PROMOTING GREEN BUILDINGS TOWARDS ACHIEVING SUSTAINABLE DEVELOPMENT GOALS: A REVIEW

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Abstract

Buildings are responsible for at least 40 per cent of energy use in most countries, contributing to greenhouse gas emissions (World Council for Sustainable Development). IPCC estimated that by 2050, buildings are projected to emit 3,800 megatonnes of carbon. With the rapid growth in the real estate and construction sectors, it is crucial to promote green buildings. Green buildings are designed to minimize the demand for non-renewable resources and maximize the utilisation efficiency of renewable energy sources. Against this backdrop, this paper reviews the initiatives taken in India towards promoting Green Buildings and constraints in diffusing the concept of green buildings.

Keywords: *Green buildings, Climate change, Energy, India, SDGs*

Introduction

Buildings are responsible for at least 40 per cent of energy consumption in most countries, contributing to greenhouse gas emissions (World Council for Sustainable Development). IPCC estimated that by 2050, buildings are projected to emit 3,800 megatonnes of carbon. The United Nations Environment Programme says, as nearly one-third of the total greenhouse emissions come from buildings, "green buildings" are essential to any policies addressing climate change and environmental concerns. According to a study by Energy Information Administration (EIA), US DoE, the growth rate in total energy consumption has been greater than the population growth rate which is expected to grow at 1.3 per cent while the energy consumption rate is expected to grow at 4.3 per cent indicating the building sector is a major energy consumer to a large extent. IPCC Report 1996 predicts that the real estate industry will consume 38 per cent of the global energy and emit 3,800 megatonnes of GHGs annually.

According to the International Energy Outlook projections for 2030 of the US Department of Energy, China and India account for nearly half of the total increase in residential energy use in non-OECD countries. A study by CII-Godrej Green Business Council, Ahmedabad indicates that 35 per cent of savings in energy were made possible. Being a rising economic power, India's energy demands are expected to overtake the energy demands of China by 2050. Commercial and residential buildings in India accounts for more than 30 per cent of the country's total electricity consumption. Buildings in India consume around 20 per cent of the total power and impact the environment and resources. The

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construction industry is growing by 10 per cent compared to the world average of 5.2 per cent. With the rapid boom in real estate, construction sectors and huge energy consumption, it is crucial to have more green buildings in the coming years. Thus, besides providing business opportunities, green building technology is the need of the hour.

Green buildings are designed to minimize the demand for non-renewable resources and maximize utilisation efficiency through reuse, recycling and use of renewable energy sources like sun, water and wind and healthy indoor environment. IPCC says energy-efficient buildings and utility systems can reduce energy demands by as much as 40 per cent. In recent years, the green building concept has gained importance due to its non-toxic, reduced waste generation, resource-efficient structure during the operation of the building. Green buildings offer one of the most cost-effective solutions to climate change and can lead to significant environmental, economic and social benefits around the world. Since the approach towards green buildings is holistic, it will address concerns other than a reduction in energy usage wherein they focus on the design right from the planning stage by envisioning sustainable features at the beginning and considering the whole supply chain - material sourcing, energy modelling, resource reuse, civic amenities, waste disposal. However, possibilities of using the local resources innovatively are left to the creativity of the concerned designer architect.

Photo 1: Using Disposed of Keyboards to Design Creative Roofs, Bangalore, S Vishwanath

Photo 2: Ecofriendly Earth Walls and Ceilings, Green Building in Bangalore, by S Vishwanath

Green buildings with their unique features of construction like economic use of resources, conservation of energy, support the Sustainable Development Goals in more than one way. They can improve people's health and wellbeing (SDG 3, Good Health and Well Being); they use renewable energy which becomes cheaper to run (SDG 7, Affordable and Clean energy); green building infrastructure creates jobs and boosts the economy (SDG 8, Decent Work and Economic Growth); the design of green buildings can spur innovation and contribute to climate-resilient infrastructure (SDG 9, Industry, Innovation and Infrastructure); they are the fabric of sustainable communities and cities (SDG 11, Sustainable Cities and Communities); resources are not wasted in green buildings as they use 'circular' principles (SDG 12, Responsible Consumption and Production); they produce fewer emissions, and help combat climate change (SDG 13, Climate Action); green buildings can improve biodiversity, save water and help to protect forests (SDG 15, Life on Land); and through green buildings, a strong, global partnerships can be created (SGD 17, Partnerships for the Goals) (World Green Building Council, https://www.worldgbc.org/green-building-sustainable-development-goals)

Source: World Green Building Council, https://www.worldgbc.org/green-building-sustainable-development-goals

Against this backdrop, the objective of this paper is to provide a systematic review of the existing literature that examine the advantages of green building in terms of environmental and economic aspects. It further probes the rating agencies that certify green buildings and the initiatives of the government to promote green buildings.

What are the Benefits of Constructing Green Buildings?

Research studies have identified several benefits of green buildings (both tangible and non-tangible) such as resource savings (energy and water), increased property value, decreased maintenance cost, improved well-being of occupants, higher productivity, health benefits, reduced carbon emissions and waste generation. Jian Zuo and Zhen-YuZhao (2014) in their paper indicate that the existing studies predominately focus on the environmental aspect of green buildings.

