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Evaluating Green Building Standards: A Comparative Analysis of LEED and GRIHA

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Abstract: ***Building construction is witnessing growth at highest rate in last 10 years in India. This has an impact on available resources of material for construction, also direct and indirect effect on natural environment and increase in greenhouse Gas emissions. Green building rating systems have been contributing to assessing building performance based on their efforts to minimize this impact on the natural environment. This study analyzes the criteria and their significance in two basic green building rating systems in India LEED and GRIHA. With an urban population exceeding that of the entire USA, India has two systems for encouraging environmentally sustainable growth for its rapidly growing urban population. Leadership in Energy and Environmental Design (LEED)-India is associated with the internationally known LEED program, which is administered in India by the Indian Green Business Council. Meanwhile, the Ministry of New and Renewable Energy and The Energy and Resource Institute (TERI) developed GRIHA (the Green Rating for Integrated Habitat Assessment). This indigenous green building standard is similar to the LEED system in recognizing development that meets certain environmental and sustainable development practices. This research will analyze and provide important insight into these two competing urban sustainability programs in India and begin a discussion of the merits of each.***

Keywords: Sustainable, Rating systems, LEED, Green Building, GRIHA, environment, Construction, Greenhouse.

I. INTRODUCTION/OVERVIEW

Construction sector in India is fastest growing construction sector in world. The built floor area has almost doubled in the last ten years. This is driven by rapid urbanization. About 30% of India's 221.1 million households are now in urban areas with the urban population projected to more than double by 2050. Greenhouse Gas emissions associated with Building Material manufacturing is also likely to impact on energy use patterns of occupants, increasing the need to consider lower embodied energy approaches to construction. Along with these attempts have been made to rate the type of construction based on its direct and indirect impact on environment by green building rating systems around the globe and by their Indian versions. The successful designing of green buildings requires balancing energy and resource efficiency while providing a comfortable, healthy and productive environment. This requires careful selection of criteria to rate the performance of green building assessment mechanism. In India, two programs have been developed to create a more sustainable pattern of development: LEED-India and GRIHA (Green Rating for Integrated Habitat Assessment). These programs seek to create more efficient urban forms through better planning, design and engineering. Additionally, these programs hope to use India's limited resources more efficiently and improve resident's overall quality of life.

II. METHODOLOGY

Previous research into the spatial distribution of green buildings has revealed an uneven pattern to green development in the USA (Cidell 2009). It is hypothesized that this uneven spatial distribution of green projects will also exist in India as certain locations draw a disproportionate share of green projects. The amalgamation of green projects in certain locations may be partially explained by market forces and government interventions.

To explore this research question, data were collected from the Indian Green Building Council (IGBC) on LEED-India projects and from the Association for Development and Research of Sustainable Habitats (ADaRSH) for GRIHA projects. After collecting data on all green projects that are either under review or have been certified by one of the rating systems from the respective organizations, each project was reviewed to determine its geographic location (i.e. state or union territory) and type of project (e.g. residential, commercial, industrial, etc.). Note that the data presented in this analysis were current as of November 2013 and new projects continue to be registered and certified. In the end, 810 projects were allocated to a specific geography and classified by type. These projects were then mapped using ArcGIS 10. Supporting documentation and background information on the respective green rating systems were also collected for each organization.

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III. OVERVIEW AND SCOPE OF RATING PROGRAMS FOR NEW CONSTRUCTION

LEED-India is associated with the internationally known LEED program, which is administered in India by the IGBC. Started in 2001 as an offshoot of the United States Green Building Council (USGBC) LEED program.

LEED-India is a voluntary program and, to be eligible for LEED certification, a proposed project must go through several steps including registration, credit interpretation, certifica tion and documentation, and certification award. If a project does not get certified, there is an appeal process (IGBC 2013b). In sum, the cost of obtaining LEED status can be thousands of dollars. However, the marketing of a green/LEED building and the operationalized cost savings may well be worth the cost.

LEED-India is the benchmark for the design, construction and operation of high-performance green buildings and focuses on five main areas: sustainable site development, water savings, energy efficiency, material selection and indoor environmental quality. These key areas are tackled by LEED-India through the administration of rating systems for a variety of project types. For residential development, IGBC offers the Green Homes Rating System that specifically focuses on energy and water savings. For larger projects, IGBC has created the Green Townships Rating System.

