing access road is providing access to the proposed block, then part of it should be included in the virtual site boundary. The case presented in figure 10 shows two projects within the same campus, at distance from each other. In such a scenario, virtual boundaries should be created for each project as demonstrated in the site plan shown.

FIGURE 10: Virtual boundary created in campus projects

2. Once registered, a GRIHA logo policy will be shared with the project team for the logo which should be displayed at the site of construction. The project team must adhere to the shared policy.
3. The project team must submit all the required documents to GRIHA Council and attain rating within 7 years from the date of registration, failing which the project team will have to pay additional fees to GRIHA Council.

The registered project would be entitled to an orientation workshop and three due diligence site visits for hand-holding.

Step II: Orientation workshop

The orientation workshop conducted by GRIHA officials/field experts assigned by GRIHA Council is a rigorous training session of one day for the whole project team comprising the owners, architects, green consultants, contractors, and team members from civil, plumbing, electrical, and mechanical departments. The workshop is advised to be conducted before commencement of the construction activities on-site and after all the teams are taken on board.

The workshop is an important step towards making a green building because it gives the project team a platform to understand the rating system while getting familiarized with the on-site challenges and possible solutions available for their scope of work. It allows the project team to discuss project-specific queries with the GRIHA officials directly. It is an integrated design approach which aims at providing the following:

» Overview of green buildings

» Brief introduction to GRIHA, its variants, the sections covered, weightage points, and the evaluation process

» Explanation of the rating system: criteria, appraisals, and points related to rating

» Documentation requirement

» Case studies of GRIHA-rated buildings

» Target setting for the desired rating

Step III: Site visit I and II

The workshop is followed by three mandatory site visits which are conducted by GRIHA Council at different stages of construction to assess the development of the project and to facilitate the project team to achieve the desired rating. Any shortcomings observed during these visits will be communicated to the project team with solutions possible to overcome the same.

» **Site Visit I:** The visit shall be conducted to validate sustainable measures adopted during the construction phase. The visit will be scheduled after the project has reached the plinth level and the structural work is in progress.

» **Site Visit II:** The second site visit shall be conducted to validate internal finishes and electrical, plumbing, and mechanical components installed in the project. The visit will be scheduled after the completion of the structural work while the internal finishing work is in progress.

Observations of the visits shall be recorded in the form of site visit reports after every due diligence conducted. The same reports shall be uploaded on the online panel and sent to the client and other team members within 20 working days from the date of the respective site visits. These reports shall capture not just the observations, but also the actions that are required to be taken by the project team to make the project compliant with GRIHA requirements at the given stage and later during the evaluation stage. To demonstrate compliance, the project team must submit a compliance report within the next 15 working days from the receipt of the site visit reports, showing the implementation of measures advised in the reports.

Compliance check during site visit I and II

The site visits proposed by GRIHA are intended to inspect all relevant criteria mentioned in table 6. However, compliance with the criteria mentioned in table 8, also referred to as Phase I criteria, will be evaluated based on the site visits, compliance reports and documents submitted after the visits, and there will be no further submission required for these criteria during the final evaluation stage.

TABLE 8: Phase I Criteria to be verified during Site visit I and II

Section	Criterion No.	Criterion Name
2. Construction Management	4	Air and Soil Pollution Control (refer to Volume 2)
	5	Topsoil Preservation (refer to Volume 2)
	6	Construction Management Practices (refer to Volume 2)
9. Socio-Economic Strategies	23	Safety and Sanitation for Construction Workers (refer to Volume 6)
	26	Positive Social Impact (refer to Volume 6, appraisal 26.1.4.)

The following cases may arise during the site visits in evaluation of Phase I criteria:

» **Case I: Project complies with all mandatory criteria**

- Site visit I: GRIHA Council uploads project specific site visit report on the online panel. First 'compliant' is recorded upon uploading the report by the council.
- Site visit II: GRIHA Council uploads the site visit report and second 'compliant' is recorded.

Once the two ' compliant' are recorded and project team submits all relevant documents, submission of all other criteria is allowed for the project team and these criteria will close for submission.

» **Case II: Project does not comply with mandatory criteria in site visit I**

Project team must submit a compliance report on the online panel in response to the site visit I report received from GRIHA Council. Site visit II will not be conducted until the first compliance report is submitted.

» **Case III: Project does not comply with mandatory criteria in site visit II**

Project team must submit the compliance documents within 30 days of receipt of site visit II report from GRIHA. If not submitted, the project would be ineligible for rating.

» **Case IV: Project does not comply with optional criteria in 1st or 2nd or both the site visits**

Compliance report should be submitted and approved by GRIHA Council. The window for submission of compliance documents remains open till 30th day of receipt of site visit II report from GRIHA. In case of non-compliance, points will be denied for the optional appraisals. These criteria will be closed for submission hereafter.

The following are the points of consideration for the project team with respect to Phase I criteria mentioned in table 8 and the process of compliance demonstration:

» Online access to these criteria would be closed for project teams after 30 days of receipt of site visit II report. Complete documentation for all these criteria/appraisals shall be uploaded on the panel within this period.

» Documentation submission for these criteria/appraisals (optional and mandatory appraisals both) will not be permitted during the final evaluation stage. Please note, the online panel for all the other criteria (except the ones mentioned in table 8) will remain open throughout the rating process for uploading of documents. However, the 'submit' button will be accessible only after the submission of documents for criteria mentioned in table 8 after site visit II.

» No 'reappeal' is applicable for the criteria mentioned in Table 8.

Step IV: Submission of documentation

As the project nears completion, the project proponent should upload the documents for all the criteria on the online panel. A list of the documents is provided under each criterion on the panel. Further, online calculators provided on the panel (for select criteria) need to be duly filled and submitted. Once online submission of the documents for all the criteria is done, the evaluation process for rating would commence.

Step V: Preliminary evaluation

After the online submission, preliminary evaluation is carried out by a team of professionals from GRIHA Council which also includes external evaluators, who are experts in their respective fields recognized by GRIHA Council. The documentation must be complete in every aspect for all the attempted criteria along with the commissioning report. A preliminary evaluation report shall be uploaded on the online panel by the council within 40 working days after documents submission. The review report will help the project team in understanding the status of the submitted documentation and the issues in achieving final rating. Project team is made aware of all the missing or incomplete documentation so that the same can be submitted to achieve the desired rating.

Step VI: Final site visit

The final site visit shall be conducted to verify the submitted documentation with respect to on-site implementation. The visit is done once the project is complete and all equipment and systems are installed and commissioned.

Step VII: Submission of Final Documentation:

Project team must submit all missing documentation as communicated by GRIHA Council during the site visits and through preliminary evaluation feedback. Final rating would be awarded to the project on the basis of the submitted documents.

Step VIII: Final evaluation and award of rating

The GRIHA Council officials along with external evaluators shall then evaluate the final round of submitted documentation (including the documents submitted as a response to the preliminary evaluation and final site visit). On the basis of this evaluation, GRIHA Council shall prepare a final score card within 25 working days after the project team furnishes all requisite information sought by the evaluators. In the end, the rating is awarded based on the final evaluation and is valid up to 5 years.

Step IX: Reappeal

Any request for re-evaluation or fresh attempt of any criterion (other than the ones mentioned in table 8) from the project team shall be addressed by the GRIHA Council on chargeable basis per criterion. The rating will be revised based on the fulfillment of compliance requirements and verification by GRIHA Council.

Step X: Green awareness drive

The GRIHA Council will conduct an additional due diligence visit after the award of final rating for green awareness among the project occupants. This visit aims to impart basic knowledge and understanding on green buildings and their operational mechanism. This awareness programme will be organized within 12 months of occupancy of the project.

Step XI: Submission of audit data

Project team must submit an audit report showing the performance of the project with respect to energy, water, waste management etc. The data must be collected for one year after achieving 70% occupancy. Energy audit must be done by BEE (Bureau of Energy Efficiency) certified auditors.

Rating renewal

There are two ways in which the rating can be renewed after the validity period ends after 5 years:

1. Submit an audit data report (for a span of three consecutive years) showing the performance of the project with respect to energy, water, waste management etc. The energy audit must be conducted a BEE certified auditor.

   OR

2. Enroll the project for GRIHA Existing Building rating to maintain its certification for the next cycle of 5 years.

Renewal process will be initiated once the applicable fees is paid.

Feasibility site visit

A feasibility site visit shall be conducted in cases where the project proponents could not register their projects with GRIHA at the right stage under certain circumstances, but are motivated to reduce

the environmental impact of construction and have been working towards the same right from the beginning of the projects. The site visit shall be conducted by GRIHA Council upon receiving request for registration from the project proponent along with feasibility fee payment and verification of documents assimilated by them demonstrating the following:

» Inclusion of sustainable design and construction strategies

» Procurement of low energy materials and systems

» Compliance with the mandatory GRIHA requirements

The visit shall be conducted to verify the same being implemented on-site. A feasibility report shall be prepared thereafter, which will confirm if the project is eligible for the rating or not and the requisite measures to be taken in case the project is eligible. On submission of a valid compliance report, the project shall be registered with GRIHA following the process mentioned above.

NOTE: Logistics related to travel and accommodation of GRIHA Council officials for orientation workshops and site visits are not included in the registration cost and the same shall be borne by the project team.

Roles and Responsibilities

The successful completion of construction of a green building project and the rating process involves diligent delivery of duties by different teams involved in the rating process. The categories of the teams involved in the process are broadly classified into the following:

Project proponent

The project proponents are the team members handling the project or the decision makers for the project-related tasks. This may include project owner, design and execution team, and green consultants.

Referring to the rating process, a project proponent has the following responsibilities before and during the course of GRIHA rating:

» **Registration:** A project proponent must register the project with GRIHA Council as specified in the 'Rating Process'. Registration is the first step towards creating the link with the Council for further facilitation of the rating process. Once the project is registered, its team gets access to the GRIHA online panel wherein they have to submit criteria-wise documents of their project and use the performance calculators. The same panel will later serve as a platform for the project team to receive feedback from GRIHA Council on the submitted documents.

» **Facilitating one day orientation workshop and site visits:** As a part of the rating process, a one day orientation workshop and three site visits will be conducted by GRIHA officials. The logistics arrangement for the same shall be made by the project team.

» **Inter-team coordination:** The project team should ensure data management and collation within the team before submitting the documents to GRIHA Council on the panel.

In order to enable smooth communication between GRIHA Council and the project team, single point communication is encouraged that involves emails being sent by the project coordinator (or their assistants). The necessary communications should involve all the decision makers in the loop.

Following such a system would help in keeping definitive record of the rating process.

Submission of documentation: All the documents must be submitted by the project team on the online portal, criteria wise, to the Council for the final evaluation. The project team may upload the documents intermittently or in one go towards the completion of the project. However, the submission must be done only once the complete set of documents is uploaded.

The GRIHA Council

The Council members work towards enabling a smooth rating process for the project proponents, and provide them with fair evaluation procedure for awarding certification. The following tasks would be undertaken by the Council:

Administerial Assistance

» **Registration:** Once the project is registered with the GRIHA Council, the project proponent is provided with a user ID and password to access the GRIHA online panel.

Hand-holding and monitoring

» **One day orientation workshop:** The technical team of GRIHA Council shall deliver a one day knowledge session for the project team, as specified in the rating process. During this hand-holding process, the aim is to make the project team well-versed with the fundamentals of the rating system, thereby, enabling the implementation of green building strategies at the site level and preparing documentation for submission.

» **Site Visit-I, II, and III:** The Council members will conduct visits to the project site at various stages of construction to guide the project team in implementing sustainable design strategies on-site as per GRIHA and to monitor the site for compliance with the rating.

Evaluation and award of rating

» **Appointment of external evaluator:** GRIHA Council shall appoint third party evaluators to analyze the documents submitted by the project proponent under various sections of GRIHA rating project. The third-party evaluators are subject experts practicing in the field of sustainable design and services. They have practical and research-based knowledge experience to evaluate the submitted documents.

» **Critical analysis:** The Council will critically analyze the submitted documents and verify the evaluation report submitted by the third-party evaluators.

» **Award of rating:** Based on the critical evaluation of submitted documents, GRIHA Council will award rating to the project and the project team would be handed over the rating plaque, the certificate, and the final evaluation report.

Green awareness drive

With the aim to spread knowledge about sustainable living and making the occupants aware about the green features of the building they have inhabited, GRIHA Council will conduct a green awareness drive.

CRITERION 1

Green Infrastructure

Intent

The intent of this criterion is to ensure that the site complies with the relevant master plan/local development plans and guidelines. This makes sure that the necessary compliance requirements for the building projects along with the applicable building regulatory requirements are adhered to. Additionally, it emphasizes on enhancing natural biodiversity through preservation and plantation of native vegetation. This criterion further intends to assess proximity to different nodal transport and amenities to manage last mile connectivity as well as reduce dependence on personal motorized vehicles. It also incentivizes land use optimization, which is a pressing concern in densely populated urban areas.

Maximum Points: 5

1.1 Appraisals

1.1.1 **Ensure that the site plan is in conformity with the development plan/master plan/Urban and Regional Development Plans Formulation and Implementation (URDPFI) guidelines. This should comply with the provisions of eco-sensitive zone regulations, coastal zone regulations, heritage areas (identified in the master plan or issued separately as specific guidelines), waterbody zones (in such zones, no construction is permitted in the water-spread and buffer belt of minimum 30m around the full tank level), various hazard-prone area regulations, and others if the site falls under any such area. Furthermore, any other relevant legal approval pertaining to the project for clearance from the necessary government authority has to be compliant (refer to Details to appraisals, Section 1.3, Table 1.4c, Volume 2 for suggested list of Approval and Sanctions).**

—Mandatory

1.1.2 **Demonstrate that the project team implements tree preservation measures as per the alternatives mentioned below:**

—Mandatory

Alternative 1: Ensure that no existing mature tree on-site is cut.

Alternative 2: Transplant existing mature trees (if applicable) within the site and ensure that they survive.

Alternative 3: Plant three trees for every one tree cut of the same native/naturalized species.

Alternative 4: Adopt any combination of the previously mentioned alternatives.

Applicability check: If there are no existing mature trees on-site, the project is exempted from Appraisal 1.1.2.

To exempt the project from Appraisal 1.1.2, please submit the following:

- Site survey plan along with Google Earth images of the site over the previous years.

1.1.3 Ensure that a minimum of one tree[2] for every 80m^2 of site area (within GRIHA project boundary) is planted and maintained in order to increase vegetation on the site. The existing preserved mature trees within the site premises should be considered in the calculation.

—1 Point

1.1.4 Ensure that per capita gross area[3] benchmark is maintained as prescribed in Table 1.1c for optimum land utilization.

—1 Point

TABLE 1.1c: Per capita total gross area (m^2) benchmark as per the building typology (including estimated floating population)

Limits	Healthcare Facility (per bed)	Hospitality	Institutional	Office	Residential	Retail	Transit Terminal
Minimum	100	35	4	5	12.5	3	0.6
Maximum	–	60	8	10	50	6	1.5

1.1.5 Ensure that the average distance[4] to at least five basic public amenities/services as per the building typology (defined in Appendix 1A, Table 1.1A and 1.2A, Volume 2) from the main entrance of the project is less than the GRIHA base case[5] as per Table 1.2c.

