Developing a Sustainability Rating Tool for Existing Residential Buildings of India-A Review

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Abstract : Sustainable building is a multidimensional concept, but attention to the issue often goes solely to environmental criteria, ignoring the substantial importance of social, economic and technical criteria. Inadequate research has been carried out till now to support the development of sustainable performance for existing residential buildings of India taking into consideration the local conditions. The purpose of this research is to provide a better understanding the concept of green building assessment tool and its role for achieving sustainable development through developing a holistic green building rating tool for existing residential buildings in India in terms of the dimensions of the sustainable development and according to the local context. This research assessed international green building rating tools such as LEED, CASBEE, BREEAM, and others and then defined new assessment criteria considering the local conditions of India. A total of 8 main criteria and 37 sub-criteria were adopted for the research. The main assessment criteria were categorized, into the four dimensions of sustainable development viz., environmental, social, economic and technical. Weightages of main criteria and sub criteria were calculated and were multiplied with each other to obtain credit points to be allocated to each sub-criterion and the parameters. Thus the outcome of the research was a suggested green building assessment framework that suits the Indian context in terms of environmental, social, economical and technical perspectives. A user-friendly software interface of the tool was developed in Dev-C++ to make it more easy to use. Finally the tool was validated by performing a case study of a residential hostel in Bangluru and the results were compared with that of GRIHA as the building has already been rated by same.

Key words: **Green building; sustainable development; main criteria; sub-criteria; credit points; dimensions of sustainable development.**

INTRODUCTION

Green building has now become a flagship of sustainable development in this century that takes the responsibility for balancing long-term economic, environmental and social health. It offers an opportunity to create environmentally efficient buildings by using an integrated approach of design so that the negative impact of building on the environment and occupants is reduced. Rating system provides an effective framework for assessing building environmental performance and integrating sustainable development into building and construction processes, as it can be used as a design tool by setting sustainable design priorities and goals, developing appropriate sustainable design strategies and determining performance measures to guide the sustainable design and decision-making processes. It can also be used as a management tool to organize and structure environmental concerns during the design, construction, and operations phases.

Green design does not only make a positive impact on public health and the environment, it also reduces operating costs, enhances building and organizational marketability, increases occupant productivity, and helps create a sustainable community. Generally green buildings are energy efficient, water conserving, durable and non-toxic, with high-quality spaces and high-recycled content materials, which presents solution for large part of Indian resources problems.

Some of the successful international rating tools

Important successful international rating tools were studied and compared with each other. All the tools have considered different assessment criteria and rate the buildings differently based on their certification criteria. Some of the well-established tools are discussed in detail as following.

1. BREEAM Building Research Establishment's Environmental Assessment Method (BREEAM) was developed in the United Kingdom in 1990 and is one of the earliest building environmental assessment methods. BREEAM covers a range of building types including offices, homes, industrial units, retail units, and schools. When a building is assessed, points are awarded for each criterion and the points are added for a total score. The overall building performance is awarded a 'Pass', 'Good', 'Very Good' or 'Excellent' rating based on the score. BREEAM has separate criteria (checklist) for evaluation of Design and Procurement and for Management and Operation of buildings. There is also a set of core credits that can be applied for, in case if the building wishes to go in for 'Core only' assessment for building performance.

BREEAM major categories of criteria for Design and Procurement include the following:

1). Management (commissioning period and process adopted, monitoring of commissioning, energy use in site activities, waste management, pollution minimization).

2). Health and comfort (adequate ventilation, humidification, presence of controllable blinds, energy efficient lighting, thermal and visual comfort, low noise levels).
3). Energy (sub-metering).
4). Transport (modes of transport to and from site, alternative transport facilities).
5). Water (consumption reduction, metering, leak detection).
6). Materials (asbestos mitigation, storage facilities, reuse of structures, specifications of envelope, use of crushed aggregate and sustainable timber).
7). Land use (previously used land, use of re mediated contaminated land).
8). Ecology (land with low ecological value or minimal change in value, maintaining major ecological systems on the land, minimization of biodiversity impacts).
9). Pollution (leak detection systems, on-site treatment, local or renewable energy sources, light pollution design, avoid use of ozone depleting and global warming substances).