"The 'IGBC Green Townships Rating System' is designed to address the issues of urban sprawl, automobile dependency, social and environmental disconnect. Developments are evaluated on the following broad aspects: environmental planning, land-use planning, resource management and community development" (IGBC 2013c). Finally, the IGBC has developed a program for industrial buildings called the Green Factory Building Rating System in an effort to bring sustainable design to the workplace.

GRIHA is a quasi-public system for promoting sustainable building practices and techniques in India. Developed in the early 2000s and available for project certification beginning in 2005, GRIHA is an indigenous green rating system that hopes to overcome the shortcomings of LEED programs. Specifically, GRIHA focuses on the sustainability of projects after they are constructed by requiring ongoing reporting of performance factors as part of GRIHA recognition. GRIHA utilizes a 1–5-star rating system that focuses on energy/power consumption, water consumption, water generation and renewable energy integration (ADaRSH 2013a). These factors are different than LEED standards and are tailored to the Indian context.

In general, GRIHA has become the preferred and mandated green certification program and process for public entities. The process for achieving GRIHA recognition is also like the LEED program.

LEED and GRIHA new building rating program covers all types of buildings based on their functional planning with both air conditioned and non-air-conditioned spaces either occupied by owner or by tenant Both systems have updated periodically. The overall comparison of green features under various categories is shown in Table 1.

Table 1: LEED and GRIHA Assessment Criteria

LEED New construction (rating points)	GRIHA (rating points)
Site selection and Planning (14)	Site Planning (08)
Energy Efficiency (28)	Energy (20)
Building material and resources (16)	Sustainable building material (14)
Indoor Environmental Quality (12)	Occupant comfort and wellbeing (12)
Water Conservation (18)	Water (17)
Sustainable architecture and design (05)	Construction management (09)
Innovation and design (07)	Performance validation and monitoring (12)

Comparative observations of above table are promptly highlighting efforts provided by GRIHA in incorporating performance monitoring as one of governing criteria in assessment. Analyzing credit points in rating system shows efforts by both system in optimizing energy and water use in buildings. This is to be monitored for making the system sustainable over its life cycle.

A. Characteristics and spatial distribution of LEED-India and GRIHA projects

Numerous green projects have been submitted for certification or have been certified in India under the LEED umbrella or through the GRIHA system. These projects range from individual residential developments to large developments upwards of 50 hectares (123 acres). In the following section, this paper will explore the spatial and project characteristics of developments submitted for green recognition under LEED and GRIHA standards. Note that while the two programs have similar goals, they cannot always be compared equivalently due to differences in terminology and criteria. In sum, 810 green projects are under review or have been certified by the two rating systems in India according to data collected from the respective organizations. LEED-India had 445 projects registered for certification, while GRIHA has 365 projects under consideration for certification.

Table 2: Comparison of type of Development project for green building rating system

Rating systems	Development Type				
LEED	Green Homes 199	Green buildings 229	Green factories 16	Green SEZ 1	Total No. Of Projects 445
GRIHA	Residential 89	Commercial 52	Mixed use 53	Institutional 109	Total No. Of Projects 365

Out of the 445 projects associated with LEED-India, the majority (229 projects or 51.4%) of them are characterized as green buildings and include commercial, office and industrial developments (Table 2). Almost 45% of LEED-India projects are identified as green homes for residential use and may include single-family residences or multi-unit developments. Less than 4% of LEED India projects are classified as green factories or green Special Economic Zones, two of LEED-India's newest designations. GRIHA's projects are more evenly distributed along the range of development types (Table 2).

The largest percentage of GRIHA-identified projects is classified as institutional (29.9%). This is not an unexpected finding given the government support for the program and the mandate that new public structures meet GRIHA standards. The government of India has mandated that all new national government projects obtain a GRIHA rating. GRIHA also has 89 residential projects (24.4%) under review or recently certified. Finally, approximately 14.5% of GRIHA projects are classified as mixed use or commercial. The spatial distribution of the 810 green projects highlights an uneven and complex geography (Figure 1).

Table 3: States having highest number of green rated buildings

S no.	State	LEED India Projects	% of total LEED projects	GRIHA Projects	% of total GRIHA projects	Total green projects	% of total green projects
1.	Maharashtra	160	35.95	127	33.97	284	35.06
2.	Tamil Nadu	80	17.97	12	3.28	92	11.35
3.	Karnataka	49	11.01	18	4.93	67	8.27
4.	Andhra Pradesh	42	9.43	17	4.65	59	7.28
5.	Uttar Pradesh	23	5.16	23	6.30	46	5.67
6.	Haryana	22	4.94	21	5.75	43	5.30
7.	Delhi	7	1.57	34	9.31	41	5.06
8.	Gujarat	16	3.59	20	5.47	36	4.44
9.	West Bengal	9	2.02	13	3.56	22	2.71
10.	Rajasthan	8	1.79	13	3.56	21	2.59

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In total, the state of Maharashtra had the greatest number of green projects in India with 284 green buildings or 35.06% of all green projects under development in India (Table 3). Most of these projects are located in the Greater Mumbai metropolitan region.