—2 Points

TABLE 1.2c: Point allocation for reduction in average distance to amenities against GRIHA base case

Reduction from Base Case (x)[5]	Points
$10\% \leq x < 25\%$	1
$x \geq 25\%$	2

[2] Only native/naturalized species should be planted. Potted plants cannot be used to demonstrate compliance with Appraisal 1.1.3.

[3] Gross area includes all circulation areas, service areas, toilets, and so on, but excludes basement and parking areas within the site premises.

[4] Radial distances are not acceptable, walking distance has to be calculated.

[5] An average distance of 600m to the amenities from the site entrance has been considered as the GRIHA base case.

1.1.6. Adopt any one strategy from the list, as given below, to promote sustainable transportation within the site premises.

—1 Point

- Strategy 1: Provide at least four designated parking spaces for informal modes of transport within the site premises.
- Strategy 2: Non-motorized transport/E vehicles

  Part A: Provide E-vehicle parking facility for at least 5% of the total four-wheeler parking space along with charging facility for E-vehicles and adequate signage.

  Part B: Additionally provide designated vehicular tracks for NMT vehicles for site areas >50,000 m^2.
- Strategy 3: Provide bicycle users with at least 5% of the total four-wheeler parking space designated to them along with changing rooms, showers, and lockers as per Table 1.3c within the site premises with adequate signage.

TABLE 1.3c: Number of combined shower, locker, and changing room facility for each bicycle parking space

Building Typology		Number of Facilities
Healthcare facility (per bed)		1 per 4
Hospitality		1 per 10
Institutional		1 per 40
Office		1 per 100
Residential		-
Retail		1 per 100
Transit terminal	Junction stations, intermediate stations, and bus stations	2 per 1000
	Terminal railway and bus stations	3 per 1000
	Domestic and international airports	4 per 1000

1.2 Compliance

1.2.1 Submit all relevant approvals, sanctions, and clearances[6] to demonstrate conformity to local development plans/master plan to demonstrate compliance with Appraisal 1.1.1.

1.2.2 Submit a site survey plan and a landscape plan (in .dwg format) with legends mentioning species and highlighting (in different colour coding/layers) the existing trees that have been transplanted, cut, and/or preserved/protected as well as new plantation to demonstrate compliance with Appraisals 1.1.2 and 1.1.3.

[6] Refer to Table 1.4c Volume 2 for the list of necessary approvals/sanctions as applicable for the project to be submitted to demonstrate compliance. Please note the list is indicative and is not exhaustive.

1.2.3 Submit letter from the local governing body permitting cutting of trees on-site to demonstrate compliance with appraisal 1.1.2.

1.2.4 Submit purchase orders highlighting full quantities of new plantation to demonstrate compliance with Appraisals 1.1.2 and 1.1.3.

1.2.5 Submit calculations on the GRIHA online portal for the number of new trees planted and the number of existing trees preserved to demonstrate compliance with Appraisal 1.1.3.

1.2.6 Submit occupancy calculations on the GRIHA online portal to demonstrate compliance with Appraisal 1.1.4.

1.2.7 Submit floor plans (in .dwg format) and area calculations indicating habitable areas considered for per capita gross area calculation to demonstrate compliance with Appraisal 1.1.4.

1.2.8 Submit Google Map images highlighting walking distances to each basic amenity from the main entrance of the project along with date-stamped photographs of services/amenities as marked in the Google Map images to demonstrate compliance with Appraisal 1.1.5.

1.2.9 Submit calculations for average distance travelled to basic amenities on the GRIHA online portal to demonstrate compliance with Appraisal 1.1.5.

1.2.10 Submit calculations for percentage of sustainable modes of transport provided on-site to demonstrate compliance with Appraisal 1.1.6.

1.2.11 Submit date-stamped photographs of sustainable modes of transport provided on-site to demonstrate compliance with Appraisal 1.1.6.

1.2.12 In case of informal mode of transport, submit a site plan (in .dwg format) highlighting the location of designated parking spaces provided within the site premises to demonstrate compliance with Appraisal 1.1.6.

1.2.13 In case of NMT vehicles, submit the calculation for percentage of parking space designated for NMT on-site to demonstrate compliance with Appraisal 1.1.6.

1.2.14 Submit a site plan (in .dwg format) highlighting the location of designated parking spaces provided and charging points for E-vehicles to demonstrate compliance with Appraisal 1.1.6, Strategy 2.

1.2.15 In case bicycle usage is promoted on-site, submit the building floor plans (in .dwg format) highlighting changing spaces, showers, and lockers for bicycle users within the project premises. Also, submit a site plan (in .dwg format) highlighting the location of designated parking spaces provided for the bicycle users to demonstrate compliance with Appraisal 1.1.6.

CRITERION 2

Low-Impact Design Strategies

Intent

The intent of this criterion is to promote design strategies that enable the project to factor in ways by which natural site features (topographical/microclimatic) can be protected and/or incorporated into the project design.

Maximum Points: 5

2.1 Appraisals

2.1.1 Demonstrate reduction in environmental impact by adoption of various low-impact planning and design strategies as per Table 2.1c. Different strategies are listed for reference under GRIHA V 2019, Volume 2, Section 2.3, Table 2.2c to 2.6c.

TABLE 2.1c: Point allocation for low impact design strategies

No. of Strategies Adopted	Points
2 (with at least 1 passive strategy)	1
3 (with at least 2 passive strategies)	3
5 (with at least 3 passive strategies)	5

2.2 Compliance

2.2.1 Submit analysis along with calculations/simulation reports with input and output files to demonstrate compliance with low-impact design strategies as mentioned in Details of Appraisals, Tables 2.2c to 2.6c, Volume 2 or any other low impact strategy.

2.2.2 Submit drawings/schematics (in .dwg format) highlighting the integration of the low-impact design strategies into the building design/site planning.

2.2.3 Submit the narrative and date-stamped photographs of the strategies implemented.

CRITERION 3

Design to Mitigate UHIE

Intent

The intent of this criterion is to ensure incorporation of design strategies that will aid in the reduction of UHIE.

Maximum Points: 2

3.1 Appraisals

3.1.1 Demonstrate the temperature reduction (in °C) from the GRIHA base case as per the alternatives mentioned below.

–2 Points

Alternative 1: Demonstrate temperature reduction in the predicted hourly average air temperature (°C) from the GRIHA base case by performing calculations as per Table 3.1c.

TABLE 3.1c: Reduction in predicted hourly average air temperature (°C)

Reduction in Predicted Hourly Average Air Temperature (°C)	Points
1.5°C ≤ base case*	1
2.5°C ≤ base case*	2

**Base case as per Details of Appraisal 3.3.2, Volume 2 UHIE Analysis Details*

Alternative 2: Demonstrate that the difference in peak air temperature has been achieved through dynamic UHIE simulation from the GRIHA base case as per Table 3.2c.

TABLE 3.2c: Reduction in peak air temperature (°C)

Reduction in Peak Air Temperature (°C)	Points
1°C ≤ base case*	1
2°C ≤ base case*	2

**Base case as per Details of Appraisal 3.3.2, Volume 2 UHIE Analysis Details*

3.2 Compliance

3.2.1 Submit a site plan and site section (in .dwg format) with legends, mentioning the building heights and external surface finishes such as soft paved/covered with high solar reflectance index paints/shaded by trees/vegetated pergolas/solar panels.

3.2.2 Submit purchase orders reflecting full quantities of high albedo paints/tiles, solar panels, and so on.

3.2.3 Submit the technical specifications/brochures of high albedo paints/tiles, solar panels, and so on.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the products.

3.2.4 Submit the narrative and date-stamped photographs of the strategies implemented.

3.2.5 Submit calculations using the GRIHA UHIE calculator to demonstrate compliance with Alternative 1.

3.2.6 Submit calculations and supporting drawings (in .dwg format) for sky view factor, average surface albedo, average height to building ratio, wall area, hard paved area, and green area to demonstrate compliance with Alternative 1.

3.2.7 Submit a simulation report (along with input and output files) to demonstrate compliance with Alternative 2.

CRITERION 4

Air and Soil Pollution Control

Intent

The intent of this criterion is to minimize air and soil pollution due to construction activities.

Maximum Point: 1

4.1 Appraisals

4.1.1 Adopt at least six measures to minimize air and soil pollution during construction, with the first three strategies being mandatory.

–Mandatory

- **Provide 3m high continuous barricading along the site boundary/virtual boundary.**
- **Provide wheel washing facility/gravel bed at all vehicular entrances and exits of the site.**
- **Ensure DG sets have an exhaust with stack height of at least 2m from the top of the generator with a cowl.**
- Ensure DGs are in compliance with CPCB norms.
- Implement a spill prevention plan for storage of diesel, admixtures, curing compounds, bitumen, and other hazardous materials.
- Ensure that fine aggregate, excavated earth, and other construction materials with a tendency to get airborne are covered or are sprinkled regularly with non-potable water.
- Ensure sprinkling of water on unpaved pathways on the site with non-potable water.
- Limit the speed of vehicular movement on-site to 10km/h.
- Ensure that vehicles carrying waste materials out of the site are covered.

4.1.2 Ensure that the soil erosion channels are constructed and they are connected to a sedimentation tank in order to reduce movement of soil outside the site throughout the construction phase of the project.

–1 Point

4.2 Compliance

4.2.1 Submit tender document (relevant section only) mentioning the measures to be taken by the contractor during the construction phase to prevent air and soil pollution. It must also include the construction of soil erosion channels and sedimentation tanks for demonstrating compliance with Appraisals 4.1.1 and 4.1.2.

4.2.2 Submit a site management plan (in .dwg format) highlighting the location of strategies implemented on-site to minimize air and soil pollution during construction and soil erosion channels connected to a sedimentation tank demonstrating compliance with Appraisals 4.1.1 and 4.1.2.

4.2.3 Submit date-stamped photographs describing various strategies adopted to minimize air and soil pollution and soil erosion channels and sedimentation tank during construction phase for demonstrating compliance with Appraisals 4.1.1 and 4.1.2.

4.2.4 Submit test reports of smoke released from the exhaust of all the DG sets on-site (minimum three reports to be shared over the entire period of construction) indicating that emission parameters are within permissible limits, as prescribed by the CPCB, demonstrating compliance with Appraisal 4.1.1 (refer to Appendix 2A: Emission limits as prescribed by CPCB, 2016, Volume 2).

4.2.5 Submit copies of challans if treated water (in sewage treatment plant) is being used on-site to demonstrate compliance with Appraisal 4.1.1.

4.2.6 Submit a section of sedimentation tank (in .dwg format) indicating that minimum depth of tank should be 1m to manage storm-water run-off for demonstrating compliance with Appraisal 4.1.2.

Note: Compliance with Appraisals 4.1.1 and 4.1.2 would be verified during site visit I and II. Please refer, Rating Process, step III for more details.

CRITERION 5

Topsoil Preservation

Intent

The intent of this criterion is to ensure the preservation of available fertile soil on-site and avoid its degradation during the process of construction.

Maximum Point: 1

5.1 Appraisal

5.1.1 Ensure that topsoil from disturbed areas on the site is preserved, stabilized, and its fertility is maintained throughout the construction period. Additionally, ensure that 100% of the soil requirement for landscaping including roof garden(s) is met through this preserved soil.

–1 Point

Applicability check: If the topsoil present on-site before construction is not fertile and cannot be made fertile through organic means, the project is exempt from Appraisal 5.1.1.

To exempt the project from Appraisal 5.1.1, kindly submit topsoil fertility test report conducted by an Indian Council of Agricultural Research (ICAR)-accredited laboratory indicating that the topsoil is not fertile and cannot be made fertile.

5.2 Compliance

5.2.1 Submit fertility test report of topsoil from the site conducted by an ICAR-accredited laboratory, indicating fertility of the topsoil (refer to Appendix 2B: Parameters of fertile soil, Volume 2).

5.2.2 Submit calculations indicating the total quantity of topsoil preserved and used in landscape activity post construction.

5.2.3 Submit a site plan (in .dwg format) highlighting the areas of excavation and preservation of topsoil.

5.2.4 Upload date-stamped photographs with description of the measures implemented.

Note: Compliance with Appraisal 5.1.1 would be verified during site visit I and II. Please refer, Rating Process, step III for more details.

CRITERION 6

Construction Management Practices

Intent

The intent of this criterion is to ensure adoption of good management practices on-site during the construction phase.

Maximum Points: 2

6.1 Appraisal

6.1.1 Adopt construction management practices (e.g., stacking and storage of construction materials at different stages of construction) and ensure safe disposal of waste generated during construction.

–1 Point

6.1.2 Adopt at least two strategies from the list, as given below, to minimize water consumption during construction, with the first strategy being mandatory.

–1 Point

- **Use gunny bags, ponding technique, or curing compound.**
- Meter and monitor the consumption of water during construction.
- Use water-reducing admixtures in concrete mix.
- Use treated wastewater and/or captured storm-water.

Note: This is not a mandatory appraisal. In the event a project fails to demonstrate compliance with this appraisal, their rating won't be denied. However, if a project intends to comply with this appraisal, then the first strategy becomes mandatory for them in order to achieve 1 point.

6.2 Compliance

6.2.1 Submit a site management plan (in .dwg format) highlighting the location of storage areas for various construction materials, such as steel, building blocks, or stone, and for waste generated, such as empty cement bags, packaging waste, or construction/demolition debris, to demonstrate compliance with Appraisal 6.1.1.

6.2.2 Submit copies of log sheets for the total quantity of waste generated, reused, and/or sold to recyclers on-site, demonstrating compliance with Appraisal 6.1.1 (refer to Appendix 2C: Template for total amount of waste generated on-site, Volume 2).

6.2.3 Submit copies of challans for all the waste materials sold to recyclers demonstrating compliance with Appraisal 6.1.1.

6.2.4 Upload date-stamped photographs with description of construction management practices adopted on-site and measures to minimize water consumption during construction to demonstrate compliance with Appraisals 6.1.1 and 6.1.2.

6.2.5 Submit a purchase order reflecting full quantities of curing compound used during the construction phase to demonstrate compliance with Appraisal 6.1.2.

6.2.6 Submit a technical specification sheet/brochure of curing compound used during the construction phase.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the product to demonstrate compliance with Appraisal 6.1.2.

6.2.7 Submit a narrative describing various strategies adopted to reduce water consumption to demonstrate compliance with Appraisal 6.1.2.

6.2.8 Install a water meter on all sources of water such as tube well, municipal supply, and others to monitor the consumption of water and submit date-stamped photographs demonstrating compliance with Appraisal 6.1.2.

6.2.9 Submit copies of logbooks for the total quantity of water consumed, demonstrating compliance with Appraisal 6.1.2 (refer to Appendix 2D: Template for source of water used in construction activity, Volume 2)

6.2.10 Submit a design mix report and a batch mix report indicating the use of admixtures to demonstrate compliance with Appraisal 6.1.2.

6.2.11 Submit a purchase order reflecting full quantities of admixtures used during the construction phase to demonstrate compliance with Appraisal 6.1.2.