2. CASBEE Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) was developed in Japan, in 2001. The family of assessment tools is based on the building's life cycle: pre-design, new construction, existing buildings, and renovation. CASBEE presents a new concept for assessment that distinguishes environmental load from environmental quality and building performance.

CASBEE major categories of criteria include:

Building Environmental Quality and Performance

1). Indoor environment (noise and acoustics, thermal and visual comfort, and indoor air quality).
2). Quality of services (functionality and usability, amenities, durability and reliability, flexibility and adaptability).
3). Outdoor environment on site (preservation and creation of biotope, townscape and landscape, local characteristic and outdoor amenities).

Building Environmental Loadings

1). Energy (Building thermal load, utilization of natural energy, efficiency in building service systems and efficient operations).
2). Resources and materials (water conservation, materials of low environmental loads).
3). Off-site environment (air pollution, noise and vibration, odour, sunlight obstruction, light pollution, heat island effect, and load on local infrastructure).

3. LEED Leadership in Energy and Environmental Design (LEED) was developed and piloted in the US in 1998 as a consensus-based building rating system based on the use of existing building technology. The rating system addresses specific environmental building related impacts using a whole building environmental performance approach. The Indian Green Building Council has adapted LEED system and has launched LEED India version for rating of new construction. In addition, Indian Green Building Council (IGBC) has launched several other products for rating of different typologies of buildings including homes, factories, among others.

4. GRIHA stands for Green Rating for Integrated Habitat Assessment, the National Rating System of India. Internationally, voluntary building rating systems have been instrumental in raising awareness. However, most of the existing rating systems have been tailored to suit the building industry of the country where they were developed. That is why The Energy and Resources Institute (TERI), jointly with the Ministry of New and Renewable Energy (MNRE) of India, took the responsibility of developing a tool for measuring and rating a building's environmental performance in the context of India's varied climate and building practices. GRIHA is a building 'design evaluation system' which is suitable for all kinds of buildings. The aim is to minimize the demand for non-renewable resources by focusing on reducing water and energy consumption, limiting waste generation through recycling, and reducing pollution. The primary objective of the rating system is to help design green buildings and, in turn, help evaluate the 'greenness' of buildings. The rating system follows best practices along with national/international codes that are applicable to the green design of buildings. The stages of the life cycle that have been identified for evaluation are pre-construction, building design and construction, and building O&M (operation and maintenance). GRIHA emphasizes cost effectiveness and the integration of traditional heritage with scientific tools. GRIHA is a rating tool that helps people assess the performance of their building against certain nationally acceptable benchmarks. It will evaluate the environmental performance of a building holistically over its entire life cycle. An appraisal of the guidelines and criteria may be done every three years. The Government of India, the MNRE specifically, has recently announced that all government buildings must be at a minimum 3-star GRIHA compliant. In addition, the Energy Conservation Building Code (ECBC) has been made mandatory in eight States of India. GRIHA is a five star rating system for green buildings which emphasizes on passive solar techniques for optimizing indoor visual and thermal comfort. In order to address energy efficiency, GRIHA encourages optimization of building design to reduce conventional energy demand and further optimize energy performance of the building within specified comfort limits. A building is assessed on its predicted performance over its entire life cycle from inception through operation.

Problem Statement

The construction sector poses a major challenge to the environment. Globally, buildings are responsible for at least 40% of energy use. An estimated 42% of the global water consumption and 50% of the global consumption of raw materials is consumed by buildings when taking into account the manufacture, construction, and operational period of buildings. In addition, building activities contribute an estimated 50% of the world's air pollution, 42% of its greenhouse gases, 50% of all water pollution, 48% of all solid wastes and 50% of all CFCs (chlorofluorocarbons) to the environment. India too faces the environmental challenges of