The state of Maharashtra may have a large portion of green projects due to local government incentives that reward green building standards (Sustainable Initiatives–News2014). The state of Tamil Nadu is the second most popular location for green buildings in India with 92 green projects (11.35%). Although most of the Tamil Nadu's green projects are LEED India projects (80 out of 92 green developments). Chennai, a major city in the state of Tamil Nadu, has a high concentration of certified green buildings due to a climate of corporate social responsibility, high return of investment and low operating costs associated with green buildings.

Surprisingly, Delhi is the seventh-ranked state/union territory for green building activity. It was expected that Delhi would rank higher on the overall rankings of green building activity due to its large population size (second largest population in India) and the large impact of government projects that must meet green standards in the region.

Twelve states and/or union territories did not report any green building activity under the LEED-India and GRIHA programs. These states and union territories include Andaman and Nicobar Islands, Arunachal Pradesh, Dadra and Nagar Haveli, Daman and Diu, Jammu and Kashmir, Lakshadweep, Manipur, Mizoram, Nagaland, Puducherry, Sikkim and Tripura. The Union Territory of Chandigarh only had one green project reported. In general, these 13 areas are located on the periphery of the country, away from the urbanizing megapolitan regions of India. Additionally, many of these places are also near contested political boundaries that may limit the opportunity or desire for investment.