6.2.12 Submit a technical specification sheet/brochure of admixture used during the construction phase.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the product to demonstrate compliance with Appraisal 6.1.2.

NOTE: Compliance with Appraisals 6.1.1 and 6.1.2 would be verified site visit I and II. Please refer, Rating Process, step III for more details.

CRITERION 7

Energy Optimization

Intent

The intent of this criterion is to ensure that the projects are made energy efficient by enhancing the envelope performance while also reducing energy consumption through installation of efficient equipment and lighting fixtures.

Maximum Points: 12

7.1 Appraisals

7.1.1 **Ensure that the project demonstrates compliance with the mandatory requirements of ECBC 2017 as per Table 7.5c, Details to Appraisals, Volume 3.**

–Mandatory

7.1.2 Ensure that the heat gain through the building envelope below the GRIHA threshold for peak heat gain as per Table 7.1c.

–2 Points

TABLE 7.1c: Threshold for peak heat gain (W/m^2) for different building typologies

Operating Hours	Daytime Occupancy		24–hours Occupancy					
	5 days a week		7 days a week					
Climate Zone	Institutional	Office	Health care Facility	Hospitality	Office	Residential	Retail	Transit Terminal
Composite	40	30	35	35	45	45	30	30
Hot and dry	40	40	35	35	45	45	30	30
Warm and humid	35	25	35	30	45	45	25	25
Moderate	30	25	35	25	35	35	25	30
Cold	30	30	40	40	30	30	25	60

Note: For buildings/projects with more than 80% built-up area (both FSI and non-FSI) falling under residential use shall be considered as a residential project. Peak heat gain of each building in the project will be assessed on its respective typology.

Additionally, residential typology of projects can demonstrate compliance as per RETV method defined in Eco-Niwas Samhita 2018 for the building envelope (except roof) for four climate zones, namely, Composite, Hot-Dry, Warm-Humid, and Temperate, and shall comply with the maximum RETV of 12 W/m^2

7.1.3 Demonstrate that 100% of exterior lighting fixtures[7] (lamp + ballast) meet the luminous efficacy of 80lm/W.

–1 Point

7.1.4 **Ensure that the project demonstrates reduction from the GRIHA benchmark for EPI as per Table 7.2c**. Additional reduction in EPI will be awarded points as mentioned in Table 7.3c.

Mandatory + 8 points

TABLE 7.2c: GRIHA benchmark for EPI (kWh/m²/year) for different building typologies[8]

Operating Hours	Daytime Occupancy		24–hours Occupancy					
	5 days a week		7 days a week					
Climate Zone	Institutional	Office	Health care Facility	Hospitality	Office	Residential	Retail	Transit Terminal
Composite	90	90	250	275	225	70	225	300
Hot and dry	90	90	250	275	225	70	225	300
Warm and humid	90	90	275	275	225	70	225	300
Moderate	75	75	250	250	210	50	210	300
Cold	90	120	275	300	275	100	225	275

TABLE 7.3c: Additional reduction from GRIHA benchmark for EPI

Reduction from GRIHA Benchmark for EPI (x)	Points
$0\% \leq x < 10\%$	Mandatory
$10\% \leq x < 20\%$	1
$20\% \leq x < 30\%$	2
$30\% \leq x < 40\%$	4
$40\% \leq x < 50\%$	6
$x \geq 50\%$	8

7.1.5 Ensure that the equipment installed within the project (whichever applicable as per Table 7.4c) is either BEE star labelled or of equivalent performance.

Mandatory + 1 point

[7] Special purpose lighting occasionally used as floodlights, stage lights, pool lights/underwater lights, etc., are exempted from the calculations as mentioned in Appraisal 7.1.3. However, the façade lighting is not exempted.

[8] For buildings/projects with more than 80% built-up area (both FSI and non-FSI) falling under residential use shall be considered as a residential project. In case the occupied hours of a project is more than 6 days and 14 hours per day, then 24x7 occupied office benchmark EPI will be considered or else if the occupied hours are less than 6 day and 14 hours per day, then day time occupied office benchmark EPI will be considered.

TABLE 7.4c: List of BEE star-labelled equipment

Equipment	Star Labelled	3 Stars and Above
LED/TFL	Mandatory	1 Point
Unitary/Split air conditioners		
Ceiling fans		
Geysers		
UPS		
Solid state inverters		

7.2 Compliance

7.2.1 Submit a narrative with descriptions of various systems and their components as indicated in Table 7.5c, Volume 3 to demonstrate compliance with Appraisal 7.1.1.

7.2.2 Submit technical specification sheets/brochures of various systems and their components to demonstrate compliance with Appraisal 7.1.1.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the products to demonstrate compliance with Appraisal 7.1.1.

7.2.3 Submit the purchase orders reflecting the full quantities of various systems and their components to demonstrate compliance with Appraisal 7.1.1.

7.2.4 Submit a simulation report with input and output files for all building blocks in a project highlighting the peak heat gain values for the building envelope to demonstrate compliance with Appraisal 7.1.2.

7.2.5 Submit window-to-wall ratio (WWR) and SRR calculations with supporting drawings (.dwg format) such as floor plans, elevations, and building sections to demonstrate compliance with Appraisals 7.1.2 and 7.1.4.

7.2.6 Submit the envelope cross-sections (for walls, roof, and glazing) indicating material specification, thickness, etc., to demonstrate compliance with Appraisals 7.1.2 and 7.1.4.

7.2.7 Submit the technical specification sheets/brochures of building material used, highlighting the U-values in the case of walls to demonstrate compliance with Appraisals 7.1.2 and 7.1.4.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the products to demonstrate compliance with Appraisals 7.1.2 and 7.1.4.

7.2.8 Submit the technical specification sheets/brochures of glazing material used in the project, highlighting the U-value and SHGC to demonstrate compliance with Appraisals 7.1.2 and 7.1.4.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the products to demonstrate compliance with Appraisals 7.1.2 and 7.1.4.

7.2.9 Submit the purchase orders reflecting the full quantities of wall, roof, and glazing assembly and subassembly materials to demonstrate compliance with Appraisals 7.1.2 and 7.1.4.

7.2.10 Submit the calculations for luminous efficacy of each type of lamp used in outdoor lighting to demonstrate compliance with Appraisal 7.1.3.

7.2.11 Submit the technical specification sheets/brochures for the lamps, ballasts, luminaires, and automatic controls to demonstrate compliance with Appraisal 7.1.3.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the products to demonstrate compliance with Appraisal 7.1.3.

7.2.12 Submit the purchase orders reflecting the full quantities of outdoor lamp fixtures to demonstrate compliance with Appraisal 7.1.3.

7.2.13 Submit a simulation report with input and output files for all building blocks in the project highlighting HVAC and internal lighting energy consumption as well as all input parameters used in the simulation to demonstrate compliance with Appraisal 7.1.4.

7.2.14 Submit a narrative and calculations demonstrating compliance and/or reduction from the GRIHA benchmark for EPI as per Appraisal 7.1.4.

7.2.15 Submit an operating schedule for electrical, lighting, HVAC systems, and equipment of the project as per the building typology (refer to ASHRAE 90.1, Appendix G or ECBC 2017, Whole Building Method, Clause 9.6, and Tables 9–10 and 9–22).

7.2.16 Submit an occupancy schedule for the project as per the building typology to demonstrate compliance with Appraisal 7.1.4 (refer to ASHRAE 90.1, Appendix G or ECBC 2017, Whole Building Method, Clause 9.6, Tables 9–10 and 9–22).

7.2.17 Submit the purchase orders reflecting the full quantities of equipment/appliances purchased to demonstrate compliance with Appraisal 7.1.5.

7.2.18 Submit a copy of the tenant agreement in the case of leasing out to a tenant, highlighting the clause that mandates the use of BEE-star labelled or equivalent equipment/appliances as per Appraisal 7.1.5.

7.2.19 Submit the technical specification sheets/brochures for all installed equipment/appliances indicating BEE-star labelling or ascertaining equivalent performance to demonstrate compliance with Appraisal 7.1.5.

OR

Submit a valid GRIHA Product Catalogue Certificate as applicable for the products to demonstrate compliance with Appraisal 7.1.5.

CRITERION 8

Renewable Energy Utilization

Intent

The intent of this criterion is to promote the use of RE in the projects and, thereby, reduce the project's dependency on fuels derived from conventional sources.

Maximum Points: 5

8.1 Appraisal

Alternate 1 (On-site/On-site and off-site combination renewable energy system)[9]

8.1.1 Ensure installation of on-site and off-site RE system to offset a part of the annual energy consumption of internal artificial lighting, HVAC, and domestic hot water systems as mentioned in Table 8.1c.

TABLE 8.1c: Point weightage for on-site and off-site renewable energy system installation[10]

Daytime Occupancy		24-hours Occupancy						Points
5 days a week		7 days a week						
Institutional	Office	Healthcare	Hospitality	Office	Residential	Retail	Transit Terminals	
5%	5%	1%	1%	1%	-	1%	1%	**Mandatory (On site)**
10%	10%	3%	3%	3%	10%	3%	3%	1
15%	15%	5%	5%	5%	15%	5%	5%	2
20%	20%	7%	7%	7%	20%	7%	7%	3
25%	25%	10%	10%	10%	25%	10%	10%	5

Alternate 2 (Off-site renewable energy system)

Note: This alternative cannot be attempted by residential projects.

8.1.1 Demonstrate that 100% of the annual energy consumption of internal artificial lighting, HVAC, and domestic hot water systems is offset through off-site RE systems.

- Mandatory + 5 Points

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9 All renewable energy systems recognized by the MNRE can be accepted under this criterion.

10 For buildings/projects with more than 80% built-up area (both FSI and non-FSI) falling under residential use shall be considered as a residential project.

8.2 Compliance

8.2.1 Submit calculations indicating the energy required for heating water for domestic purposes as per Table 8.2c.

Table 8.2c: Typical hot water consumption for different activities

Building Typology	Subcategory	Hot Water Requirement
Healthcare Facility	Dispensary	10.00lpcd
	Hospital	20.00lpd/bed
Hospitality	Guest house, hotel, service apartment	40.00lpcd
Institutional	College, laboratory, library, school, sports complex, university	10.00lpcd
Office	Core and shell building, co-working space, industry, IT building, owner-occupied building	0.50lpcd
Residential	Bungalow, hostel, multi-dwelling unit project, mansion, villa	25.00lpcd
Retail	Shopping complex	16.00lpcd
	Multiplex	0.50lpcd
	Banquet/wedding hall, cafeteria, club, food court, restaurant	14.00lpcd
Transit terminal	Airport and heliport	0.50lpcd

8.2.2 Submit calculations and simulations for sizing the RE system, based on domestic hot water consumption calculation, HVAC, and internal lighting in consistency with Criterion 7, Appraisal 7.1.4.

Alternative 1

8.2.3 Submit calculations and simulations for on-site and off-site RE generation potential.

8.2.4 Submit technical specification sheets/brochures of the RE system, highlighting the system performance (as per the standard test conditions).

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the systems and their components.

8.2.5 Submit drawings (.dwg format) showing the location of RE systems on-site.

8.2.6 Submit purchase orders reflecting the full quantities of RE systems installed on-site.

Alternative 2

8.2.7 Submit documents supporting off-site generation of energy through RE systems.

These may be RECs for at least 5 years along with a declaration that the RECs are not being used for any other obligatory requirements and will be purchased every year.

OR

Submit power purchase agreement from the utility for purchase of green power. In the agreement, the address of the particular site must be mentioned.

CRITERION 9

Low ODP And GWP Materials

Intent

The intent of this criterion is to ensure the use of materials with low GWP and ODP in building insulation, HVAC, refrigeration equipment, and firefighting systems.

Maximum Point: 1

9.1 Appraisal

9.1.1 Ensure that all the insulation used in the building envelope and for HVAC systems are CFC and HCFC free.

– Mandatory

9.1.2 Ensure that the refrigerant used in the HVAC systems and refrigeration equipment is CFC and HCFC free.

– Mandatory

9.1.3 Ensure that the fire suppression systems and fire extinguishers installed in the project are halon free.

– Mandatory

9.1.4 Ensure that all the insulation used in the building envelope and for HVAC systems; refrigerant used in the HVAC systems and refrigeration equipment are HFC free.

– 1 Point

9.2 Compliance

9.2.1 Submit a narrative with date-stamped photographs highlighting the insulation and refrigerants used in different applications in the building to demonstrate compliance with Appraisals 9.1.1– 9.1.4.

9.2.2 Submit technical specification sheets/brochures of the insulation, refrigeration equipment, and fire-fighting systems to demonstrate compliance with Appraisals 9.1.1–9.1.4.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the products to demonstrate compliance with Appraisals 9.1.1–9.1.4.

9.2.3 Submit purchase orders reflecting the full quantities of insulation, HVAC systems, refrigeration equipment, and fire-fighting systems used in the project highlighting their respective types to demonstrate compliance with Appraisals 9.1.1–9.1.4.

CRITERION 10

Visual Comfort

Maximum Points: 4

Intent

The intent of this criterion is to ensure that visual comfort (daylighting and artificial lighting) is provided to the building occupants through the integration of active and passive design measures.

10.1 Appraisals

Daylighting

Demonstrate mean DA or UDI compliance as per Alternative 1 or Alternative 2.

Alternative 1

10.1.1 Demonstrate through simulation[11] that mean DA requirement (<3000lux) is met for 100% of the annual analysis hours for 100% of the regularly occupied areas.

– Mandatory

10.1.2 Demonstrate through simulation that mean DA requirement (>300lux) is met for the annual analysis hours as listed in Table 10.1c for 100% of the regularly occupied areas.

TABLE 10.1c: Daylight autonomy benchmarks for percentage hours exceeding 300lux for different building typologies

Daylight Autonomy Annual Analysis Hours Benchmarks for Different Building Typologies							
Points	**Office**	**Retail***	**Residential**	**Healthcare**	**Hospitality**	**Institutional**	**Transit Terminal****
Mandatory	25%	5%	25%	20%	25%	25%	10%
2 Points	30%	10%	30%	25%	30%	50%	20%
4 Points	35%	15%	35%	30%	35%	60%	30%

* Retail spaces to be considered in the calculation: All regularly occupied spaces (excluding retail shops with special display lighting requirements, lobby areas, atriums, food courts, toilets, entryways, corridors, and other congregation/circulation spaces)

** In case of transit terminals, all regularly occupied spaces must be considered for calculations except security checkpoints and retail shops that have special lighting requirements. For example, concourse, entryways, check-in counters, waiting areas, food courts, toilets, atriums, and other congregation/circulation spaces.

Alternative 2

10.1.1 Ensure that WWR[12] does not exceed 60% and the vertical fenestration complies with minimum visual light transmittance (VLT) of 0.27.

–Mandatory

[11] Grid size of 1m x 1m has to be used in DA simulation.

[12] Windows and walls to internal courtyards (open to outside air) should be included for WWR calculations and need to comply with SHGC requirements.

10.1.2 **Ensure that the project meets the SHGC compliance as per Table 10.2c.**

Or

Ensure that the project meets the weighted average facade SHGC for each orientation as per Table 10.2c requirements.