Increased Comfort, Health and Productivity for Occupants

Several studies have identified the high indoor environmental quality with less indoor pollution have improved occupant's health and productivity compared with conventional buildings. In this direction, Issa *et al* (2010) revealed that the green attributes of buildings can enhance indoor environmental quality, therefore resulting in healthier and ultimately more productive occupants. Joseph G. Allen *et al* (2015) examined the state of evidence on green building design as it specifically relates to indoor environmental quality and human health and revealed that better indoor environmental quality in green buildings versus non-green buildings, with direct benefits to human health for occupants of those buildings. Breysse *et al* studied the effectiveness of green renovations in public housing using the validated surveys and revealed significant decreasing trends in the number of reported non-asthma respiratory problems 18 months after moving into the renovated space, both in children and adults. The

overall health status of adults and children also improved, although the effect was only significant for the adults. Ries *et al* (2006) studied the differences in satisfaction levels between green and conventional building occupants in a manufacturing company that moved from an old conventional facility to a new green facility and revealed that that employees in the green facility were more satisfied with the temperature, humidity, airflow speed, visual conditions and air quality than employees in the conventional facility.

Amanjeet Singh MS (2010) investigated the effects of improved indoor environmental quality (IEQ) on perceived health and productivity in occupants who moved from conventional premises to green (LEED-rated) office buildings and found that improved IEQ contributed to reductions in perceived absenteeism and work hours affected by asthma, respiratory allergies, depression, and stress. It also led to self-reported improvements in productivity indicating that green buildings may positively affect public health.

Positive Environmental Benefits

Green buildings reduce waste and carbon dioxide emissions during construction, operation and demolition phases (Jo *et al*, 2009; Yeheyis *et al*, 2013). A case study by Bosco Verticle, Milan by Giacomello (2015) documents one of the most intensive green facades the "green skyscraper" and highlights its microclimate benefits and several environmental benefits. It is an active interface with dynamic plant life and special architectural quality. The study includes the site conditions, design concept, structural performance tests, restraint system which includes temporary bind, basic bind and redundant bind and plant containers with bituminous waterproofing membrane preserved by protective sheet against root penetration. According to the study, the water network of irrigation is composed of four elements ¬ the principal tower network, the control group in the plant containers, the widespread distribution element in the plant container and the humidity control system. The article concludes by saying, the new experiment symbolises the new idea of sustainability, that biodiversity is an element of environmental enhancement, and Bosco serves as the next generation of living facades on tall terraces. The article also discusses challenges and resolutions.

Another case study on Eco Tower by Singh (2016) focuses on the eco-friendly facility, energy production, waste management and eco-san and the design approach covers structure, climatic condition, water management techniques and energy production techniques. The study's thrust area is sustainable design, eco-architecture and bioclimatic architecture. The results of the study showed passively ventilated atrium and solar shafts achieved good points. The analysis is done based on Sun analysis on the effectiveness of efficient Sun shading louvres.

A case study of GRIET Hyderabad, India by Prakash and Ravinder (2018) revealed only 11.9% of the site is used for construction purpose and minimum disturbance to the existing site as the large area is dedicated to landscape to enhance micro-climate. The building boasts of lighting energy with maximum savings as compared to an electrically light building of the same size. Vegetation that was lost to the built area was replaced by gardens. The building achieves a recycling capacity of nearly 80% of the wastewater generated from it. By considering all these aspects GRIET has achieved 38 credits as

per LEED certification with savings up to 5.68% of total energy consumption daily and net savings of water collected through Rainwater harvesting accounts for 13.66% of peak water demand.

Susorova (2014) revealed that the energy efficiency of green walls lies in their ability to affect heat transfer between a building's interior and exterior environment. The author analyses plant layer in detail to show that plant shading helps reduce heat transfer through exterior walls which leads to reduced building heat gain and cooling loads. This decrease in cooling load reduction can translate into a reduction in annual space conditioning energy use and peak electricity demand.

Green buildings offer improved living and working environment thereby leading to increased productivity. As highlighted by Ries *et al* (2006) productivity increases about 25%, and energy use decreased about 30% in a green precast concrete manufacturing facility certified by the Leadership in Energy and Environmental Buildings (LEED) green rating system.

Jain (2017) discussed in detail Suzlon, which is one of the top three players in the wind energy sector in the world, by studying design benchmarks and targets like Project Performance Targets with respect to Energy, Water, Waste management, renewable energy utilisation in terms of BIPV and solar panels, recycle, recharge, and reuse of water. The Health and well-being of occupants, other energy-efficient measures, transportation energy, construction on renewable energy and appreciating aspect of Green education in the campus were also studied. The study revealed data on performance impact with respect to water use, energy use, cost, material use, payback period.

Economic Aspects of Green Buildings: Do Green Buildings Cost More than Conventional Buildings?

We wanted to know if there is enough evidence in the existing literature to indicate and justify the notion and commonly held belief about green buildings being expensive compared to conventional buildings.

Green buildings have both tangible and intangible benefits. While the tangible benefits are not visible obviously, lifetime payback is much higher in comparison to that of conventional buildings accrued from operational cost savings, reduced carbon emission credits and potentially higher rental/capital values. While the intangible benefits may be attributed to social advantages of positive implications of green environments, quality of life with aesthetics appealing to the body and mind, better working conditions and productivity increase thereof and reduction in health ailments. More natural light and a pleasing indoor environment improving the Indoor Environmental Quality (IEQ) for residents as there is less usage of toxic interiors, low emitting adhesives, paints, carpets, composite wood, natural light, better ventilation. Green buildings reduce absenteeism rate by 40 per cent and increase productivity by 5 per cent, thus health and productivity gains is quantified at $130 for each US employee.