the construction sector. The assessment methods created for one nation or region might not be applicable to others because number of factors may prevent the transfer of currently available environment assessment tools to other nations. Some of these factors include site conditions, climate, geography, resource consumption and level of public awareness. India exhibits a range of different climates, cultures and topographic features and would benefit from implementing a domestic assessment method of measuring building performance. However LEED attempted to make their assessment tools compatible with conditions of different regions in the World. However it is revealed that they were not able to fully incorporate the social, economic and cultural elements in the sustainability assessment criteria. Considering the need for developing a domestic building assessment tool, GRIHA, the national green building rating system, was developed by TERI (The Energy and Resources Institute) in 2007 after a thorough study and understanding of the current internationally accepted green building rating systems and the prevailing building practices in India. But from keen observations it was found that some of the criterion like Transportation and Management were not considered in GRIHA for environmental assessment. Hence there is a need to develop a sustainable criterion framework considering the entire assessment criterion suitable to local site conditions. Complete details about the criterion lagging in GRIHA are discussed in the following chapters.

Moreover all the existing rating tools are oriented towards environmental sustainability assessment. There are presently no specific assessment tools that encompass the economic, social and technical aspects in the assessment criteria. This indicates disregard of the economic, social and technical aspects of sustainability, which could lead to a loss of balance among sustainability dimensions, thereby missing the real goal of sustainable development. Hence, there exists a need to find the importance of environmental, economic, technical and social aspects of sustainability.

Literature Review

1. Chethana et.al (2017)[1] identified eight rating tools based on the extent of usage worldwide, namely, LEED, BREEAM, Green Star, GBI, Green Mark, BEAM Plus, IGBC rating, and CASBEE. The key credit criteria have been identified as 'Site', 'Energy', 'Water', 'IEQ', 'Material', 'Waste and pollution', and 'Management'.

- The majority of the credit criteria of six out of eight rating tools could be successfully allocated into these key credit criteria except for IGBC and CASBEE. Therefore, these seven key credit criteria can be established as the main parameters in evaluating green buildings.
- 'Energy' criterion has the highest consideration followed by 'Water; and 'IEQ' criteria respectively in green building rating tools. In contrast, 'Management' criterion is not that much considered in the tools even though it is identified in the literature to a greater extent.
- CASBEE rating tool follows a different allocation of credit points, and also it focuses on many credit criteria which are not identified by others. The reason to this is the difference in geographical location, and CASBEE is developed to cater those requirements of that region.

2. Ali and Al Nsairat (2009)[2] recommended that Jordan is one of the countries with lack of water resources, thereby 'Water efficiency' criterion is given a higher priority in the rating tool. The water efficiency parameter included 27.7% of the credit points. This is then followed by the 'Energy efficiency' criterion. The main credit criteria for the rating tool have been identified as 'Site', 'Energy efficiency', 'Water efficiency', 'Material', 'IEQ', 'Waste and pollution' and 'Cost and economics'. In this research, it is argued that, for developing countries like Jordan, 'economic pillar' of sustainable development is essential and therefore, it is necessary to include the last credit criteria i.e. 'Cost and economics' to the rating tool. Therefore, in this green building rating tool, 10% of the credit points are attributed to economic criteria. In this green building tool all the three aspects, namely environmental, social and economic are represented through different credit criteria.

3. **Vivian W. Y. Tam et.al (2013)[3]** analyzed the credit points of the selected international green building rating tools based on the extent to which those credit points reflect the three pillars of sustainability. The main focus on green building rating tools was environmental sustainability. When considering the eight green building rating tools considered in the research, except for CASBEE rating tools, all tools allocated the majority of credit points to environmental sustainability. Social sustainability was considered by all the green building rating tools. Generally, up to 20% of the credit points reflected the social sustainability of buildings, which is evident from table:

Green building rating tool	Environmental sustainability (%)	Social sustainability (%)	Economic sustainability (%)	Other (%)
Green Star	75.00	18.00	0.00	7.00
LEED	74.59	18.03	0.82	6.56
BREEAM	74.62	16.15	2.31	6.92
Green Mark	77.40	18.64	0.00	3.95
GBI	69.57	21.74	0.00	8.70
BEAM Plus	56.43	29.29	0.00	14.29
IGBC	79.55	14.77	0.00	5.68
CASBEE	25.00	17.95	0.00	57.05