–Mandatory

Table 10.2c: Maximum SHGC for vertical fenestration for different climate typologies

Orientation of Fenestratation		Composite	Hot and Dry	Warm and Humid	Temperate/ Moderate	Cold
Maximum SHGC Non-North*		0.27	0.27	0.27	0.27	0.62
Maximum SHGC North	For latitude ≥ 15°N	0.5	0.5	0.5	0.5	0.62
	For latitude < 15°N*	0.27	0.27	0.27	0.27	0.62

* For residential buildings with operable windows, the ECBC thresholds have been revised to 0.45 (based on maximum shading dimensions as permitted under the building bye-laws)

Source: BEE (2017)

Or

Use Tables 9 and 10 of SP 41 to design the shading device for all the windows.

Or

Conduct solar path analysis for all regularly occupied spaces (both conditioned and non-conditioned) to ensure that the windows are completely shaded for the duration between 0900 hours on March 15 to 1500 hours on September 15.

Or

Use any combination of the above strategies to show compliance for 100% of the fenestrations.

10.1.3 **Ensure that the skylight roof ratio (SRR) does not exceed 5% and SHGC for skylights[13] does not exceed 0.35.**

Only transparent, semi-transparent, or translucent horizontal fenestrations installed for the purposes of daylighting and/or views are considered skylights.[14]

–Mandatory

10.1.4 Ensure that all regularly occupied spaces meet or exceed illuminance level between 100lux and 2000lux for the minimum percentage of floor area prescribed in Table 10.3c for 90% of the potential daylight time in a year. UDI compliance must be demonstrated through simulation using a validated software.

[13] Skylights in temporary roof coverings or awnings over unconditioned spaces are exempted from Appraisal 10.1.3.

[14] Opaque structures installed for the purposes of shading are not considered skylights and are exempt from the SRR calculations.

TABLE 10.3c: UDI benchmarks for percentage of above grade floor area for different building typologies[15]

	UDI Benchmarks for Different Building Typologies						
Points	**Office**	**Retail***	**Residential**	**Healthcare**	**Hospitality**	**Institutional**	**Transit Terminal**
Mandatory	40%	10%	45%	30%	45%	40%	10%
2 Points	50%	15%	55%	40%	55%	50%	20%
4 Points	60%	20%	65%	50%	65%	60%	30%

* Retail spaces to be considered in the calculation: All regularly occupied spaces except retail shops with special display lighting requirements, for example, lobby areas, atriums, food courts, toilets, entryways, corridors, and other congregation/circulation spaces.

** In the case of transit terminals, all regularly occupied spaces must be considered for calculations except security checkpoints and retail shops that have special lighting requirements. For example, concourse, entryways, check-in counters, waiting areas, food courts, toilets, atriums, and other congregation/circulation spaces.

Artificial lighting

10.1.5 Artificial lighting design to fall within limits (lower and higher range limits) as recommended space/task-specific lighting levels as per National Building Code (NBC) 2016[16] and to meet a minimum uniformity ratio of 0.4.

–Mandatory

10.2 Compliance

10.2.1 Submit drawings in .dwg format (floor plans, elevations and sections and doors-windows schedule, skylight schedule with North clearly marked) highlighting various shading devices.

10.2.2 Submit a narrative detailing the alternative opted for and the simulation methodology used for daylight simulation.

10.2.3 Submit technical specification sheets for all glazing types highlighting SHGC and VLT.

Or

Submit a valid GRIHA Product Catalogue certificate, as applicable for the product.

10.2.4 Submit purchase orders reflecting full quantities of all glazing.

10.2.5 Submit date-stamped photographs of all elevations/windows installed.

Alternative 1

10.2.6 Submit a daylight simulation report (input and output files)[17] highlighting areas meeting the requisite mean DA requirements to demonstrate compliance for all regularly occupied areas as per Appraisals 10.1.1 and 10.1.2.

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15 Based on ECBC 2017.

16 NBC 2016- Part 8 (BUILDING SERVICES Section 1 Lighting and Natural Ventilation) Table 4

17 Output grid data on excel along with false colour image and compiled report showing all modeled zones and geometry conditions including context massing and note on simulation methodology. Context massing refers to the buildings in the immediate surroundings of the project.

10.2.7 Submit narrative and calculations demonstrating compliance with the DA requirements through extrapolation in the case of mixed use buildings.

Alternative 2:

10.2.8 Submit WWR calculation for the entire building envelope along with drawings (in. dwg format) highlighting the opaque, translucent, and transparent areas in the façade to demonstrate compliance with Appraisal 10.1.1.

10.2.9 Submit narrative and calculations demonstrating compliance for Appraisal 10.1.2.

- Effective SHGC calculation for all fenestration as prescribed in ECBC 2017
  And/Or
- Fenestration design in accordance with Table 9 and Table 10 of SP41
  And/Or
- Solar path analysis
  Or
- Any combination of the above strategies can also be used to show compliance for 100% of the fenestrations.

10.2.10 Submit calculations detailing the SRR and SHGC for skylights to demonstrate compliance with Appraisal 10.1.3.

10.2.11 Submit the following documents for all the above grade floor areas as per Appraisal 10.1.4.

- Simulation report (input and output files) highlighting areas meeting the requisite UDI requirements.
- Narrative and calculations demonstrating compliance with the UDI requirements.

Artificial lighting

10.2.12 Submit artificial lighting simulation report for all representative spaces using validated software demonstrating that the artificial lighting levels meet the recommended lux levels and uniformity ratio as per Appraisal 10.1.5.

10.2.13 Submit interior artificial lighting layout plans/reflected ceiling plans.

10.2.14 Submit technical specification sheets for all internal lighting fixtures highlighting the lumen output and wattage.

Or

Submit a valid GRIHA Product Catalogue certificate, as applicable for the product.

10.2.15 Submit purchase orders reflecting the full quantities of all interior lighting fixtures.

CRITERION 11

Thermal and Acoustic Comfort

Maximum Points: 2

Intent

The intent of this criterion is to ensure that occupants of the building are thermally and acoustically comfortable through compliance with relevant standards and intelligent design features.

11.1 Appraisals

11.1.1 Demonstrate that the project meets the thermal comfort requirements for all regularly occupied spaces as specified in Table 11.1c.

–Mandatory

TABLE 11.1c: Thermal comfort requirement for all regularly occupied spaces

Air-conditioned Spaces	Non-air-conditioned Spaces (With Operable Windows)	Mixed Mode Spaces
» Demonstrate using simulation that the regularly occupied spaces meet the thermal comfort requirements as per NBC 2016, ASHRAE 55, or the Indian Adaptive Comfort model ensuring that the maximum number of unmet hours do not exceed 300	Alternative 1: » Demonstrate using simulation that the regularly occupied spaces meet the thermal comfort requirements as per NBC 2016, ASHRAE 55 or the Indian Adaptive Comfort model for 90% of the occupied hours for buildings in composite, moderate, hot and dry, and cold climates, and 60% of the occupied hours for buildings in warm and humid climate	» Demonstrate using simulation that the regularly occupied spaces meet the thermal comfort requirements as per NBC 2016, ASHRAE 55 or the Indian Adaptive Comfort model for 90% of the occupied hours for buildings in all climate typologies
	Alternative 2: » Demonstrate using at least 7 strategies (refer to Table 11.2c for prescribed strategies) that all the exterior fenestration is designed in accordance with NBC 2016 in terms of window orientation, size, placement, and shading design to facilitate wind flow into the interior spaces	
	» Demonstrate that the optimum size/number of fans are installed in rooms of different sizes in accordance with NBC 2016. Refer to Tables 11.3c and 11.4c	

TABLE 11.2c: Strategies for natural ventilation (NBC 2016)

S. No.	Strategies for Natural Ventilation
1	A building need not necessarily be oriented perpendicular to the prevailing outdoor wind; it may be oriented at any convenient angle between 0° and 30° without losing any beneficial aspect of the breeze. If the prevailing wind is from east or west, the building may be oriented at 45° to the incident wind so as to diminish the solar heat without much reduction in the air motion indoors
2	Maximum air movement at a particular plane is achieved by keeping the sill height of the opening to at least 85% of the critical height (such as head level) for the following recommended levels of occupancy: » For sitting on chair (0.75m) » For sitting on floor (0.40m)
3	For the normal-sized rooms with identical windows on opposite walls, the average indoor air speed increases rapidly by increasing the width of the window up to at least two-thirds of the wall width. Beyond this, the increase is in much smaller proportion than the increase of the window width
4	The air motion in the working zone is the maximum when the window height is at least 1.1m. A further increase in the window height promotes air motion at a higher level of window but does not contribute additional benefits as far as air motion in the occupancy zones in the buildings is concerned
5	The greatest flow per unit area of openings is obtained by using inlet and outlet openings of nearby equal areas at the same level
6	The total area of openings (inlet and outlet) should be at least 25% of the floor area; however, even under the most favorable conditions, the maximum average indoor wind speed does not exceed 40% of the outdoor velocity
7	The size of the inlet should be kept within at least 45% of the total area of openings
8	In case of rooms with only one wall exposed outside, provision of two windows on that wall is preferred over a single window
9	Windows located diagonally opposite to each other give better performance than other window arrangements for most of the building orientations
10	Provision of horizontal sashes inclined at an angle of 45° in an appropriate direction helps in promoting indoor air motion. Sashes projecting outwards are more effective than projecting inwards
11	In the case of narrow buildings, cross-ventilation can be obtained through one side of the building to the other (with single-loaded corridors) by the provision of large and suitably placed windows or a combination of windows and wall ventilators for the inflow and outflow of air

contd...

TABLE 11.2c: Strategies for natural ventilation (NBC 2016) (contd...)

S. No.	Strategies for Natural Ventilation
12	A verandah opening on three sides is preferred since it causes an increase in the room air motion for most of the orientations of the building with respect to the outdoor wind
13	Provision of a partition with spacing of 0.3m underneath helps in augmenting air motion near floor level in the leeward compartment of wide-span buildings
14	Air motion in two wings oriented in parallel to the prevailing breeze is promoted by connecting them with a block on downstream side
15	In the case of multiple buildings on-site, under the purview of the building owner, air motion in a building is not affected by constructing another building of equal or smaller height on the leeward side but it is slightly reduced if the leeward building is taller than the windward block

Source: NBC (2016)

TABLE 11.3c: Optimum fan size/ number of fans for rooms of different sizes NBC 2016

S. No.	Room Width (m)	Optimum Size (mm)/Number of Fans for Room Length										
		4m	5m	6m	7m	8m	9m	10m	11m	12m	14m	16m
1	3	1200/1	1400/1	1500/1	1050/2	1200/2	1400/2	1400/2	1400/2	1200/3	1400/3	1400/3
2	4	1200/1	1400/1	1200/2	1200/2	1200/2	1400/2	1400/2	1500/2	1200/3	1400/3	1500/3
3	5	1400/1	1400/2	1400/2	1400/2	1400/2	1400/2	1400/2	1500/2	1400/3	1400/3	1500/3
4	6	1200/2	1400/2	900/4	1050/4	1200/4	1400/4	1400/4	1500/4	1200/6	1400/6	1500/6
5	7	1200/2	1400/2	1050/4	1050/4	1200/4	1400/4	1400/4	1500/4	1200/6	1400/6	1500/6
6	8	1200/2	1400/2	1200/4	1200/4	1200/4	1400/4	1400/4	1500/4	1200/6	1400/6	1500/6
7	9	1400/2	1400/2	1400/4	1400/4	1400/4	1400/4	1400/4	1500/4	1400/6	1400/6	1500/6
8	10	1400/2	1400/2	1400/4	1400/4	1400/4	1400/4	1400/4	1500/4	1400/6	1400/6	1500/6
9	11	1500/2	1500/2	1500/4	1500/4	1500/4	1500/4	1500/4	1500/4	1500/6	1500/6	1500/6
10	12	1200/3	1400/3	1200/6	1200/6	1200/6	1400/6	1400/6	1500/6	1200/7	1400/9	1400/9
11	13	1400/3	1400/3	1200/6	1200/6	1200/6	1400/6	1400/6	1500/6	1400/9	1400/9	1500/9
12	14	1400/3	1400/3	1400/6	1400/6	1400/6	1400/6	1400/6	1500/6	1400/9	1400/9	1500/9

TABLE 11.4c: Additional requirements for energy savings (NBC 2016)

Requirement	Description
Capacity of a ceiling fan	The capacity of a ceiling fan to meet the requirement of a room with the longer dimension D meter should be about 55 Dm^3/min
Height of fan blades	The height of fan blades above the floor should be $(3H + W) \div 4$, where *H* is the height of the room and *W* is the height of the work plane
Minimum distance between fan blades	The minimum distance between fan blades and the ceiling should be about 0.3m
Regulators	Electronic regulators should be used instead of resistance-type regulators for controlling the speed of fans
Ventilation zone	When the actual ventilated zone does not cover the entire room area, then the optimum size of the ceiling fan should be chosen based on the actual usable area of the room, rather than the total floor area of the room. Thus, a small-sized fan could be chosen and energy saving could be achieved

Source: NBC (2016)

11.1.2 Demonstrate that acoustic comfort requirements are met for all regularly occupied spaces in the building as per Appraisal 11.1.2 A and B:

–2 points

Part A Measure outdoor noise levels[18] and adopt at least three of the following strategies in accordance with NBC 2016, Part 8, Section 4 if the average outdoor noise level is above 70dBA for conditioned buildings with sealed windows and 60dBA for naturally ventilated and mixed mode buildings to mitigate its effect on the indoor noise levels.

- Interposing buffer zones in building plan.
- Protection of habitable spaces by introduction of green belts (greater than 30m with broadleaf evergreen trees), public gardens, etc.
- Shading and screening by interposing less vulnerable buildings between the noise sources and more vulnerable buildings.
- Shading and screening by providing a solid barrier wall around the project boundary that is at least 8 feet high.
- Provision of adequate sound insulation in buildings envelope (walls and roofs). (Only applicable for conditioned buildings with non-operable windows).

Part B Demonstrate that indoor noise levels are within acceptable limits as per NBC 2016, Part 8, Section 4 and key noise sources on-site (DG, chiller plant, etc.) have sufficient acoustic insulation as per NBC 2016.

[18] Outdoor noise levels to be measured at least four different points on-site and 1m outside the building facade (in all cardinal/ inter-cardinal directions {refer to NBC 2016, 3.4.3.3}.

11.2 Compliance

Thermal comfort

11.2.1 Submit drawings in .dwg format highlighting area distribution for air-conditioned, non-air-conditioned, and mixed-mode spaces.

Air-conditioned spaces

11.2.2 Submit a simulation report (input and output file) to demonstrate that thermal comfort conditions are met for the project highlighting which thermal comfort model is being adopted and the total unmet hours.

11.2.3 Submit a single-line diagram of high-side and low-side HVAC system with set points for all seasons.

Non-air conditioned spaces (Alternative 1)

11.2.4 Submit a simulation report (input and output file) to demonstrate that thermal comfort conditions are met for the project highlighting which thermal comfort model is being adopted and the total unmet hours.