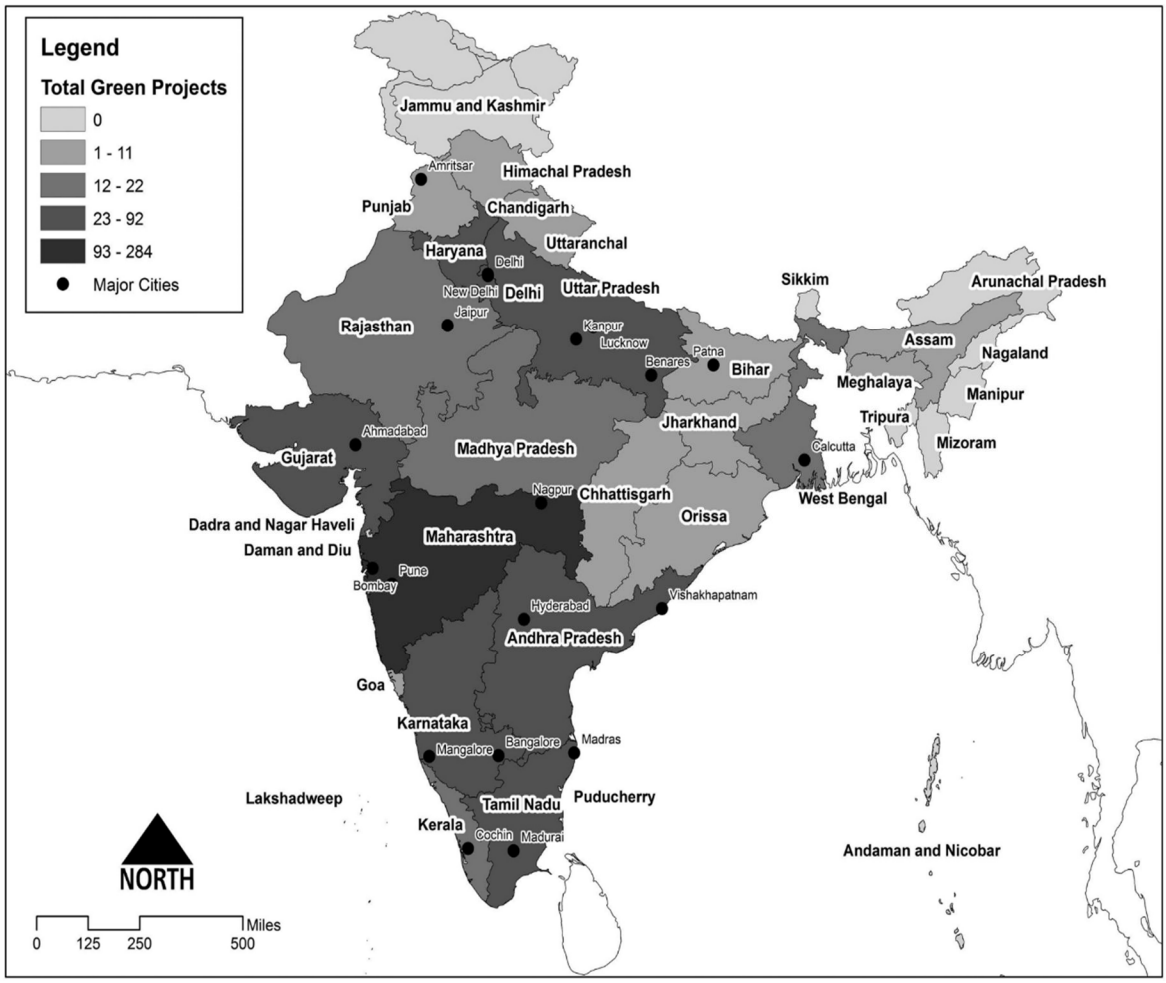


Figure 1. Total number of green projects in India by state/union territory.
Source: IGBC, ADaRSH and author's calculations.

Further examination of the spatial distribution of green buildings in India reveals another unique pattern. In general, LEED-India projects tend to be concentrated in the western and southern part of India with almost 75% of all LEED-India projects being in four western and southern states.

Specifically, LEED-India buildings are plentiful in the states of Maharashtra (35.95%), Tamil Nadu (17.97%), Karnataka (11.01%) and Andhra Pradesh(9.43%). Surprisingly, Delhi only accounted for 7 LEED-India projects or 1.57% of total LEED-India activity.

GRIHA projects are more evenly distributed throughout the states of India. However, the state of Maharashtra has a large concentration of GRIHA projects with 124 developments or 33.97% of the total GRIHA activity in India. There is also a slightly higher concentration of GRIHA projects in the states of northern India. This is especially true around the capital region of Delhi. Delhi (9.31%), Uttar Pradesh (6.30%) and Haryana (5.75%) account for more than one-fifth of the total number of GRIHA projects. This finding may be the result of central government requirements that link a GRIHA rating to all new government projects.

A geographical analysis of green building in India has revealed an uneven and complex spatial distribution to sustainable building practices. Several states (i.e. Maharashtra, Tamil Nadu and Karnataka) generated a disproportionate share of green building within India, while other states/union territories did not experience any green building during the study period (e.g. Arunachal Pradesh, Jammu and Kashmir, Sikkim, etc.). Several explanations can be offered for these findings including the role of foreign investment (i.e. Multinational Corporations (MNCs)/Transnational Corporations), government incentives and regulations, and local environmental and infrastructure pressures.

Local governments in some states are also offering additional incentives to developers that utilize green building standards. Pimpri-Chinchwad, a suburb of Pune in the state of Maharashtra, has provided numerous incentives to green developments (TNN 2013). Additionally, Noida and Greater Noida (near Delhi) offer incentives for both GRIHA- and LEED-rated projects (Kaushika 2010; TNN 2011). Numerous other locals are also considering adopting green incentive programs and/or regulations that could further impact the spatial distribution of green developments (Staff Reporter 2012; Mehta 2013). These incentives and/or regulations may be driving some of the green development within specific geographies.

Selection of the most feasible site to carry out a specific function of building is a very important and challenging task which also has financial implication on feasibility of project in longer run. Ideal site selection will further assist in achieving ratings in other heads like availability of local material, energy efficiency by orientation of building and so on. Table 3 shows comparison of sub criteria handled by both systems in selecting green rated site for proposed project.

Finally, local environmental and infrastructure conditions may be contributing to the locational variability of green building projects. For example, acute water shortages in the city of Chennai, Tamil Nadu, spurred a local rain harvesting movement (Sharma and Agarwal 2012). The now mandatory rainwater harvesting provision for all developments in Chennai is also part of the LEED rating system and may be leading some developers to consider green building practices. Additionally, limited electricity in some parts of the country has resulted in a movement to solar energy. The Greater Hyderabad Municipal Corporation explored the use of green building practices to solve some of their energy shortages and encourage the use of alternative energy sources.