Green buildings are not expensive in comparison to conventional buildings. Green buildings do not require extra cost while it is more of applying conventional wisdom, the orientation of the building, concern for neighbourhood and application of mind to minimise the use of materials. It was also stated that even the Platinum Green Buildings of IGBC that was costing more by 15 per cent 8 years ago has reduced to 9-12 per cent more than non-green buildings (Khattar 2014). Mr. Dennis Kelsey, Director,

Building Technology and Services, Asia of Johnson Controls reflected that smart buildings deliver integrated lighting, improved comfort, greater security and better sanitation facilities at the lowest costs as well (IGBC Meet 2014). For instance, D. Nirmal Ram, National President, Indian Society of Heating, Refrigerating and Air Conditioning Engineers, in the IGBC Congress 2014 emphasised the importance of designing and planning while installing ACs and refrigerators in green homes. There was scope for minimizing or even avoiding homes/commercial structures with AC usage, given the fact that our country is spending about 70 units per sq km per annum on energy consumption. He also stressed the need for awareness creation among the public about the purchase, usage of ACs and refrigerators.

There are distinct savings in the operation and maintenance expenditure. Green buildings are around 25-30 per cent more energy-efficient and they obtain 2 per cent of their energy from renewable sources. It is also substantial when energy costs increase. It reduces the demand for fossil fuels-generated power besides reducing pollution and emission of GHGs. Residents living in green buildings consume less water compared to people living in conventional buildings. While residents in conventional buildings consume 150 lpcd, it is just 90 lpcd in green buildings as residents use water-saving faucets and taps, according to Mr. Hariharan, BCIL. Green buildings use 20-30 per cent less water comparatively thereby reducing operational water expenses and pressure on civic amenities. Nearly 70 to 100 per cent of water is used for landscaping, air-conditioning, flushing etc. reducing the load on the sewage system. Green buildings reduce construction waste by 50 per cent. Waste generation is reduced right from the construction stage and green buildings do not add to the debris as reuse and minimisation of construction waste are sent to recycling units besides using reclaimed material, recyclable content in construction material, designing to produce less waste etc. The payback period for existing green buildings ranges from two to seven years depending on the type of certification level.

Although the estimates for the cost premium for green building construction vary, platinum LEED buildings in India have a longer payback period than gold or silver. The cost over time is expected to get lesser with the development of the green buildings industry. Several materials that had to be sourced from far off destinations are available locally, cutting the costs even further. Besides, there is also an influx of knowledge of sustainable practices that makes it more innovative and economical. Laurie Baker constructed green buildings intending to provide economical housing in India by using local materials. From a green building perspective, the cost is one of the several aspects that is evaluated to consider a building as green. IGBC looks at sustainable development preventing environmental degradation, conservation of natural resources, healthy place and reducing life cycle costs as well. Green Buildings can have several benefits like 50-70 per cent energy cost reduction, 40 per cent reduction in the use of potable water, higher productivity/improved quality of life, a significant reduction in emission of greenhouse gases.

Lower Operating Costs

Ries *et al* (2006) assessed that the energy consumption of a manufacturing company decreased by approximately 32% on a square foot basis after moving from an old conventional facility to a new LEED-certified facility. Based on a post-occupancy evaluation (POE), Turner and Frankel (2008) found that LEED-certified buildings in the US saved 28% energy on average compared to code baselines, which

was close to the 25% savings predicted by modelling in the submittals. Fowler *et al* (2010) assessed the pot-occupancy evaluation of the performance of 22 LEED-certified or energy-efficient buildings in the US and revealed that on average the aggregate operating cost (including water utilities, energy utilities, general maintenance, grounds maintenance, waste and recycling, and janitorial costs) of green buildings was 19% lower than the industry average and particularly, the energy consumption of the studied green buildings was 25% less than the industry average.

In an empirical study by Sabapathy *et al* (2010), the authors noted that LEED-certified facilities could achieve an average energy saving of approximately 34% compared to similar non-LEED facilities if factors associated with equipment, occupancy, operation and maintenance were controlled. Von Paumgartten (2003) studied the costs and benefits of implementing green building standards and indicated that buildings constructed according to LEED standards can save more than 250 per cent of their upfront costs over the course of their 40-year useable lifecycle.

However, a significant gap between the predicted and actual energy performance of green buildings has also been observed in some recent studies. Newsham *et al* (2009) analysed 100 LEED-certified commercial and institutional buildings in the US and found that though on average LEED-certified buildings used 18.39% less energy per floor area than their conventional counterparts, 28.35% of them used more energy than their conventional counterparts. Reichardt (2014) even found that operating expenses for Energy Star-rated buildings were 3.9% higher compared to conventional buildings.

The study also points out that though the cost of green buildings is slightly higher than conventional buildings there is a decreasing trend in the incremental cost over the years. He concludes that construction of green building can be cost-effective if the concept is implemented in the designing stage.

As Jakob (2006) points out that most of the green measures require an investment during the construction stage while maintenance costs are low and the share of incremental costs at the stages before operation accounts for approximately 100%.

K Leleedhar Rao and Kambam Gireeshma (2016) highlight that though the cost of Green Buildings is high in the short run, it will be paid back significantly over time in the form of savings of energy and natural resources**.** Kats (2003) pointed out that the incremental benefits of green buildings include lower operating costs, increased health and productivity and positive environmental externalities. Another study by Kats *et al* (2014) compared the cost of 33 LEED-certified green buildings with a conventional design for the same buildings. It revealed that the green buildings cost less to run and save energy on an average of 30%. They further argue that by adding other benefits, such as reduced water consumption, maintenance cost, improved health and productivity, the financial benefits are 10 times higher as the average cost premium equals 1.84%. Further, Kats (2010) studied the green cost premium of more than 170 green buildings in the United States and other countries and revealed that most green buildings cost slightly higher than conventional buildings ranging from 0% - 18%. Matthiessen & Morris (2014) analysed the cost of a larger sample consisting of 221 buildings, of which 83 buildings were seeking LEED certification and 138 buildings were designed following conventional standards. They revealed that the average cost of green buildings is not significantly different from the

average cost of non-green buildings, and a majority of projects were able to meet LEED certification levels without the need for extra budget.