11.2.5 Submit a technical specification sheets and purchase orders (reflecting full quantities) of ceiling fans.

Non-air conditioned spaces (Alternative 2)

11.2.6 Submit detailed narrative of the strategies adopted for adequate window design.

11.2.7 Submit drawings (plans, elevations, sections, interior elevations with D/W schedules) in .dwg format supporting the adopted strategies.

11.2.8 Submit floor plans of all relevant spaces highlighting ceiling fan layout.

11.2.9 Submit technical specification sheets/GRIHA product Catalogue certificate and purchase orders (reflecting full quantities) of ceiling fans.

Mixed-mode spaces

11.2.10 Simulation report (input and output file) to demonstrate that thermal comfort conditions are met for the project highlighting which thermal comfort model is being adopted and the total unmet hours.

11.2.11 Submit a narrative and HVAC schedule highlighting duration of conditioned and unconditioned modes, respectively.

Acoustic comfort

11.2.12 Submit third-party outdoor noise test report (from NABL/Central Pollution Control Board-accredited laboratory) highlighting the noise levels observed on-site (the noise levels tested should be before commencement of construction).

11.2.13 Submit calculations for average outdoor noise levels on-site.

11.2.14 Submit photographs highlighting the strategies adopted in the project to mitigate the effect of outdoor noise.

11.2.15 Submit drawings (landscape plan highlighting species and canopy areas of mature trees, floor plans, wall sections, and elevations) in .dwg format supporting the adopted strategies.

11.2.16 Submit technical specification sheets/brochures of HVAC/other mechanical equipment highlighting corresponding NR values.

11.2.17 Submit technical specification sheets of noise insulation and/or glazing used in the building for noise reduction, highlighting its NRC/STC/CAC rating or equivalent (as per ASTM International Classification E413, E 1414, and E90).

OR

Submit a valid GRIHA Product Catalogue certificate, as applicable for the product.

11.2.18 Submit indoor noise audit report for all representative spaces.

CRITERION 12

Indoor Air Quality

Maximum Points: 6

Intent

This criterion ensures design and monitoring of ventilation systems such that IAQ meets the minimum requirement as recommended by the relevant standards.

Applicability Check – If the project comprises spaces with operable windows, then such spaces are exempted from Appraisals 12.1.1 and 12.1.2. For exemption from Appraisals 12.1.1 and 12.1.2, submit the following:

- Floor plans, building elevations, and window sections (in .dwg format)
- Photographs clearly indicating that the windows installed in the building are operable

12.1 Appraisals

12.1.1 Ensure that the minimum requirements of CPCB (National Ambient Air Quality Standards [NAAQS]) for assessing the quality of fresh air are fulfilled.[15]

–1 point

12.1.2 Ensure that the minimum requirements of ASHRAE Standard 62.1–2010, Sections 4–7, Ventilation for Acceptable Indoor Air Quantity (with errata), or NBC 2016, Volume 2, Part 8, Section 3, for quantity of fresh air are met.

–1 point

12.1.3 Ensure continuous monitoring of CO, CO_2, temperature, and RH levels such that they meet the permissible thresholds as per Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE) standard 10001:2016, Table 6, for all habitable areas either at space level or at AHUs by installation of sensor(s) deployed with feedback system as per the alternatives mentioned in Table 12.1 c and 12.2c.

[15] Appraisal 12.1.1 shall cover treatment of outdoor air predominantly for PM_{10} & $PM_{2.5}$.

TABLE 12.1c: Requirements of sensors/monitoring devices and display for maintaining good IAQ

Requirement	Alternative 1 (Space Level)	Alternative 2 (AHU Level)	Points
Sensors/ monitoring devices	Install one sensor for each space ≥30m^2 and ≤100m^2 For spaces >100m^2, install additional sensor for every 100m^2	Install one sensor at each AHU (return air duct)	1
Display	Install digital display showing monitored values for CO, CO_2, temperature, and RH at each floor level (common areas) with permissible thresholds (as per Table 12.2c only for CO and CO_2) and clear visibility for all occupants		1

TABLE 12.2c: Permissible thresholds as per ISHRAE standard 10001:2016

Parameter	Threshold
CO	<9 (ppm)
CO_2	Ambient + 500 (ppm)

12.1.4 Ensure that all interior wall and ceiling finishes (including, but not limited to, primers and paints) have low volatile organic compound (VOC) content as per Table 12.3c and are lead-free.

–Mandatory

TABLE 12.3c: VOC limits for liquid coating

Paint Application	Type of Finish	VOC Limit (g/L)
Interior coatings	Flat	<50
	Non-flat	<150
Exterior coatings	Flat	<200
	Non-flat	<100
Anti-corrosive	Gloss/semi-gloss/flat	<250

12.1.5 Ensure that all adhesives and sealants used have low VOC content as per Tables 12.4c and 12.5c and that interior composite wood products do not have urea–formaldehyde as a bonding resin.

–1 Point

TABLE 12.4c: VOC limits for adhesives

Architectural Adhesive Application	VOC Limit (g/L)
Wood flooring	100
Industrial/rubber flooring	60
Ceramic tiles	65
Structural glazing	100
Multi-purpose construction	70
Sub-floor	50
Wall boards/panels	50
PVC welding	285
Adhesive primer for plastic	250
Structural wood member	140
Sub-specific use metal to metal	30
Wood	30
Fiber glass	80
Plastic foam/porous materials (except wood)	50

TABLE 12.5c: VOC limits for sealants

Sealant Application	VOC Limit (g/L)
Architectural/roadways	250
Single-ply roof material installation/repair	450
Other	420
Sealant primer application architectural non-porous	250
Sealant primer application architectural porous	775
Other sealant primer applications architectural	750

12.1.6 Ensure improved IAQ by adopting a minimum of three strategies from Table 12.6c.

–1 Point

TABLE 12.6c: Suggested strategies for improved IAQ in habitable space

S. No.	Strategy	Requirement
1	Installation of indoor plants	1% of carpet area to be covered by potted plants
2	Promoting use of carpets and mats at all entrances	To capture particulates from occupants' shoes at all regularly used entrance(s) to the project, including doors with pedestrian traffic only to/from terraces or patios (no traffic to/from surrounding grounds), one of the following is installed and is maintained on a weekly basis. Three level of mats Scraper mat: 6ft. (1.83 m) Absorption mat: 6ft. (1.83 m) Finishing mat: 8ft (2.44 m)
3	Use of green cleaning products for housekeeping	Policy/tenant agreement to be formulated elaborating use of green cleaning (green seal or equivalent rated and non-irritant) products in all regularly occupied spaces
4	Installation of separate exhaust system for janitor/storage rooms for chemicals	In conformity with ASHRAE 62.1(2016), Normative Index B, separation of exhaust outlets and indoor air intakes
5	Installation of air curtains	Air curtains to be installed at all major entrances and exits
6	Air sanitization (filtration of microbes, isolation systems, UVGI system, negative air ionization, etc.)	Air sanitation is the system of removing the impurities present in air inside the buildings to protect its occupants from infections. Sanitation of air is essential in enclosed places like in buildings which are conditioned and have non-operable windows to prevent the spread of infections
7	Demand control ventilation	Carbon dioxide or air quality sensors may be used to check the level of pollutants in the occupied space and indicate to the building management system to control the opening of outside air dampers, thereby effectively providing ventilation on demand A demand-controlled ventilation system uses a variable speed drive based on the opening and closure of the fresh air dampers, controlled by the carbon dioxide sensors (refer to NBC 2016, Volume 2, Part 8, Section 3, Clause 11.5.4 and Part 11, Clause 11.6 a) A typical basement exhaust system may use a variable speed drive controlled by carbon monoxide sensors' centrifugal/screw chillers with variable speed drives. Projects in composite climates with 24-hour working schedules may incorporate free cooling systems

12.2 Compliance

12.2.1 Submit documentation detailing the specifications of the filtration system to demonstrate that fresh air quality meets the minimum requirements of CPCB (NAAQS) to demonstrate compliance with Appraisal 12.1.1.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the product demonstrating compliance with Appraisal 12.1.1.

12.2.2 Submit space-by-space heat load calculations highlighting the provision of sufficient fresh air in the HVAC system design as per the ASHRAE 62.1 or NBC 2016, Volume 2, Part 8, Section 3, Clause 6.3.1, Table 3, to demonstrate compliance with Appraisal 12.1.2.

12.2.3 Submit floor plans and/or HVAC system plans (in .dwg format) highlighting the location of various CO, CO_2, temperature, and RH sensors, and digital displays to demonstrate compliance with Appraisal 12.1.3.

12.2.4 Submit technical specification sheets/brochures of the filters, sensors, and digital displays installed in the project to demonstrate compliance with Appraisal 12.1.3.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the product demonstrating compliance with Appraisal 12.1.3.

12.2.5 Submit purchase orders reflecting the full quantities of the filters, sensors, and digital displays installed in the project to demonstrate compliance with Appraisal 12.1.3.

12.2.6 Submit technical specification sheets/brochures of all interior walls and ceiling finishes, highlighting that they have low VOC content and are lead free to demonstrate compliance with Appraisal 12.1.4.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the product demonstrating compliance with Appraisal 12.1.4.

12.2.7 Submit purchase orders reflecting full quantities of all interior walls and ceiling finishes, to demonstrate compliance with Appraisal 12.1.4.

12.2.8 Submit the technical specification sheets/brochures of all adhesives and sealants highlighting that they have low VOC content to demonstrate compliance with Appraisal 12.1.5.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the product demonstrating compliance with Appraisal 12.1.5.

12.2.9 Submit purchase orders reflecting full quantities of all adhesives and sealants to demonstrate compliance with Appraisal 12.1.5.

12.2.10 Submit technical specification sheets/brochures of the bonding resin used in the making of composite wood-based products highlighting that they are urea-formaldehyde free to demonstrate compliance with Appraisal 12.1.5.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the product demonstrating compliance with Appraisal 12.1.5.

12.2.11 Submit purchase orders reflecting full quantities of the bonding resin used in the making of composite wood-based products to demonstrate compliance with Appraisal 12.1.5.

12.2.12 Submit a documentation to demonstrate compliance with the strategies adopted to improve IAQ as per Appraisal 12.1.6.

CRITERION 13

WATER DEMAND REDUCTION

Intent

The intent of this criterion is to reduce overall building and landscape water demand of the project..

Maximum Points: 4

13.1 Appraisal

Building water demand reduction

13.1.1 Demonstrate reduction in building water demand from the GRIHA base case as per Table 13.1c.

TABLE 13.1c: Percentage reduction in building water demand

Reduction from GRIHA Base Case (x)	Points
10% < x ≤ 20%	Mandatory
20% < x ≤ 30%	1
x ≥30%	2

Note: All faucets, which are installed in spaces with water head heights less than 5m/17ft, in a gravity-fed system, are exempt from calculations in Appraisal 13.1.1.

13.1.2 Ensure that all washing equipment (clothes and dishes) are in compliance with GRIHA benchmark (refer to Table 13.5c, Volume 4) for water factor limit

–Indicative

Landscape water demand reduction

13.1.3 Demonstrate reduction in landscape water demand from the GRIHA base case as per Table 13.2c.

TABLE 13.2c: Percentage reduction in landscape water demand

Reduction from GRIHA Base Case (*x*)	Points
50% < *x* < 75%	1
x ≥ 75%	2

13.2 Compliance

Building water demand reduction

13.2.1 Submit calculation(s) using GRIHA building water demand reduction calculator to demonstrate compliance with Appraisal 13.1.1.

13.2.2 Submit technical specification sheets/brochures for all fixtures installed within the project highlighting the flow rates at 45 psi or 3.1 bar pressure to demonstrate compliance with Appraisal 13.1.1.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for all the fixtures installed within the project to demonstrate compliance with Appraisal 13.1.1.

13.2.3 Submit purchase orders reflecting full quantities and model numbers for the low-flow fixtures installed in the project to demonstrate compliance with Appraisal 13.1.1.

13.2.4 Submit the technical specification sheets/brochures for all washing equipment (clothes and dishes) highlighting their water factor limit to demonstrate compliance with Appraisal 13.1.2.

13.2.5 Submit purchase orders reflecting full quantities and model numbers for all washing equipment (clothes and dishes) installed in the project to demonstrate compliance with Appraisal 13.1.2.

13.2.6 Upload date-stamped photographs of low-flow fixtures and washing equipment installed within the project

Landscape water demand reduction

13.2.7 Submit calculation(s) using GRIHA landscape water demand reduction calculator to demonstrate compliance with Appraisal 13.1.3.

13.2.8 Submit a detailed landscape plan (in.dwg format) demarcated with separate polylines of surface finishes indicating the list of plants along with the area statement demonstrating compliance with Appraisal 13.1.3.

13.2.9 Submit technical specification sheets/brochures for the irrigation system(s) highlighting its type and efficiency to demonstrate compliance with Appraisal 13.1.3.

OR

Submit a valid GRIHA Product Catalogue Certificate as applicable for the irrigation system(s) installed on-site to demonstrate compliance with Appraisal 13.1.3.

13.2.10 Submit purchase orders reflecting full quantities and model numbers for the irrigation systems installed on-site to demonstrate compliance with Appraisal 13.1.3.

13.2.11 Submit landscape irrigation plan (.dwg format) indicating the irrigation system installed on-site such as sprinklers, drip irrigation, etc., highlighting the areas to which it caters to demonstrate compliance with Appraisal 13.1.3.

13.2.12 Upload date-stamped photographs of the irrigation system installed on-site.

CRITERION 14

Wastewater Treatment

Intent

The intent of this criterion is to promote grey-water and black-water segregation and further treat them on-site to reduce the project's dependency on freshwater.

Maximum Points: 2

14.1 Appraisal

14.1.1 Ensure that 100% of wastewater generated on-site is treated through either a chemical-based or a natural wastewater treatment system.

–1 Point

14.1.2 Ensure that 100% of wastewater is segregated (into grey water and black water) and treated independently on-site.

–1 Point

Applicability Check – If the wastewater (both black and grey water individually) generated in the project is less than 5KLD, then Appraisals 14.1.1 and 14.1.2 will not be applicable.

To claim non-applicability from Appraisals 14.1.1 and 14.1.2, submit the following:

- Water balance diagram for the project indicating the quantity of wastewater generated on-site and various freshwater intake sources (municipal supply, borewell, tanker, stored rainwater, etc.).
- Detailed calculations showing various demand/supply values considered in water balance diagram along with reference(s).

14.2 Compliance

14.2.1 Submit technical specification sheets/brochures for wastewater treatment system installed on-site highlighting its type, capacity, efficiency and sludge disposal to demonstrate compliance with Appraisals 14.1.1 and 14.1.2.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for wastewater treatment systems installed on-site to demonstrate compliance with Appraisals 14.1.1 and 14.1.2.

14.2.2. Submit purchase orders/work order highlighting the capacity and technology of the wastewater treatment system installed on-site to demonstrate compliance with Appraisals 14.1.1 and 14.1.2.

14.2.3 Upload contextual photographs of wastewater treatment systems installed on-site to demonstrate compliance with Appraisals 14.1.1 and 14.1.2.

14.2.4 Submit calculation demonstrating the amount of blackwater and greywater generated from the project.

14.2.5 Submit a detailed plumbing design basis report indicating wastewater treatment system details to demonstrate compliance with Appraisals 14.1.1 and 14.1.2.