4. Ricardo Mateus et.al (2010)[4] recommended that the sustainable design, construction and use of buildings are based on the best trade-off between environmental pressure (relating to environmental impacts), social aspects (relating to users' comfort and other social benefits) and economic aspects (relating to life-cycle costs). Sustainable design strives for greater compatibility between the artificial and the natural environments without compromising the functional requirements of the buildings and the associated costs. This paper contributes to the evolution of generic methodology and international understanding by introducing an approach that takes the different dimensions of sustainability into account and incorporates a standardized LCA method to assess the environmental dimension. This paper presented the SB Tool methodology, whose scope is to assess the sustainability of existing, new and renovated residential buildings in urban areas, specifically in the Portuguese context. Although this paper only presented the SB Tool module to assess the sustainability of residential buildings, the approach used in the other modules is based in the same framework.

5. Yu et al., 2015 identified[5] seven credit criteria for developing a rating tool for green store buildings in China. These credit criteria are 'Landscape', 'Energy efficiency', 'Water efficiency', 'Material and resources', 'IEQ', 'Construction management' and 'Operation management'. It was illustrated that due to the specialized characteristics of stores, such as significant depth, high occupant density and intensive use of air conditioning, credit criteria such as 'IEQ', 'Energy consumption' and 'Operational management' should be given priority. The significance of these criteria depends on these specialized characteristics. Therefore, when identifying the credit criteria, it is a necessary focus on the type of building that is considered. In this green building rating tool, the weightages for these credit criteria are given as follows; Landscape - 15%, Energy efficiency - 35%, water efficiency - 10%, Material and resources -15% and IEQ- 25%.

6. Hikmat H. Ali, et.al (2008)[6] studied international green building assessment tools such as LEED, CASBEE, BREEAM, GB Tool and others. Then defined new assessment items respecting the local conditions of Jordan and discussed them with (60) various stakeholders; 50% of them were experts of sustainable development. After selecting the assessment items they were weighted using the AHP method. The outcome of this research was a suggested green building assessment tool (SABA Green Building Rating System) – that suits the Jordanian context in terms of environmental, social and economic perspectives.

7. Vyas and Jha (2016)[7] evaluated widely used green building assessment tools such as BREEAM, LEED, SB-Tool, CASBEE, LEED India, Green Rating for Integrated Habitat Assessment (GRIHA) and Eco-housing to develop a suitable assessment tool for India. This research extracted nine components for green building assessment namely; site selection, environment, building resources and re-use, building services and management, innovative construction techniques, environmental health and safety, mechanical systems, indoor air quality and economy.

8. Raji Banani, et.al (2016)[8] proposed a framework for developing domestic sustainable non- residential building assessment criteria for Saudi Arabia. To create this framework, five major building assessment methods were compared with respect to their application methods, major characteristics and categories. Surveys were conducted with a range of Saudi sustainable construction experts. Nine criteria and 36 sub-criteria were defined in this study for inclusion as the most appropriate assessment criteria for sustainable non-residential construction in Saudi Arabia. These criteria include water efficiency and energy efficiency, indoor air quality, materials selection, effective management, land and waste, whole-life cost, quality of service and cultural aspects.

9. Mohamed Taifour, et.al (2013)[9] set the objective of their research as to develop an environmental assessment methodology for existing buildings in Syria that represent the Syrian construction professionals' opinion which can be generalized to similar construction markets in other developing countries. This research concluded that the comparison between those standards coupled with those standards identified by the questionnaire reveals more interest to cover the main environmental aspects for its environment as identified by LEED with the highest weight given for energy while the lowest weight is given for water efficiency. "Innovation and Regional Priority" was largely excluded. This is why they want to develop a methodology that suits the current existing environmental aspects of buildings in Syria.