Another study by Dalibi (2014) focused on the factors that affect the decision of the stakeholders in embracing the "green" concept. Uncertainty among developers arose with questions concerning the exact cost of designing, operation and construction, property value, economic returns and the actual cost of attaining a favourable green rating. End users' apprehensions were related to cost of rent, green building rating in relation to its value and environmental impact of such buildings. The author concludes that adhering to green building principles may increase initial cost but leads to huge cost savings in the form of energy, water and sewer bills. The initial cost will also be offset by reduced operational cost, increased user comfort and added asset value.

Madew (2014) identified few economic benefits of green buildings: 1-25% productivity increase, minimum 14% higher rate of return, 60% reduction in water and energy consumption, 10% higher market value for the asset, 5–10% higher rental rate, in addition to free promotion. Yudelson (2008) highlighted 30 to 50% of energy and water savings, reduced maintenance cost, increased property value, improvement in productivity (3 to 5%) and reduced absenteeism (5%) in addition to other health benefits.

A study conducted based on the US economy has shown that sustainability has become an increasingly important attribute of economic activities describing methods of production It also highlights qualities of consumption and attributes of capital investment. Small increases in the sustainability of buildings, or the energy efficiency of their operation, leads to a considerable effect on the use of energy and the lifecycle energy consumption. It has been seen that the concept of green building is becoming more popular among planners, developers, and investors. Green buildings have a higher rent and occupancy rate. Property investors attribute a lower risk premium for more energy-efficient and sustainable commercial space. It is also found that buildings that are rated by more than one system are considered to be more valuable. (Eichholtz, Kok, & Quigley, 2013)

As argued by several researchers, economic benefits are the other advantage of green buildings in terms of reduced utilisation of resources and low operation and maintenance cost. Lau *et al* (2009) say that a low energy office building with green features, such as solar design and a utility-interactive Photovoltaic (PV) system, saves 50.1% of the energy cost compared to conventional buildings.

While some of the researchers have argued that the construction cost of green buildings is higher compared to conventional buildings. Shrestha & Pushpala (2012) analysed the construction cost and time of completion of 30 green school buildings and another 30 non-green school buildings and concluded that green school buildings cost was 46% higher than that of conventional school buildings. This indicates that the mean construction cost per square foot of the green schools was significantly higher than that of the conventional schools. Kim *et al* (2014) reported an increase of 10.77% in the construction cost due to incorporating a new green building code for residential projects.

Green Buildings - What Works Best?

Given the benefits discussed by Green Buildings, we tried to understand what literature indicates on what works to make Green Buildings more expansive.

Design is Key

Parekh (2016) emphasises the need for sustainability in designing buildings for environmental protection. The author investigates the aspects and importance of Green Building while discussing various strategies for designing them using green materials that benefit both building occupants and owners.

Technology Matters

A study on Green Building Innovative Technologies by Wipro Eco-Energy (2009) discussed the various aspects of building design (daylight, heat, shade and strategies) which leads to less energy consumption and also building materials that curtails heat transmission. The study discussed the saving approach through technology application which results in a power consumption schedule giving a saving of Rs. 178 million for 5 years. This study also focussed about, a first-in-India Eco-Energy and Renewable Energy systems used in LEED-certified Data centres. This also includes Innovative Cooling solutions with Earth Air tunnel, Comfort cooling in a factory environment and Geothermal Cooling. The merits of the chilled beam system are also briefly mentioned.

Materials Count

Lu (2012), while discussing the sustainable nature of the green building, categorises sustainable building materials into two types - Renewable materials, which are made from resources that can be replaced by nature or recycle, and Green materials, which are generally more efficient than traditional products because they require fewer resources to produce. Apart from these, materials that help cut down a building's water or energy consumption can be considered sustainable. This will also help the residents by reducing the utility bill on electricity and water.

Do Good Institutional Assessments Aid Promotion of Green Buildings?

It is important to understand the role of assessments and their role in promoting green buildings. Several studies have discussed them and the practice followed across the world.

Rating Tools

Zuo and Zhao (2014) discuss the various assessment tools used by countries all over the world. These tools are voluntary rather than mandatory, which is put together by the Green Building Council in each region or country and undertaken by accredited professionals. The World Green Building Council coordinates the efforts of the various councils around the world. Green Buildings are built and designed according to the climatic conditions of the region or country to suit local requirements. Therefore, the

assessment criteria for these green buildings are different for different countries. For example, landscape water efficiency accounts for 8.3% of total points available for the water category in GBCA Green Star Office V3 tool (Australia) whereas it is as high as 40% in LEED New Construction and Major Renovation tool (United States). They also criticised by saying that although there is no negative impact of green buildings, the higher upfront cost poses as one of the biggest issues to the investors. It is difficult to convince clients to invest extra in the green features in their building plans. Also, energy efficiency does not necessarily mean energy cost savings. One of the most important barriers in the implementation of energy policies is that the cost of potential energy savings, typically considered being the only financial benefit, does not quite motivate investments. (Popescu, Bienert, Schützenhofer, &Boazu, 2012)

Reed *et al* (2009) made a comparison of global sustainable rating tools by examining their characteristics and differences. They also focused on which tools from different countries can be directly compared with each other to get some clarification of the assessment tools for sustainable buildings, which further helps to make decisions about green buildings. The results highlighted that removing some of the uncertainty associated with sustainable buildings it will increase transparency for stakeholders and facilitate their acceptance.