CRITERION 15

RAINWATER MANAGEMENT

Intent

The intent of this criterion is to manage rainwater efficiently to minimise run-off generated from the project.

Maximum Points: 5

15.1 Appraisal

15.1.1 Demonstrate that the post-construction storm-water run-off from the site is being managed within the GRIHA project boundary as per Table 15.1c based on the peak hourly rainfall (mm/h).

TABLE 15.1c: Percentage of storm-water runoff managed on-site

Post-construction Storm-Water Runoff Managed On-site (x)	Points
$25\% \leq x < 50\%$	1
$50\% \leq x < 75\%$	2
$75\% \leq x < 100\%$	4
$x = 100\%$	5

15.2 Compliance

15.2.1 Submit site plan (.dwg format) demarcated with the separate polylines of surface finishes, and provide a detailed area statement for the verification of all areas considered in the calculation.

15.2.2 Submit soil percolation test report highlighting the percolation rate of soil of the site.

15.2.3 Submit calculation(s) using GRIHA rainwater management calculator.

15.2.4 Submit storm-water drainage plan (.dwg format) for the site indicating the location of rainwater storage tank or/and harvesting pit on-site.

15.2.5 Submit drawings (.dwg format) depicting cross-section and plan of rainwater storage tank or/and harvesting pit on-site.

CRITERION 16

Water Quality and Self-Sufficiency

Intent

The intent of this criterion is to evaluate both the quality and the quantity of water available for a project to push it towards becoming self-sufficient (net zero) and reduce dependency on municipal or ground water sources.

Maximum Points: 5

16.1 Appraisal

16.1.1 Ensure that the project meets water quality norms for drinking/domestic use as per BIS 10 500 : 2012 and treated water for irrigation and discharge should be as per the CPCB (refer to Table 16.2c -16.9c, Volume 4)

–Mandatory

16.1.2 Ensure that the project demonstrates reduction from GRIHA benchmark WPI(Water Performance Index) as per Table 16.1c.

TABLE 16.1c: Percentage reduction from GRIHA benchmark for WPI

Reduction from GRIHA Base Case (*x*)	Points
10% ≤ *x* < 25%	1
25% ≤ *x* < 50%	2
50% ≤ *x* < 75%	4
x ≥ 75%	5

Note: WPI does not include water requirement for medical procedures and luxury practices such as swimming pool, steam bath.

16.2 Compliances

16.2.1 Submit third-party (from labs accredited by NABL) water quality test reports for water used for various purposes in the project demonstrating compliance with Appraisal 16.1.1..

16.2.2 Submit the calculations using GRIHA WPI calculator to demonstrate reduction from GRIHA benchmark as per Appraisal 16.1.2.

16.2.3 Submit a water balance diagram for the project indicating the quantity of wastewater generated on-site and various freshwater intake sources (municipal supply, borewell, tanker, stored rainwater, etc.) demonstrating compliance with Appraisal 16.1.2.

16.2.4 Submit date-stamped photographs along with descriptions of various measures implemented on-site to reduce the WPI of the project demonstrating compliance with Appraisal 16.1.2.

CRITERION 17

Waste Management—Post Occupancy

Intent

The intent of this criterion is to provide the necessary infrastructure to future occupants of the project so that they can sustainably manage on-site solid waste during the operation phase and comply with the statutory norms for disposal in a way that augments resource recovery.

Maximum Points: 4

17.1. Appraisal

17.1.1 **Demonstrate compliance with all relevant government-notified waste management rules.[19]**

—Mandatory

All the entities listed in Table 17.1c are considered bulk consumers and they need to mandatorily comply with the designated waste management rules.

TABLE 17.1c: List of bulk consumers of respective waste typology

Bio-Medical Waste	E-waste	Hazardous Waste	Plastic Waste
Hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathological laboratories, blood banks, clinical establishments, research or educational institutions, health camps, medical or surgical camps, vaccination camps, blood donation camps, first-aid rooms in schools, forensic laboratories, and research labs generate bio-medical waste. Comply with all duties of Occupier as per the Bio-Medical Waste (M) Rules 2016 (Appendix 6A.1, Volume 4)	Central government or state government departments, public sector undertakings, banks, educational institutions, multinational organizations, international agencies, partnership, and public or private companies that are registered under the Factories Act (63 of 1948) and the Companies Act, 2013 (18 of 2013) and healthcare facilities that have a turnover of more than 1 crore or have more than 20 employees (Appendix 6A.2, Volume 4)	Any project (e.g., research laboratories, testing facilities, etc.) that involve processes as per Schedule I and/ or generate waste in concentrations as per Schedule II of Hazardous Waste Management Rules 2016 (Appendix 6A.3, Volume 4)	All waste generators, local bodies, Gram Panchayats, manufacturers, Importers and producers. (Appendix 6A.5, Volume 4)

[19] Comprising but not limited to SWM Rules 2016, E-Waste Management Rules 2016, Hazardous Waste Management Rules 2016, Bio-Medical Waste Management Rules 2016, Plastic Waste Management Rules 2016, Battery (Management and Handling) rules, (Amendment) 2010. Refer to Appendix 6A.1-6A.6, Volume 4 for duties of the generator/occupiers for handling different types of waste.

17.1.2 Provide infrastructure (multi-coloured waste bins/different refuse chutes to store e-waste, biomedical waste, organic waste, plastic waste, paper waste, and other inorganic solid waste) for building occupants to ensure segregation of waste at the source.

17.1.3 Ensure that dedicated, segregated, and hygienic storage spaces are provided within the project site (for different types of waste listed in Appraisal 17.1.2) before treatment/ recycling.

17.1.4 Provide contractual tie-ups with waste recyclers for safe handling and recycling of all types of inorganic waste generated on site. Also, ensure that 100% of recyclable waste is recovered/diverted (by means of recycling/processing through dedicated recyclers) and other inorganic waste (apart from recyclable waste) should be disposed off through authorized vendors.

– Together 4 Points [17.1.2, 17.1.3, and 17.1.4]

17.2 Compliance

17.2.1 Submit a copy of the agreement/tender document for the facility management team highlighting the practices for SWM to be adopted on site (segregation, collection, and transportation). Additionally, ensure that it includes clauses to demonstrate compliance with all applicable waste management rules as per appraisal 17.1.1.

17.2.2 Submit the SWM plan for the project—detail of the sizing of segregated waste storage facilities, strategy for primary and secondary collection, and storage to demonstrate compliance with Appraisal 17.1.2 and 17.1.3. Refer Appendix 6B, Volume 4 for the waste bin guidelines for different buildings and spaces.

17.2.3 Submit a site plan (.dwg format) and building floor plans (.dwg format) indicating the location of various primary (multi-coloured waste bins) and secondary storage facilities to demonstrate compliance with Appraisal 17.1.2 and 17.1.3.

17.2.4 Submit purchase orders reflecting full quantities of all bins to be placed at refuse chamber/ waste storage facilities, specifically highlighting their sizing specifications to demonstrate compliance with Appraisal 17.1.2 and 17.1.3.

17.2.5 Submit documents highlighting contractual tie-ups with recyclers for ensuring safe recycling of recyclable inorganic wastes along with their quantities to demonstrate compliance with Appraisal 17.1.4.

17.2.6 Submit estimated calculations demonstrating percentage of inorganic waste that is targeted to be recovered by either recycling or processing to demonstrate compliance with Appraisal 17.1.4. (as per Table 17.3c, Volume 4)

17.2.7 Maintain duly filled forms as per Appendices 6C, 6D and 6E, Volume 4 for keeping records of e-waste, hazardous waste and battery waste handled or generated that would be verified during the additional site visits.

17.2.8 Upload date-stamped photographs with description of the measures implemented.

CRITERION 18

Organic Waste Treatment

Intent

The intent of this criterion is to divert organic waste from landfill sites by adopting strategies for treating it (preferably on-site otherwise off-site) and thereby mitigating its adverse effects on the surrounding environment.

Maximum Points: 2

18.1 Appraisal

18.1.1 Ensure that the organic waste generated on-site from the building (as per Criterion 17) and landscape areas is quantified, and adopt strategies to treat 100% organic waste onsite/ offsite/combination of onsite and offsite to convert it into usable resources (manure, biogas, etc.).

–2 Points

18.2 Compliance

18.2.1 Submit narrative detailing the strategies adopted for organic waste treatment, design and sizing of the organic waste treatment system installed (if on-site) along with supporting date stamped contextual photographs.

Onsite treatment

18.2.2 Maintain log books highlighting the quantity of the by-product (compost/biogas) used on-site, which would be validated during the additional site visits.

18.2.3 Submit site plan/building plan (.dwg format) highlighting the location of organic waste treatment plant on-site if applicable.

18.2.4 Submit purchase orders of the organic waste treatment system installed on-site.

18.2.5 Submit technical specification sheet/brochure specifying the capacity of the system along with its model number.

Or

Submit a valid GRIHA Product Catalogue certificate, as applicable for the product.

Offsite treatment

18.2.6 Submit a copy of challans/receipts/ contract document/photographs, etc. demonstrating the treatment of organic waste outside the site.

18.2.7 Submit supporting documents (such as reports, certificates, website display, etc.) from the treatment agency on the treatment strategies adopted, to demonstrate compliance.

CRITERION 19

Utilization of Alternative Materials in Building

Intent

The intent of this criterion is to encourage use of alternative materials, which minimize the detrimental impact of construction on environment by conserving natural resources, further minimizing the use of virgin materials and diverting usable (as per industry standards) wastes from the landfills to the construction industry.

Maximum Points: 5

19.1 Appraisals

Structural system[21]

19.1.1 Ensure minimum replacement of Ordinary Portland Cement (OPC) with the Bureau of Indian Standards (BIS) recommended waste materials by weight of cement used in structural concrete as per Table 19.1c.

Table 19.1c: Replacement benchmarks for structural system

Replacement Benchmark	Points
$20\% \leq x < 30\%$	1
$x \geq 30\%$	2

19.1.2 Ensure minimum 5% replacement of natural aggregate with recycled concrete aggregate (RCA)/recycled aggregate (RA) by weight of that category of aggregate in structural concrete.

–1 Point

Load-bearing and non-load-bearing walls

19.1.3 Ensure that all internal and external, load-bearing, non-load-bearing and partition walls are constructed with any, or combination of the below listed, alternative materials:

–1 Point

- Concrete blocks (hollow, solid, or AAC) with minimum 40% fly ash content by weight
- Hollow clay blocks
- Adobe bricks/stabilized adobe/CSEB/stabilized mud blocks
- Rammed earth walls
- Stones from India (not including stone cladding)
- Bamboo/any other rapidly renewable material (not including bamboo cladding)

[21] Structural system will include both substructure and superstructure.

» Monolithic concrete wall demonstrating minimum 20% replacement of OPC with BIS recommended waste material by weight of cement

» C&D waste blocks demonstrating minimum 30% C&D waste material by weight

» Dry walls/boards with minimum 5% recycled content by weight

Masonry mortar and plaster

19.1.4 Ensure minimum 30% replacement of OPC with BIS recommended waste by weight of cement used in masonry mortar and plaster.

–1 Point

Applicability Check: Projects where both cement mortar and plaster have not been used are exempted from Appraisal 19.1.4.

To exempt the project from Appraisal 19.1.4, please submit the following:

- Tender document along with date-stamped photographs highlighting the type of wall to be constructed, and the type of binding and finishing agent used for the same.
- Purchase orders reflecting full quantities of the alternative materials and the type of binding and finishing agent used for the same.

19.2 Compliance

Structural system

19.2.1 Submit a design mix report of each grade of concrete highlighting the technical properties of the ingredients to demonstrate compliance with Appraisal 19.1.1 and 19.1.2.

19.2.2 Submit a batch mix report for each grade of concrete to demonstrate compliance with Appraisal 19.1.1.

19.2.3 Submit a signed and stamped BOQ (relevant section only) highlighting the quantity of each grade of concrete used in the structural system to demonstrate compliance with Appraisal 19.1.1.

19.2.4 Submit a third-party test report of PPC highlighting the quantity of Pozzolana in the same to demonstrate compliance with Appraisal 19.1.1.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the product to demonstrate compliance with Appraisal 19.1.1.

19.2.5 Submit calculation of the replacement benchmark achieved, in excel format, to demonstrate compliance with Appraisal 19.1.1 and/or Appraisal 19.1.2

19.2.6 Submit purchase orders reflecting full quantities of recycled aggregates along with declaration from the manufacturer highlighting the source and process of manufacturing these aggregates to demonstrate compliance with Appraisal 19.1.2.

Load-bearing and non-load-bearing walls

19.2.7 Submit purchase orders reflecting full quantities of all types of materials used for constructing walls to demonstrate compliance with Appraisal 19.1.3.

19.2.8 Submit a signed and stamped BOQ (relevant section only) highlighting the quantity and type of material to be used for construction of all walls as mentioned in Appraisal 19.1.3.

19.2.9 In case concrete blocks are used for walls, submit a mix design of the blocks highlighting the BIS-recommended waste content in the same to demonstrate compliance with Appraisal 19.1.3.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the product to demonstrate compliance with Appraisal 19.1.3.

19.2.10 In case of monolithic concrete walls and shear walls, submit batch mix and design mix reports of concrete highlighting replacement of OPC with BIS-recommended waste material to demonstrate compliance with Appraisal 19.1.3.

19.2.11 In case of dry wall construction, submit technical specifications/brochures of the material highlighting recycled content in the same to demonstrate compliance with Appraisal 19.1.3.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the product to demonstrate compliance with Appraisal 19.1.3.

19.2.12 Submit date-stamped photographs showing type of material used for constructing walls as mentioned in Appraisal 19.1.3.

Masonry mortar and plaster

19.2.13 Submit calculation of the percentage of replacement made, in excel format, to demonstrate compliance with Appraisal 19.1.4.

19.2.14 Submit purchase orders reflecting the quantities of PPC and/or ready-mix plaster used for masonry mortar and plaster work in the project to demonstrate compliance with Appraisal 19.1.4.

19.2.15 Submit signed and stamped BOQ (relevant section only) highlighting the type of cement and mix proportion used for mortar and plaster to demonstrate compliance with Appraisal 19.1.4.

19.2.16 Submit a third-party test report of PPC and/or ready-mix plaster highlighting the quantity of Pozzolana in the same to demonstrate compliance with Appraisal 19.1.4.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the product to demonstrate compliance with Appraisal 19.1.4.

CRITERION 20

Reduction in Global Warming Potential through Life Cycle Assessment

Intent

The intent of this criterion is to reduce the impact of material selection on the environment and encourage the project to optimize construction product consumption efficiency by selecting low GWP ($kgCO_2eq$) products through LCA of the building.

Maximum Points: 5

20.1 Appraisals*

20.1.1 Demonstrate reduction in the GWP value of the building superstructure as per the LCA benchmarks mentioned in Table 20.1c.

Table 20.1c: Reduction from the GRIHA LCA benchmark

Reduction from the GRIHA LCA Benchmark (x)	Points
$10\% \leq x \leq 15\%$	1
$x > 15\%$	2

20.1.2 Demonstrate reduction in the GWP value of the building interiors and finishes as per the LCA benchmarks mentioned in Table 20.2c.