10. Elena Bernardi, et.al (2017)[10] discovered "all rating systems for assessing the environmental impact of buildings are suitable for both new and existing buildings and, apart from the SBTool, cover the refurbishment of buildings as well; BREEAM, CASBEE, DGNB, and HQETM can be used to assess all types of buildings, while LEED does not cover industrial buildings and the SB Tool is the most limited since it does not cover urban planning projects, and building types other than residential, office, commercial, and educational buildings; BREEAM, CASBEE, DGNB, and HQETM cover all the life cycle phases of a building; SB Tool is the only system that has also been designed for certifying a low performance level of a building; Regarding the categories assessed by the schemes, energy performance, solid waste management, material, and water are the most considered categories from a quantitative perspective; The categories that are considered less are resistance against natural disasters, earthquake prevention, and olfactory comfort."

11. Shraddha Pandey (2016)[11] states that "In a developing country like Malaysia, the construction industry needs to develop and grow rapidly in the coming decades. In this era of real and anticipated energy crises, as the building sector continues to be one of the largest consumers of energy, it is extremely important that we optimize energy usage by buildings, all around the world. Green building rating systems can play a significant role in promoting this shift toward energy efficiency. But unlike the technologies called upon in other fields of endeavor, the technology needed to create energy efficient buildings demands indigenous knowledge, and different set of solutions in different parts of the world. Any green building rating system must strike a balance between the

dynamics of user response, vernacular requirement, positive awareness, and the goal of large-scale energy saving. GBI as a rating system has a long way to go before it can become sufficiently successful in pushing building developers and architects to make efforts towards creating sustainable green buildings. It needs to reassess its structural framework, in light of users' response to it."

12. Apoorva V.Kotkar (2017)[12] The conclusion for the studies can be classified into three different categories i.e. definitions and scope of green building, benefits and costs of green building and ways to achieve green building. It has been observed that in most of the literature reviews, the focuses are on environmental aspects of sustainability such as energy consumption, water efficiency and greenhouse gas emissions and also with their technical solutions. Also, the life cycle assessment approach, which is extensively applied in the environmental aspects of green building can be a useful tool for social sustainability. New rating tools are developing rapidly worldwide. But more studies in these fields are required to support these new rating tools and also help in assisting the decision-making for the investors and the developers.

13. Anshul P Gujarathi (2016)[13] Green Buildings can be made cost neutral with the right implementation of strategy at the correct aspect. Maintaining the balance between the cost raise and cost decrease a neutral approach can be attained where in a premium rating at no additional cost can be realized. The benefits on the life cycle performance are the added advantage for the project with long terms savings. Every activity associated with green is for the wider cause of the sustainable parameter and always proves beneficial to every stakeholder directly or indirectly. A sufficient economic return on energy-efficiency investments is crucial for the sustainable development of the green building industry. The concern of environment and sustainable development has been increased recently. These problems force the countries to adopt a number of policies that enhance energy efficiency and apply baseline parameters in accordance with international standards. Green building has now become a forefront of sustainable development in this century that takes the responsibility for balancing long-term economic, environmental and social health. It offers an opportunity to create environmentally efficient buildings by using an integrated approach of design.

14. Müjde Altın (2016)[14] Most of the GBRSs have similarities in common more than differences. This is due to the fact that all of these systems are trying to help us create a better world and leave our children a better and cleaner world. Therefore, the principles are and should be nearly the same: principles to decrease the harm given to the environment. GBRSs are assessing the buildings according to environmental/ecological and economic issues today. In addition to the environmental and economic aspects, there is also the social aspect of sustainability. In order to have a proper assessment, social aspect also has to be taken into consideration during the assessment process. Most of the GBRSs in the world are assessing the ecological therefore green building properties of the buildings. Therefore they are called as "Green Building Rating Systems". But the trend is towards creating "Sustainable Buildings" than "Green Buildings". As a result, towards the future real sustainability of the buildings will be assessed. It is seen in the change of the name of SB-Tool. Formerly, it was called as GB-Tool, short for "Green Building Tool". It was assessing how green the buildings were. But in time it was developed and social aspects are added inside the assessment criteria. Then its name was changed into SB-Tool, short for "Sustainable Building Tool". All the GBRSs are still being developed and most probably one day they will turn into "Sustainable Building Rating Systems" or "Sustainable Building Assessment Tools" as GB-Tool had turned into SB-Tool. The name doesn't matter, but they will be better than today and they will help creating more sustainable built environment by helping to create more sustainable buildings.