Many scholars have explored the costs and benefits of implementing green building standards (Von Paumgartten 2003; Eichholtz, Kok, and Quigley 2010) and studies have determined that green building standards had a positive impact on the reduction of energy costs. Additionally, benefits like lesser absenteeism among lower levels of employee and a more productive workforce have also been observed in green buildings.

Smith (2015) suggests that the creation of sustainable urban development could be a potential solution to the issues India faces about urban growth and highlights the role of policy decisions in encouraging certain green rating systems in specific geographies. The role of incentives and government mandates shows that there is a local variation between the two tools - LEED-India and GRIHA. The study also observed that there is a need for a more uniform policy as there is a lack of green development projects in certain areas in India.

ASLA professional network's blog in November 2015 evaluates vegetation, site, and location-related credits achieved by LEED-Certified Buildings, highlighting a green building could get certification without having landscaping principles. This article evaluates the performance of green buildings under LEED rating and also discusses Quantitative Measures of Landscape Principles (QMLPs) on which LEED-certified buildings are scored.

Çiftçioğlua and Sözen (2017) developed a conceptual framework that can assist in selecting and filtering a set of sustainable landscape development indicators for North Cyprus. The author discussed the concept of Sustainable Landscape Development and its indicators which include environmental, economic, socio-cultural aspects, visuality, policy-related and green infrastructure indicators.

There are various rating tools all over the world and localised tools have been developed to promote green buildings and promote the aiding promotion of Green buildings.

Certification Processes for Green Buildings in India

Worldwide, green buildings are certified through an independent body, the US Green Building Council (USGBC), through its LEED (Leadership in Energy and Environmental Design) certification programme. This focuses on five aspects - sustainable sites, water efficiency, energy performance, use of recyclable materials and indoor environmental quality. According to the USGBC, buildings that meet its LEED certification process may be built with little increase in first costs. It has been stated that if `green' concepts are incorporated early in the design process, a certified green building may cost no more than a code-compliant building. In India, there are two mechanisms for evaluating the energy efficiency of a building. The Indian Green Building Council, which was formed in 2001, set up the Leadership in Energy and Environment Design (LEED) India committee. IGBC rated green building is a combination of India's rich architectural heritage with a blend of modern technological innovations. The second system is The Green Rating for Integrated Habitat Assessment (GRIHA) devised by TERI. The government has endorsed GRIHA as the national rating system for buildings. The adoption of the Green building ratings began with corporate houses like the Godrej Group, Tatas, M&M, Modern airports – Bangalore, Mumbai, Hyderabad, New Delhi, managed by GMR, are rated as environment-friendly constructions. The majority of the buildings are approaching the IGBC and taking the green pathway and those include IT parks, malls, residential buildings, educational institutions, airports, factories, government buildings, hospitals, hotels and other institutions. Old and heritage buildings are also being rated. Tata Group Headquarters, Bombay House, a heritage building is the first certified Green Existing Building Rating under the IGBC.

The India Green Building Council

The India Green Building Council (IGBC) was established in 2001 by the Confederation of Indian Industry. IGBC is responsible for administering the Leadership in Energy and Environment Design (LEED) certification in India and supposedly the first green building certification systems in India. Credits earned through LEED can be traded in the carbon market. Green Certification began in 2004 and so far there have been more than 1,600 LEED-certified registered buildings. Since July 2014, the process of LEED certification is taken over by Green Building Certification Institute (GBCI). Currently, the IGBC has more than 1,700 members, 1,200 accredited professionals, 15 vibrant chapters in all major metros and 3,000 registered projects covering 3.13 billion sq feet of the green building footprint. IGBC rating systems include new buildings, existing buildings, residential homes, schools, factory buildings, townships, special economic zones, green landscape and MRTS to Metro Rail and MonoRail systems (For details on IGBC Rating Systems, See Annex 1). IGBC rating credits are graded as certified, silver, gold and platinum categories (For details on Rating credits See Annex 2).

Green Rating for Integrated Habitat Assessment (GRIHA)

GRIHA (Green Rating for Integrated Habitat Assessment) is India's rating system to assess the performance of buildings against certain nationally accepted standards. It was developed by the Tata Energy Resource Institute (TERI) in 2005 and the Ministry of New and Renewable Energy and has been adopted as the national rating system for green buildings in India by the Government of India in 2007. The GRIHA rating system evaluates the performance of green buildings holistically through its entire life

cycle – inception through operation in a three-tier process (pre-construction, building planning and construction and building operation and maintenance stage). GRIHA rating system consists of 34 criteria categorised under various sections - Site Selection and Site Planning, Conservation and Efficient Utilisation of Resources, Building Operation and Maintenance, and Innovation. Eight of these 34 criteria are mandatory, four are partly mandatory, while the rest are optional. Based on the number of points for each criteria different levels of certification is awarded. Under GRIHA, there are various categories of rating system for different buildings

- SVAGRIHA (Small Versatile Affordable GRIHA) – developed for smaller buildings/projects with built-up areas < 2,500 sq. meter (may include individual residences, small offices, schools, hotels, small commercial buildings, hospitals etc. The rating comprises only 14 criteria.
- GRIHA LD (GRIHA Larger Developments) – developed to assess the environmental performance of larger developments, the singular units which together make up cities – neighbourhood/townships. It applies to the total build-up area greater than or equal to 1,50,000 sq. meter.
- GRIHA Prakriti – Rating systems developed for sustainable schools. It is to evaluate the environmental performance of existing schools in India. The rating system has 16 criteria categorised into six broad categories – energy, comfort, water, trees, solid waste management and social.