Table 20.2c: GWP reduction benchmark for building interiors and finishes

Reduction from the GRIHA LCA Benchmark (x)	Points
$10\% \leq x \leq 15\%$	1
$15\% < x \leq 30\%$	2
$x > 30\%$	3

**To ensure a fair comparison, GRIHA base case is to be prepared uniquely for each project considering the same size, function, orientation, material quantities, and operating energy performance of the building to the design case.*

20.2 Compliance

20.2.1 Submit a Life Cycle Assessment report (using a third party LCA Calculator) for each individual material as per Table 20.4c. The stages to be considered for computing the GWP values are mentioned in Table 20.3c.

OR

Submit GRIHA report (using the GRIHA online panel) demonstrating calculations for reduction in the GWP in accordance with the LCA thresholds mentioned in the appraisals.

20.2.2 Submit Google Maps images highlighting the road distance from the manufacturing source of each material to the site, along with a narrative explaining the same.

20.2.3 Submit GRIHA report (using the GRIHA online panel) demonstrating calculations for reduction in the GWP in accordance with the LCA thresholds mentioned in the appraisals.

20.2.4 Submit building floor plans, sections and elevations (drawings in .dwg format) with dimensions and legends highlighting the use of materials which have a lower GWP.

20.2.5 Submit purchase orders reflecting full quantities of all low GWP materials used in the project.

20.2.6 Submit a signed and stamped BOQ (relevant sections only) highlighting the quantities of all the materials used in the project as per Table 20.4c, Volume 5.

20.2.7 Submit technical specification sheets/brochures and/or Environmental Product Declaration (EPD) of the materials used in the building superstructure, interiors, and finishes.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the product.

20.2.8 Submit date-stamped photographs demonstrating the use of materials specified in aforementioned appraisals.

CRITERION 21

Alternative Materials for External Site Development

Intent

The intent of this criterion is to substitute conventional materials used for external site development with alternative materials, in order to reduce pressure on both mining for virgin materials and landfills required for the disposal of waste material.

Maximum Points: 2

21.1 Appraisals

21.1.1 Ensure that at least 70% of all roads and vehicular pathways within site premises are constructed with one, or any combination, of the following:

–1 Point

» Bituminous road with minimum 6% plastic waste content by weight of bitumen

» Cast *in-situ* cement concrete road with minimum 30% fly ash content by weight of total cementitious material

» Concrete blocks with minimum 40% fly ash content by weight of block

» Paver blocks containing minimum 10% C&D waste content by weight of block

» Stones from India

» Any other product with minimum 10% recycled content by weight.

21.1.2 Ensure that 100% of the pavement/footpath including kerb stone constructed on-site are constructed with one, or any combination, of the following:

–1 Point

» Bituminous pavement with minimum 6% plastic waste by weight of bitumen

» Cast *in-situ* concrete with minimum 30% fly ash content by weight of total cementitious material

» Concrete blocks with minimum 40% fly ash content by weight of block

» Paver blocks containing minimum 10% C&D waste content by weight of material

» Stones from India

» Any other product with minimum 10% recycled content by weight

21.2 Compliance

21.2.1 Submit signed and stamped tender document/BOQ (relevant section only) highlighting the materials to be used for construction of roads, vehicular pathways, pavements/ footpaths, and kerb stone.

21.2.2 Submit purchase orders reflecting full quantities of kerb stone and blocks/tiles/stones used for construction of roads, vehicular pathways, pavements, footpaths, etc. in the project.

21.2.3 Submit a site plan (drawings in .dwg format) highlighting length and width of the total roads, vehicular pathways, pavement, footpaths, etc., constructed in the project along with legends highlighting the materials used in the same.

21.2.4 Submit calculations in excel format indicating compliance.

For bituminous roads and/or pavements

21.2.5 Submit purchase orders reflecting full quantities and types of plastic waste procured.

21.2.6 Submit a job mix report of bituminous road and/or pavement highlighting the ingredients used in the same.

21.2.7 Submit date-stamped photographs of plastic waste used.

For cast in-situ concrete roads, and/or pavements

21.2.8 Submit design mix report of concrete highlighting technical properties of the ingredients.

21.2.9 Submit batch mix report of concrete.

For concrete blocks, roads and/or pavements

21.2.10 Submit a design mix report of concrete blocks highlighting the weight of each ingredient used in the same.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the product.

For roads and/or pavements made with paver blocks containing C&D waste

21.2.11 Submit brochure/C&D waste procurement receipt from the manufacturer/grant given to the manufacturer to procure C&D waste by a local government body.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the product.

For roads and/or pavements made with paver blocks containing other recycled materials

21.2.12 Submit technical specifications/brochures/relevant BIS compliance certificates or other equivalent international standards such as American Society for Testing and Materials (ASTM) and European Standards (EN) mentioning the use of recycled content in the product.

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the product.

CRITERION 22

Life Cycle Cost Analysis

Intent

The intent of this criterion is to assess the payback period for the cumulative strategies adopted across various sections: energy efficiency, water management, and sustainable building materials for enhancing the 'greenness' of the project.

Maximum Points: 5

22.1 Appraisal

22.1.1 Demonstrate using the GRIHA LCC calculator that the cumulative discounted payback period for the project (for the life stages defined in Table 22.2c, Details to Appraisals, Volume 5, Details of appraisal) is below the GRIHA benchmarks as per Table 22.1c.

Table 22.1c: GRIHA benchmarks for cumulative discounted payback period

Cumulative Discounted Payback Period for the Project (x)	Points
10 years $\geq x >$ 8 years	1
8 years $\geq x >$ 6 years	3
$x \leq$ 6 years	5

22.2 Compliance

22.2.1 Submit calculations to demonstrate the reduction in the cumulative discounted payback period for the project on GRIHA LCC calculator using LCC analysis from a third party consultant.

22.2.2 Submit LCC analysis report from a third party consultant.

Material parameters

22.2.3 Submit signed and stamped BOQ (relevant sections only), highlighting the materials used in the project (as per Table 22.3c, Details to Appraisals, Volume 5).

22.2.4 Submit purchase orders reflecting full quantities with the cost of the materials used in the project (as per Table 22.3c, Details to Appraisals, Volume 5).

22.2.5 Submit design mix reports and batch mix reports of all grades of concrete and steel used in the superstructure along with their respective quantities.

22.2.6 Submit technical specification sheets/brochures of the materials used in the building envelope (as per Table 22.3c, Details to Appraisals, Volume 5).

OR

Submit a valid GRIHA Product Catalogue certificate as applicable for the products.

22.2.7 Submit building floor plans, elevations, and sections in .dwg format with legends demarcating the location of the materials installed in the project.

Energy parameters

22.2.8 Submit signed and stamped BOQ (relevant sections only) highlighting the source of procurement of various systems and components of HVAC and interior lighting installed in the project (as per Table 22.3c, Details to Appraisals, Volume 5).

22.2.9 Submit purchase orders reflecting full quantities with the cost of various systems and components of HVAC, and interior lighting installed in the project (as per Table 22.3c, Details to Appraisals, Volume 5).

22.2.10 Submit technical specification sheet/brochure of indoor lighting (lamps, ballasts, and luminaires) highlighting luminous efficacy (as per Table 22.3c, Details to Appraisals, Volume 5).

OR

Submit valid GRIHA Product Catalogue certificate as applicable for the products.

22.2.11 Submit technical specification sheet/brochure of HVAC system highlighting chiller type, capacity, COP and IPLV or BEE or equivalent labelling for unitary, split, packaged air conditioners indicating the system type and its cooling capacity.

OR

Submit valid GRIHA Product Catalogue certificate as applicable for the products.

Renewable energy parameters

22.2.12 Submit signed and stamped BOQ (relevant sections only) highlighting the source of procurement of the renewable energy system installed on-site (as per Table 22.3c, Details to Appraisals, Volume 5).

22.2.13 Submit purchase orders reflecting full quantities with the cost of the renewable energy system installed on-site (as per Table 22.3c, Details to Appraisals, Volume 5).

22.2.14 In the case of on-site installation of renewable energy system, submit site plan in .dwg format demarcating its location.

22.2.15 Submit technical specification sheet/brochure of the installed renewable energy system on-site (as per Table 22.3c, Details to Appraisals, Volume 5).

OR

Submit valid GRIHA Product Catalogue certificate as applicable for the products.

22.2.16 In the case of off-site installation, submit Renewable Energy Certificates (RECs) or Power Purchase Agreement (PPA) from the utility for the purchase of green power highlighting the cost involved.

Water parameters

22.2.17 Submit signed and stamped BOQ (relevant sections only) highlighting the water fixtures, irrigation systems, rainwater harvesting system for water storage, STP/WTP/ETP installed on-site (as per Table 22.3c, Details to Appraisals, Volume 5).

22.2.18 Submit purchase orders reflecting full quantities with the cost of the water fixtures, irrigation systems, rainwater harvesting system for water storage, STP/WTP/ETP on-site (as per Table 22.3c, Details to Appraisals, Volume 5).

22.2.19 Submit signed and stamped BOQ (relevant sections only) highlighting each type of vegetation, such as shrubs, trees, grass, planted on-site.

22.2.20 Submit purchase orders reflecting full quantities with cost of each type of vegetation, such as shrubs, trees, grass, planted on-site.

22.2.21 Submit technical specification sheet/brochure of water-efficient fixtures highlighting flow rates, irrigation systems, STP/WTP/ETP installed in the project highlighting system capacities.

OR

Submit valid GRIHA Product Catalogue certificate as applicable for the products.

22.2.22 Submit site plan (.dwg format) demarcating the location of rainwater storage tanks, STP/WTP/ETP on-site.

22.2.23 Submit landscape plan in .dwg format with legend highlighting all existing and newly planted vegetation, and polylines demarcating the soft cover.

Note: The project team must maintain consistency in documents submitted across energy optimization, water management, sustainable building material, and LCC sections.

CRITERION 23

Safety and Sanitation for Construction Workers

Intent

The intent of this criterion is to ensure safe, healthy, and hygienic working and living conditions for construction workers involved in the project.

Maximum Points: 1

23.1 Appraisals

23.1.1 Ensure compliance with the requirements of NBC 2016 for all of the following:

–Mandatory

Part 1: Provision of necessary safety equipment and safety measures for construction workers.

Part 2: Provision of clean drinking water, hygienic working and living conditions, and sanitation facilities for the workers.

Part 3: Provision of crèche facility for children of construction workers in case their families are allowed to work/live at the construction site.

Applicability check: If there are only male workers employed and residing on site, the project is exempt from Appraisal 23.1.1 - Part 3.

Note: In case of employment of female workers, provision of crèche facility is mandatory irrespective of whether the workers are daily wage labourers or employed for a fixed tenure.

23.1.2 Adopt one alternative out of the following for the construction workers on-site.

–1 Point

Alternative 1: Provide a grocery store/canteen within the site premises and/or labour accommodation.

Alternative 2: Organize at least two events during the entire construction phase to create environmental awareness among the construction workers.

23.2 Compliance

23.2.1 Submit tender document highlighting the measures to be taken by the contractor during the construction phase to demonstrate compliance with Appraisals 23.1.1 and 23.1.2.

23.2.2 Submit drinking water test reports conducted periodically, demonstrating that the water provided to workers meets the relevant Bureau of Indian Standards (BIS) drinking water norms to demonstrate compliance with Appraisal 23.1.1.

23.2.3 Submit narrative and date-stamped photographs of the measures adopted by the project team to demonstrate compliance with Appraisals 23.1.1 and 23.1.2.

Note: Compliance with Appraisals 23.1.1 and 23.1.2 would be verified during site visit I and II. Please refer to, Rating Process, for more details.

CRITERION 24

Universal Accessibility

Intent

The intent of this criterion is to encourage the adoption of measures that make the built environment barrier free and accessible to all, including people with disabilities and elderly persons.

Maximum Points: 2

24.1 Appraisal

24.1.1 Ensure that the project complies with the provisions of Harmonised Guidelines and Space Standards for Barrier Free Built Environment for Persons with Disability and Elderly Persons, 2016.

–2 Points

24.2 Compliance

24.2.1 Submit drawings of sections, details, floor plan and site plan in .dwg format demonstrating that the project incorporates design measures as per Harmonised Guidelines and Space Standards for Barrier Free Built Environment for Persons with Disability and Elderly Persons, 2016.

24.2.2 Submit a narrative along with date-stamped photographs highlighting the measures implemented in the project.

CRITERION 25

Dedicated Facilities for Service Staff

Intent

The intent of this criterion is to promote a better working environment for service staff by providing dedicated rooms for resting and toilets for them to ensure equity at work.

Maximum Points: 2

25.1 Appraisals

25.1.1 Ensure the provision of dedicated room(s) for resting for service staff on-site.

–1 Point

25.1.2 Ensure the provision of toilets on-site for service staff as per fixtures mentioned in NBC 2016, Volume 2, Part 9, Section 2, Clause 4.2 (refer to Table 25.1c, Volume 6).

–1 Point

25.2 Compliance

25.2.1 Submit drawings of sections and floor plans with area statement (drawing in .dwg format) highlighting the location of room/s and toilets for service staff to demonstrate compliance with Appraisals 25.1.1 and 25.1.2.

25.2.2 Submit calculations indicating the total number of service staff based on the building occupancy and the total number of water closets (WCs), washbasins, urinals provided for service staff to demonstrate compliance with Appraisal 25.1.2.

25.2.3 Submit a narrative along with date-stamped photographs highlighting the location of room/s and toilets for service staff to demonstrate compliance with Appraisals 25.1.1 and 25.1.2.

CRITERION 26

Positive Social Impact

Intent

The intent of this criterion is to create a healthy environment by ensuring adoption of measures for clean indoor and outdoor air and raising environmental awareness amongst building occupants and the community.

Maximum Points: 3

26.1 Appraisals

Environmental awareness—Post occupancy

26.1.1 On-site: Ensure that the project adopts one measure on-site to create environmental awareness amongst its occupants and visitors.

–1 Point

26.1.2 Adopt one alternative out of the following for environmental awareness post occupancy:

Alternative 1 (On-site): Ensure that the project adopts an additional (to 26.1.1.) measure for occupants and visitors to create environmental awareness.

Alternative 2 (Off-site): Ensure that the project conducts a minimum of 2 programmes in a year to create environmental awareness amongst general masses.

–1 Point

Tobacco smoke control

26.1.3 Demonstrate that the project team has implemented tobacco smoke control measures in case of air-conditioned and non-air-conditioned buildings as per the alternatives mentioned below:

–Mandatory

Alternative 1: Ensure that tobacco smoking is prohibited within the site premises.

Alternative 2: Ensure that designated smoking zone(s) is provided and the smoke is managed within a controlled environment (in case of air-conditioned buildings). Additionally, smoking must be prohibited in public spaces.

26.1.4 Ensure that tobacco smoking is prohibited on-site during the entire construction phase.

–Mandatory

Liveability index

26.1.5 Ensure that the per capita availability of green spaces for the project site is more than GRIHA benchmark of minimum 9m^2 of green space per capita.

–1 Point

Note: Green spaces include trees and shrubs. It excluded lawns, play areas, sitting/resting area, grass pavers, waterbodies, etc.