15. Richard Reed, Anita Bilos et.al (2009)[15] conducted an investigation into the international evolution of sustainable rating tools for buildings, predominantly office buildings. While it has now been widely acknowledged that buildings are a major contributor to CO2 emissions, the focus is on how to use rating tools from a global perspective. In an era of international property investment where it is possible to directly compare values of individual buildings in different countries with a view to potential acquisition, unfortunately rating tools do not exhibit the same level of comparability due to their unique characteristics and focus. This in turn may hinder the take-up rate of sustainable rating tools and also be a barrier to increasing the knowledge about sustainability and buildings.

16. Dakhole Namita .G (2017)[16] Considering Indian context we follow LEED India and GRIHA, the most popular rating systems. Both the systems have their own different criteria to be followed for rating of green buildings. As India is country having different climatic zones and different geographical conditions over the country so, all the criteria cannot be followed by a particular region so which results in losing the points in certification level. Hence there must be modification in rating systems which will result in gaining maximum points in certification and achieving local incentive benefits. So there is need to decide the appropriate rating criteria according to zones, states of India. By studying local conditions for a particular state or region, decide the set of criteria which should be followed for rating of green buildings in particular state.

17. ILIYAS IKBAL SANDE (2015)[17] There are many factors which have to be considered while constructing a green building. It is very necessary to know how effective a particular project is in term of its environment friendliness. This brief comparison would check the building on various points so as to give a fair idea of where it stands in being a green building. Both rating systems are good enough to be used in certain part of the country but they are not unique in nature. Since these two systems are based on different parameters, there is a possibility of the both rating systems rate the same buildings differently. Also they are quite complex in nature and do not necessarily give a clear idea of the projects effectiveness. Each system has certain strong points and certain weak points and they are not specific on some assessment criteria. Due to this both systems are currently confusing the Indian developers, builders over the certification of their projects and buildings. As from above comparative study of LEED and GRIHA rating system some suitable points for green building which is simple and effective is suggested for small contractors to

achieve green agenda simply and economically. This point is an integration of various points such as it carries the advantages of both system where as it overcomes the individual shortcomings.

18. Neda Ziabakhsh and Maryam Bolhari (2012)[18] it is recommended to undertake further investigations among other popular and widely-used rating systems to find out comprehensive solutions. Besides, the important note is that in action, some of the rating systems measure environmental impacts and do not measure sustainability. So, the comprehensive solution ought to be designed in a way to measure sustainability in focus. Furthermore, prior to the presentation of the comprehensive solution, the characteristics that might affect its acceptance must be identified and measured.

19. Sharad R. Khese, M.N.Hedaoo, B.A.Konnur (2016)[19] all four rating systems are good enough to be used in certain part of the country but they are not unique in nature. Since these systems are based on different parameters, the above four rating systems rate the same buildings differently. Also they are quite complex in nature and do not necessarily give a clear idea of the projects effectiveness. Each system has certain strong points and certain weak points and they are not specific on some assessment criteria. We should give preference for selection of green building rating system in following manner LEED, BREEAM, GHRIHA and GREEN STAR. However, it is not just the final conclusion that matters, but the whole review process itself. The information, analyses, valuations and comparisons during the process would help architects, developers, managers, etc. to have better insight into sustainable rating tools. They provide a systematic and valuable reference source for various research which are related to sustainable development.

Conclusion

It is clear from the above mentioned works that there is not a single proper sustainability rating framework to assess the sustainability aspects for existing residential buildings of India. Such tools have been developed in foreign countries but all are framed in their respective native context. So to check the environmental degradation and reckless resource exploitation in India and along the globe, it is necessary to develop a tool in Indian context which could rate the sustainability level of buildings.

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