Some of the GRIHA-rated buildings in India are Commonwealth Games Village, New Delhi, Fortis Hospital, New Delhi, CESE (Centre for Environmental Sciences & Engineering) Bldg, IIT Kanpur, Suzlon One Earth, Pune etc. GRIHA's website shows that there are more than 500 projects registered under the system and the total footprint registered is about 18 million square metres. TERI keeps in mind green practices that are contextualised to the Indian market. They have also partnered with USGBC to promote this further.

Government's Role in Promoting Certification

The Government is also taking up initiatives through the introduction of the ***Bureau of Energy Efficiency (BEE).*** It is an agency of the Government of India set up in March 2002 under the provisions of the Energy Conservation Act 2001. The goal of BEE is to assist in developing policies and strategies with the primary objective of reducing the energy intensity of the Indian economy. BEE had developed its rating system for the buildings and has developing Energy Performance Index (EPI). The unit of Kilo watt hours per square metre per year is considered for rating the building. BEE encourages a voluntary reduction in energy consumption in India and creates standardised labels applicable to appliances, produce building codes for energy efficiency, certification and accreditation procedures etc. One of the policies and regulatory initiatives undertaken by BEE to enhance the energy efficiency of buildings is *Energy Conservation Building Code (ECBC)* for new commercial buildings unveiled on May 27, 2007. ECBC assesses energy, retrofitting process and voluntary star rating programme for commercial buildings. ECBC sets certain energy standards for commercial buildings with 100 KW. Similarly, another initiative is the Energy Conservation Building Code (ECBC) introduced by the Indian government in 2007 which was voluntary earlier and made mandatory since 2017. Buildings that adhere to ECBC will have energy savings of 40-60 per cent.

Green Buildings in India

It is interesting to note that India has the highest number of green buildings in the world and the outcome of a decade-old movement (CoreNet Global 2014). India was ranked second among the list of top ten countries in the world by the US Green Building Council (USGBC) for LEED outside of the US. It is estimated that by 2030, the Indian building stock would reach 100 billion square feet in comparison to the prevailing 25 billion square feet. The green building movement began in India with the establishment of the India Green Building Council (IGBC) in 2001, initiated by the Confederation of Indian Industries (CII) along with the World Green Building Council and the USGBC. The first green building in India, CII Sohrabji Godrej Green Business Centre was inaugurated on July 14, 2004, at Hyderabad. Currently, India has more than 2,030 registered green building projects and over 60 LEED platinum-certified constructions. Besides, India is leading the green building movement worldwide. The first green building was constructed around 2003-04. Currently, there are 2,204 green buildings, including hospitals, hotels, colleges and IT parks in the country and the number of green building is anticipated to grow from 2,204 at present across India, to about one lakh by 2025.

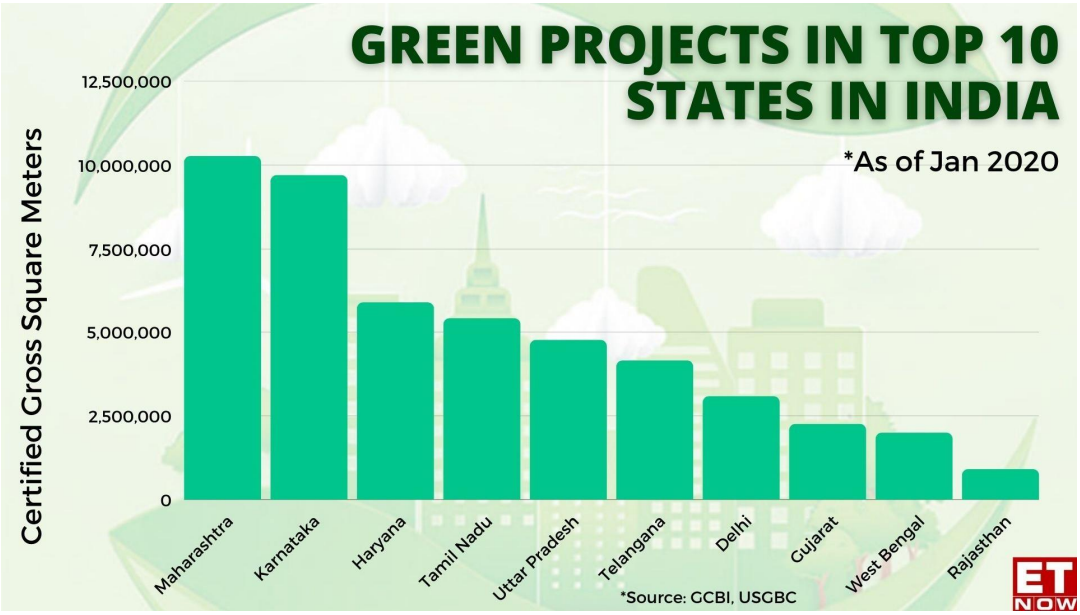
Maharashtra has the highest number of green buildings and stands first in the country. Tamil Nadu holds third position and Karnataka stands fourth. Bangalore has some of the highest-rated buildings in India. Other cities, Chennai, Hyderabad, Pune and Mumbai are also promoting the green building movement in India.

The Union Ministry of Housing and Poverty Alleviation plans to work in collaboration with all the stakeholders in promoting Green Affordable Housing and with the State Governments to map the needs and requirements for affordable housing. It is also proposed to make affordable housing a vital part of smart cities.

Photo: Interiors of a Green Home, Well-lit with Natural Lighting and Ventilation, by S Vishwanath

What Initiatives are Taken by Indian States to Promote Green Buildings?