26.2 Compliance

Environmental awareness

26.2.1 Submit a narrative along with date-stamped photographs highlighting strategies implemented on-site/off-site to create environmental awareness to demonstrate compliance with Appraisals 26.1.1 and 26.1.2.

26.2.2 Submit a policy document/agreement for off-site environmental awareness programmes conducted by project team highlighting the details of the programmes to demonstrate compliance with Appraisal 26.1.2.

Tobacco and smoke control

26.2.3 Submit drawings in .dwg format indicating the locations of permanent no-smoking signage within the site premises to demonstrate compliance with Appraisal 26.1.3.

26.2.4 **Alternative 1:** Submit a policy to prohibit tobacco smoking within the site premises along with date-stamped photographs (of no-smoking signage) to demonstrate compliance with Appraisal 26.1.3.

Alternative 2: Submit a policy to restrict tobacco smoking to the designated zone(s) within the site premises along with date-stamped photographs of permanent no-smoking signage in public spaces to demonstrate compliance with Appraisal 26.1.3.

26.2.5 **For air-conditioned spaces:** Submit drawings in .dwg format indicating the location of dedicated smoking zone(s) within site premises separated from the non-smoking areas by full height impermeable internal partitions to demonstrate compliance with Appraisal 26.1.3.

For non-air-conditioned spaces: Submit drawings in .dwg format indicating the location of designated smoking zone(s) marking air inlets and outlets for ventilation to demonstrate compliance with Appraisal 26.1.3.

26.2.6 **For air-conditioned spaces:** Submit a signed template by heating, ventilation, and air conditioning (HVAC)/architectural consultant certifying that the following conditions are met:

- Designated smoking areas are independent of non-smoking areas within the building.
- Smoking zone is directly exhausted outside such that there is no recirculation of the tobacco smoke-containing air in the non-smoking zone of the building.
- Smoking zone is operated on a separate ventilation system, with higher ventilation rates than the non-smoking areas and is designed for at least 600CFM (cubic feet per minute).

- Smoking zone operates at a negative pressure compared to the surrounding non-smoking zone.

26.2.7 Submit a policy to prohibit tobacco smoking within the site premises during the construction phase along with date-stamped photographs of no-smoking signage to demonstrate compliance with Appraisal 26.1.4.

Note: Compliance with Appraisal 26.1.4. would be verified during site visit I and II. Please refer to Rating Process, Step III for more details.

Liveability index

26.2.8 Submit a site plan in .dwg format along with date-stamped photographs indicating external development including green spaces to demonstrate compliance with Appraisal 26.1.5.

26.2.9 Submit calculations indicating the provision of green space to be more than the GRIHA benchmark to demonstrate compliance with Appraisal 26.1.5.

CRITERION 27

Project Commissioning

Intent

The intent of this criterion is to ensure that all electro-mechanical systems and their components are designed and installed according to the operational requirements of the owner.

Maximum Points: Zero

27.1 Appraisal

27.1.1 Ensure that third-party commissioning is conducted for the systems mentioned in Table 27.1c.

–Mandatory

TABLE 27.1c: Systems to be commissioned

System Type	Description
HVAC*	» Low side: Air handling unit, fan coil units, cassette units, floor-mounted units » High side: Chillers, cooling towers, primary and secondary pumps » Boilers: Service hot water, electric/gas/oil-based boilers
Lighting and electrical	» All circuits, sensors (occupancy, day-lighting, etc.) » Transformers » Diesel generator set » Low-tension panel » Renewable energy system
Water	» Water pumps and motors » Treatment plant (sewage treatment plant/water treatment plant/ effluent treatment plant)
Waste	» Organic waste composter » Vermi-composters » Garbage chute » Other mechanical waste disposal/treatment systems

*These include all types of HVAC systems not limiting to ones listed in this table. Therefore, all HVAC systems installed in the project will need to be commissioned.

27.1.2 Ensure that a commissioning plan is developed and implemented for the systems as given in Table 27.1c. Additionally, maintain a record of finding logs and their rectification during the entire period of construction, installation, and functional testing of systems.

–Mandatory

27.2 Compliance

27.2.1 Submit a document comprising an introduction to purpose and a general summary of the commissioning plan.

27.2.2 Submit a document comprising general information with an overview of the project emphasizing key delivery method characteristics, such as owner's project requirement (OPR) and basis of design.

27.2.3 Submit a commissioning plan consisting of the following:

- Commissioning scope including systems, subsystems, and equipment as per Table 27.1c
- A list of project-specific commissioning team members along with a hierarchy chart
- Communication plans, protocols, and documentation of the communication channels to be used throughout the project
- A detailed commissioning process describing project-specific tasks to be accomplished during the planning, design, construction, and tenant-occupancy stage with associated roles and responsibilities

27.2.4 Submit a project-specific commissioning schedule comprising specific sequences of events and their relative time frames, dates, and durations.

27.2.5 Submit a final commissioning report highlighting expectations, finding logs, rectification decisions, and performance of systems and equipment. It is recommended to maintain an issue and- benefits log throughout the commissioning process.

CRITERION 28

Smart Metering and Monitoring

Intent

The intent of this criterion is to promote smart metering and monitoring of energy and water consumption of the project to analyze its performance.

Maximum Points: 7

28.1 Appraisal

28.1.1 Demonstrate compliance with the source metering requirements as mentioned in Table 28.1c.

–Mandatory

TABLE 28.1c: Source metering requirements

Source	Description
Energy	Ensure regular monitoring of the project's energy consumption by installing digital meters at the following point sources at the project level for: » Utility grid » On-site renewable energy system » Diesel generator set, gas genset, etc. » Each building level (at each apartment level for residential and at each tenant level for retail and office buildings)
Water	Ensure regular monitoring of the project's water consumption by installing digital meters at the following point sources: » Municipal supply » Borewell » Treated water outlet from sewage treatment plant (grey/black) » Captured rainwater for reuse in project

28.1.2 Demonstrate compliance with the extended metering requirements as mentioned in Table 28.2c.

–2 points

TABLE 28.2c: Extended metering requirements

Source	Description	Points
Energy	Digital energy meters to be installed at the following points to monitor energy consumption: » Office/institutional/retail/transit terminals/healthcare/hospitalities: • Heating, ventilation and air conditioning central plant: Air handling unit, cooling tower, chillers [British thermal unit meters/multi-function metering, and/or distributed units (split/window ACs)] • Lighting (indoor and outdoor) • Basement parking lighting » Residential • For basement parking lighting, community/recreation centre, water pumping, outdoor lighting • Lifts and common areas	1
Water	Digital water meters to be installed at the following points to monitor water consumption: » Flushing (at each building level) » Domestic (at each building level) » Irrigation » Heating, ventilation and air conditioning	1

28.1.3 Ensure installation of smart metering[22] systems (refer to Table 28.3c) which are capable of tracking energy and water consumption through a web-hosted portal for all meters, as mentioned in Appraisal 28.1.1.

–3 points

TABLE 28.3c: Types of communicable monitoring systems

Communicable Systems	Points
Installation of one-way communicable system	1
Installation of two-way communicable system	3

[22] For all smart meters:

- All installed energy meters must be at least Class 1 with Class 1 CTs/PTs, and should have an active RS-485 port, with industry standard Modbus protocol with publicly available register maps.
- All water/British thermal unit meters should have an RS-485/RS-232 port with publicly available/industry standard protocol (Modbus, etc.) and register maps.

The metering and monitoring hardware and software should support compliance with the relevant requirements of 'IS/ISO 50001 – Energy Management Systems – Requirements with Guidance for Use'.

All smart metering and monitoring systems should be capable of the following:

- Hourly data reporting in near realtime (no more than 15-minute delay)
- Energy mix breakdown and consumption patterns
- Water consumption patterns from various sources
- Ability to set energy and water consumption targets, alarms, and pricing
- Ability to compare historical trends and benchmark data
- Real-time monitoring with user interface that operates even on mobile devices

28.1.4 Ensure sharing of monthly energy and water consumption data of the project by connecting with the GRIHA Online Benchmarking platform[23] for 5 years.

–2 Points

28.2 Compliance

28.2.1 Submit single-line diagram (in.dwg format) for energy meters and wet riser diagrams (in.dwg format) for water meters with corresponding legends to demonstrate compliance with Appraisals 28.1.1 and 28.1.2.

28.2.2 Submit purchase orders reflecting full quantities of the various meters installed in the project to demonstrate compliance with 28.1.1, 28.1.2, and 28.1.3.

28.2.3 Submit technical specification sheets indicating system capabilities and accuracy of smart meters to demonstrate compliance with Appraisal 28.1.3.

Or

Submit a valid GRIHA Product Catalogue certificate as applicable for the product to demonstrate compliance with Appraisal 28.1.3.

28.2.4 Share energy and water consumption data on a monthly basis for meters mentioned in Appraisal 28.1.1 using the GRIHA Online Benchmarking platform via an Application Programming Interface (API).

28.2.5 Submit a declaration stating that the API will be shared for a duration of five years.[24] To demonstrate complaince with Appraisal 28.1.4.

28.2.6 Submit the following to demonstrate complaince with Appraisal 28.1.4.

- API indicating sensor/meter listing
- API with monthly log as per Table 28.1c

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[23] Relaxation in recertification can be proposed in case a project connects with GRIHA's IT platform and shares energy and water consumption data for five years.

[24] In case of system breakdown/changes, due to which loss in connectivity or change in energy consumption patterns can occur, the project team must immediately inform the GRIHA Council.

CRITERION 29

Operation and Maintenance Protocol

Intent

The intent of this criterion is to ensure the incorporation of detailed O&M procedures for various systems in the building. It is compulsory for the staff to undergo the necessary training.

Maximum Points: Zero

29.1 Appraisals

29.1.1 Ensure that a core facility/service group is formed, which will be responsible for the O&M of the building systems and equipment post installation.

–Mandatory

29.1.2 Ensure the inclusion of a specific clause in the contract document of the system's supplier for providing training to the core facility/service group responsible for the O&M of the building systems.

–Mandatory

29.1.3 Ensure the development of O&M protocol in the form of a manual/compact discs (CDs)/ multimedia/information brochure enlisting the best practices for O&M of the building systems.

–Mandatory

29.2 Compliance

29.2.1 Submit documents to validate the provision for a core facility/service group responsible for the O&M of the building systems and equipment post installation to demonstrate compliance with Appraisal 29.1.1.

29.2.2 Submit a contract document (mutually signed between respective parties) confirming that training will be provided to the core facility/service group for proper O&M of systems and equipment installed in the project to demonstrate compliance with Appraisal 29.1.2.

O&M protocol should contain the following:

- Inspection plan for respective systems
- Preventive maintenance plan
- Sample records (in the form of checklist) to track the periodic inspection and maintenance

29.2.3 Submit guidelines for O&M of the systems installed in the project in the form of manuals /CDs/multimedia/information brochures for the following as per Appraisal 29.1.3:

- HVAC system:[25] Air handling unit (AHU), cooling tower, chillers and pumps, variable refrigerant flow, etc.
- Electrical equipment: Transformers, diesel generator, high tension and low tension panels, etc.
- Renewable energy systems: Solar photovoltaic panels, windmill, bio-gasifiers, etc.
- Water management systems: sewage, water, and effluent treatment plants, rainwater harvesting pits, irrigation systems, etc.
- Waste management systems: Organic waste converter, garbage chutes, vermicomposting, etc.

[25] These include all types of HVAC systems not limiting to the ones listed here. Therefore, guidelines should be submitted for all HVAC systems installed in the project.

CRITERION 30

Innovation

Intent

The intent of this criterion is to promote adoption and implementation of innovative strategies to enhance the sustainability quotient of the project.

Maximum Points: 5

30.1 Appraisal

30.1.1 Adopt any 5 innovative strategies independent of all 29 criteria to make the project more sustainable.

- Sub-category 1: Heritage conservation/Cultural enrichment provision of gender-neutral toilets /safety and security (Save Our Souls—SOS buttons)/Real-time air quality monitoring during the construction phase.

–1 Point

- Sub-category 2: Initiatives taken to form resilient and sustainable communities/zero concrete wastage sites/use minimum 5 products having Environmental Product Declaration (EPD) (as per ISO 14025) in the project.

–1 Point

- Sub-category 3: Dynamic performance/net positive energy or water.

–1 Point

- Sub-category 4: GRIHA-Certified Professional (CP)/GRIHA evaluator involved in the project from commencement to the completion.

–1 Point

- Sub-category 5: Any other innovative strategy enhancing the overall sustainability of the project.

–1 Point

Note: Project can attempt more than one strategy under each sub category. It is to be noted that maximum of 1 point will be awarded in each sub category.

30.2 Compliance

30.2.1 Submit detailed narrative and date-stamped contextual photographs clearly depicting the strategies implemented.

Heritage conservation/cultural enrichment

30.2.2 Submit a survey plan highlighting the existing heritage structure within the GRIHA-registered boundary.

30.2.3 Submit Google Earth images showing the existing heritage structure within the GRIHA-registered boundary.

Provision of gender-neutral toilets

30.2.4 Submit plans highlighting gender-neutral toilets provided on-site.

Safety and security (SOS buttons)

30.2.5 Submit a purchase order of SOS buttons provided on-site.

Real-time air quality monitoring during construction phase

30.2.6 Submit a purchase order of air quality monitors/sensors.

30.2.7 Submit date-stamped contextual photographs of air quality monitors/sensors.

30.2.8 Log sheet/digital entries of the data collected from the monitors.

Resilient and sustainable communities

30.2.9 Submit a narrative from the client stating that the project will provide a relief shelter in case of any disaster/calamity.

30.2.10 Submit a site plan highlighting the location of a relief shelter that will be provided on-site.

Zero concrete wastage sites

30.2.11 Submit quantum calculations for concrete waste generated and re-used on-site.

Use products having EPD (as per ISO 14025)

30.2.12 Submit product EPD certificates highlighting conformity with IS 14025 guidelines along with purchase orders.

Dynamic performance

30.2.13 Submit drawings and narrative of proposed smart grid system and relevant Demand Side Management systems, highlighting the following:

- Electrical drawing highlighting integration of renewable energy sources
- Details of dynamic balancing of energy supply and various energy loads
- Real-time remote monitoring and control of the smart mini grid
- Demand side management and automatic controls for common loads such as street lighting, water pumping, etc.

- Supporting purchase orders/bill of quantities (BOQ)/tender documents along with installation photographs

Net positive energy

30.2.14 Submit detailed calculations demonstrating the energy consumption of the project.

30.2.15 Submit calculations/simulation results highlighting the capacity of renewable energy system installed on-site.

30.2.16 Submit a purchase order of the renewable energy system installed on-site.

Net positive water

30.2.17 Submit a water balance diagram for the project indicating the source and quantity of potable water drawn, quantities required of various other uses on-site, quantity of wastewater generated on-site and treated, and rainwater harvested.

30.2.18 Submit the calculations to demonstrate net positive water consumption in the project.

30.2.19 Submit drawings of wastewater treatment plants and rainwater harvesting systems.

Integrated design approach

30.2.20 Submit a GRIHA Evaluator/CP certificate

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