India is considered a global leader in green buildings (ET Government 2020). It has more than 1,400 LEED-certified buildings. These include schools, hospitals, residential buildings, tech parks, libraries and more. Almost all state governments in India are encouraging the construction of their official buildings as green buildings, apart from private companies. The Economic Times report of 2020 identifies Maharashtra as the top-most state in the list of Top-10 states for the LEED rating system. It is followed by Karnataka, Tamil Nadu and Uttar Pradesh. In these 10 states, 843 million Indians are living in green buildings with 48.3 million gross square metres of green space.



Source: Bhatt, Konica. India has achieved 75% of the 'Green Building Footprint' target in 2020. Available at https://www.timesnownews.com/business-economy/real-estate/article/india-has-achieved-75-of-the-green-building-footprint-target-in/633584

Maharashtra Green Building Policy has been approved by the Government of Maharashtra to encourage green buildings. All residential and commercial buildings must abide by the state government's policy. Also, the buyers of property in green building are entitled to a property tax rebate for five years which is based on the green building rating from the agencies. That is, a buyer of a five-star or platinum-rated building is eligible to receive a property tax rebate of 10 per cent and this rate would vary and be 7.5 per cent for a four-star/ gold rating and a 5 per cent rebate on property tax for buildings with three-star / silver rating. Similarly, developers with platinum rating get a rebate of 7.5 per cent on development charges, 5 and 2.5 per cent on gold and silver rating respectively (Nambiar 2019). Karnataka is also considering encouraging a green building policy. Haryana government offers an additional FAR (Floor Area Ratio) of 9 per cent, 12 per cent and 15 per cent for green buildings with the IGBC rating of Silver, Gold and Platinum respectively (https://igbc.in/igbc/redirectHtml.htm?redVal=showGovtIncentivesnosign). Such tax rebates and additional FARs

are offered by Uttar Pradesh, West Bengal, Punjab, Rajasthan. Tamil Nadu government also has allotted Rs. 1,080 crore for the construction of 60,000 houses in rural areas (Urban Tree 2015). All these points out the efforts of the government towards promoting green buildings in the country. Apart from the various rebates, the government of India also offers fast track environmental clearance for green building projects which are Pre-certified/ Provisionally Certified by IGBC (https://igbc.in/igbc/redirectHtml.htm?redVal=showGovtIncentivesnosign).

Challenges Facing Green Building Implementation

Some researchers have studied the barriers and challenges in implementing green building practices. Mulligan *et al* (2014) argue that costs are the commonly reported barrier in the United States, in addition, low awareness of incentive policies among industry players. is another barrier that prevents people from constructing green buildings. On similar lines, Chaturvedi (2015) indicates as the cost of green building is the main barrier to its development in a developing country like India and further recommends better incentive mechanisms, in the form of policies, to achieve better energy efficiency levels and lower levels of emission.

Zhang, Liyin, *et al* (2011) have revealed that financial considerations are the biggest barriers, while lack of motivation, lack of economic incentives and weak enforcement of legislation are the other major obstacles in adopting green buildings in China (Shen *et al*, 2017).

Retzlaff (2009) indicated that cost was a major issue in implementing the LEED program as a standard for communities and a lack of expertise regarding the standards by local officials was a major impediment. Jain *et al* (2013) found additional obstacles hampering the implementation of green standards (specifically the LEED-EB standard) in India. They include lack of awareness among stakeholders, lack of technology in India, standards that were created specifically to the USA did not apply to India, lack of skilled professionals and high renovation costs associated with existing buildings.

Zhang, L, *et al* (2017) identified three categories of barriers that limit economic viability from the perspective of developers and occupants. First, some behavioural problems where developers' tend to overestimate costs and occupants' lack of attention to energy efficiency. Second, the information asymmetry makes buyers hesitant about choosing green buildings, resulting in a cost-benefit mismatch for developers and, third, energy pricing and contract structure hinder occupants from enjoying cost savings due to energy savings.

Bartlett and Howard, 2000 studied the barriers to achieve economic viability from the perspective of developers and revealed that the perception of "going green" is too costly has been pervasive among developers and weakened their initiative and suppliers of green materials and equipment are still scarce.

Yang and Yang (2015) classified the barriers into technical and design factors, economic factors, socio-cultural factors and institutional factors and identified economic factors as the most significant, followed by institutional factors in Australia confirming that the housing industry in Australia prioritises economic benefits over other softer values.

Yau (2012) stresses the information asymmetry between sellers and buyers about the environmental performance of green housing, where buyers are not fully aware of the operational benefits.

Tathagat and Dod (2015) highlight the importance of sustainable construction and discuss the role of energy efficiency in green buildings in the Indian context to reduce energy consumption and environmental degradation through greenhouse gas emission. The study briefed on Green Building Adoption Pattern in India and mentioned Green Techniques like structural, electrical and special techniques by briefing four R's. The paper listed Green Buildings in India and their scope. Also, it points out the benefits of green construction as well as the incentives from the government and municipal bodies for GRIHA-certified green building. This study also discussed the challenges and constraints. The paper concludes by saying Green buildings are a boon and lack of awareness is a major problem and suggests people pursuing Green buildings as financial burden should stop and green buildings are the solution for a sustainable tomorrow.

Akadiri *et al* (2012) presented a conceptual framework aimed at implementing sustainability principles in the building industry based on sustainability that includes three types of conservation - resource conservation (water, energy, land and materials conservation), cost-efficiency (initial cost, cost in use and recovery cost) and finally the design for human adaptation considering Protecting Health and Comfort and Protecting Physical Resources. The author highlights that the link between sustainable development and construction becomes clear when sustainable buildings pursue a balance among economic, social, and environmental performance in implementing construction projects. It also mentions that the challenge for designers is to bring together the different sustainability requirements in innovative ways.

Jain, Mital, and Syal (2013) studied obstacles in the implementation process of green standards (specifically the LEED-EB standard) in India and highlighted the lack of technology, lack of awareness among stakeholders, high renovation costs associated with the existing buildings and lack of skilled professionals to carry out the process. They also argued that the standards that were created specifically for the US could not be applied in India. In addition, the researchers found that reduced operating costs and an increase in the prestige of the project were key factors that motivated the greening of existing buildings.

Panday (2015) emphasised that an efficiently designed building can largely cut down the operational energy use in its lifetime as compared to a conventional building, keeping energy efficiency and renewable energy use optimisation in mind. Such efficiently designed green building can produce energy savings of between 30 per cent and 60 per cent of the energy that is consumed by a conventional building.

Summary

Given that, the construction industry is booming in India and is one of the largest economic activities growing at an average rate of 9.5 per cent as compared to the global average of 5 per cent, it is crucial to make the right decisions on sustainability. As 60 per cent of the infrastructure that India needs is yet to be constructed, and estimates are that by 2030, 10 billion square metres of construction will happen,

it would be valuable to make their green buildings. TERI estimates that if urban buildings were to be adopting green building concepts, savings could be up to 8,400 MW of power and enough to light 550,000 houses annually. It would be useful to focus and make this concept popular through small builders and should be adopted in smaller towns as well for extensive outreach and adaption. It would also be good to make the existing households/buildings resource-efficient. It would also be useful to make the existing homes eco-friendly, called retro-fitting (Hariharan, 2014).

As we can see, that there is a wrong perception of 'Costs' as one of the constraints in implementing green building on a large scale. As highlighted by studies earlier, the general assumption among the masses is that green buildings are costlier compared to regular conventional buildings. This may be due to a lack of sufficient technical information regarding the concept of green buildings which is still in a budding stage in India. Added to this, immaturity of the market, lack of resources, long gestation period and lack of focus on lifetime return on investment (ROI) of these buildings are other reasons. It is important to create demand by providing various measures like tax incentives (tax rebates, etc), providing improved access to finance for the purchase of green buildings, through rewards systems, etc.

There is less awareness about the benefits derived from green buildings. Green buildings would get more popular if people opt for them. But that will happen with more understanding of its benefits. Like builders, people believe that green buildings are expensive and are sceptical about the sustainability of these buildings in the long run. Currently, large scale capacity building programmes to promote the construction of green buildings are not adequate to meet the demands of the increased demand of the construction industry.

Constructing Green Buildings is not an obligation and not incentivised, hence, makes green buildings construction restricted. It is a challenge for both architects and developers. However, considering the rapid global warming taking place and depletion of natural resources, it is important that to sustain, commitment and consciousness has to be promoted. Therefore there is a need for concern for the environment, commitment to social responsibility, and application of mind and passion to do something to conserve resources to help future generations. Inadequate knowledge in the construction sector, building materials, or energy-efficient appliances is another major constraint. Lack of sufficient skills among engineers is another issue where only 6 per cent of the employees have adequate training. Shortage in the number of contractors also adds to the problem.

Lack of locally available material also may discourage builders to opt for green buildings. It needs passion and patience to procure material and creatively use the available material. In some parts of the country, particularly in rural settings, usage of locally available material is used extensively in locations with an abundance of the specific type of materials like a stone of varied kinds, leaf material, bamboo etc. There is scope for using such material in the urban contexts by procuring such material which is not completely used in rural areas.

Lack of sufficient support and consultancy services for the certification process may hinder the development of green buildings. At large, people are not aware of the processes and require systems to be put in place to ensure that it is convenient for users.

Energy efficiency codes by the Indian administration is comprehensive and elaborate, however, they need to be adopted more effectively across the states. There are capacity constraints at the local level which needs to be addressed. It is important to train and motivate them to promote energy efficiency code. It would be useful to demonstrate the efficacy of the code by increasing awareness through demonstration projects. There are simple and affordable performance-based systems like Excellence in Design for Greater Efficiencies[7] (EDGE) that makes it easier for developers to follow and resource efficiency standards for certifying agencies to confirm compliance (Khatta Dolly, 2014).

Awareness creation through Training Programmes is important by making training programmes as a part of the syllabus and tie-up with the IGBC with the concerned departments in the Engineering Colleges. IGBC conducts Green Building Training Programmes across the country and has so far trained 21,000 professionals on green building concepts. The platform exposes the participants to the latest global trends in green buildings, concepts and sharing best practices besides providing networking and business opportunities for green equipment. Advanced training programme on IGBC's Green Building Rating System aims to deal with regional priorities and approaches for innovative sustainable design strategies.

Similarly, procurement of local materials can be made easier by having a network of institutions and a platform connecting all builders to share information about the availability of local resources across the regions. Innovative ideas should also be discussed to make them more adaptable across various levels of builders.

Besides, there are lack of research studies at the micro-level on green buildings focusing on focusing on governance, awareness across the construction industry and the public, access to information to public, cost options and so on. Besides, data base on green buildings is not comprehensive. There are pieces of evidence of improved climate resilience/measurement of ecological and economic efficiency and institutional barriers in terms of capacity, resources, awareness and knowledge. Given these gaps, there is potential for firther research on various aspects of green buildings and improving governance and initiating strategies so that public and private players can be committed to action and promote green buildings.

[7] EDGE is a building design software that empowers the discovery of technical solutions at an early design stage to reduce operational expenses and environmental impacts. Based on the user's information inputs and selection of green measures, EDGE reveals projected operational savings and reduced carbon emissions. This overall picture of performance helps to articulate a compelling business case for green buildings.

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