B. Guidelines for Site Selection and planning

Table 4: Comparison of Site selection and planning Guidelines

LEED site selection and Planning (14)	GRIHA site Planning (08) and Construction Management (09)
Local Building regulations (mandatory)	Construction management practices (04)
Soil Erosion control (mandatory)	Low Impact design (04)
Preservation or transplantation trees (01)	Preserve and protect landscape during construction (04)
Heat island Reduction Roof, Non-roof (02 each)	Design to mitigate Urban heat island effect (02)
Natural topography and vegetation (02)	Air and water pollution control (01)
Basic amenities (01)	Site imperviousness factor (01)
Proximity to public transport (01)	Site Selection (01)
Low emitting vehicles (01)	
Universal design (01)	
Basic facilities for construction workforce (01)	
Green building guidelines (01)	
Outdoor light pollution reduction (01)	

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Comparative analysis of both systems shows LEED system is with lesser credit points still covers additional domains like local building regulations and basic facilities for construction workforce. It shows site selection is a critical criterion and needs to verify through maximum aspects as prescribed in LEED rating system.

C. Guidelines for Energy use and Energy Efficiency

Energy use and energy efficiency have been given highest credits in both rating program for designing a building and its process of construction. The energy criteria are governed by planning and construction of the project while design and construction. The evaluation of criteria and sub criteria for LEED and GRIHA is given in Table 5.

Table 5: Comparison of Site selection and planning Guidelines

LEED energy efficiency criteria (28)	GRIHA energy efficiency criteria (28)
Enhance energy efficiency (15)	Energy Efficiency (13)
Onsite renewable energy (06)	Renewable energy utilization (07)
Off-site renewable energy (02)	Zero Ozone Depletion Potential (ODP) material (00)
Energy metering and management (02)	
Commissioning and post installation of equipment and systems (02)	
Ecofriendly refrigerant (01)	
Ozone depleting substances (00)	
Minimum Energy efficiency (00)	
Commissioning plan for building equipment and systems (00)	

This comparison demonstrates a clear distinction regarding consideration of role of ozone depleting material in deciding energy use in built environment. LEED considers ozone depletion substances as a mandatory requirement while GRIHA denies its contribution in system. LEED also signify the importance of commissioning plans for building equipment and systems which will further assist in improving energy monitoring.

D. Guidelines For Water Use

Water, being the most important human need, is required to be protected and used efficiently. Water use criteria are governed during construction as well as after the completion of project. This needs attention at design and construction phases of project. Table 6 evaluates both rating systems for water usage.

Table 6: Water use criteria for LEED and GRIHA

LEED water efficiency criteria (18)	GRIHA water usage criteria (17)
Water efficient plumbing fixtures (05)	On site water reuse (05)
Wastewater treatment and reuse (05)	Use of low flow fixtures and systems (04)
Rainwater harvesting for roof and non-roof (04)	Reducing landscape water demand (04)
Landscape design (02)	Water quality (02)
Management of Irrigation systems (01)	Rainwater recharge (02)
Water metering (01)	

E. Guidelines for Building Material and Waste Management

Building material and resources used in buildings consumes 60 % of total project cost also it depletes the natural material availability thus this criterion is directly influencing the rating in green building assessment system.

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Table 7: Comparison for Building material and Resources

LEED building material criteria (16)	GRIHA building material and solid waste management criteria (20)
Sustainable building Material (08)	Utilization of BIS recommended waste materials in building structure (06)
Use of certified building materials, products and equipment (05)	Reduction in Embodied energy of building structures (04)
Organic Waste Management, Post Occupancy (02)	Avoided post construction Landfills (04)
Handling of waste during construction (1)	Use of Low environmental impact material in Interior (04)
Segregation of Waste Post Occupancy (00)	Treat organic waste on site (02)

This comparison aims to achieve sustainability post occupancy of the project.

F. Occupant Comfort With Indoor Environmental Quality

Table 8: Guidelines for Indoor Air Quality and Occupant comfort

LEED Indoor Environment quality criteria (12)	Occupant comfort and wellbeing (12)
Low emitting material (3)	Achieving indoor comfort requirement (06)
Indoor Air Quality Testing, After Construction and Before Occupancy (2)	Maintaining good IAQ (04)
Day lighting (2)	Use of low VOC paints and other compounds in building interiors (02)
Indoor air Quality management during construction (1)	
Occupant Well-being Facilities (1)	
Minimize Indoor outdoor pollutants (1)	
Outdoor Views (1)	
CO2 monitoring (1)	
Minimum fresh air ventilation	
Tobacco smoke control	

LEED criteria are distributed in specific requirements as shown in table 8 while GRIHA considers general requirements, this major head of rating system is to be evaluated under post occupancy stage.

G. Rating system comparison for certifying a green building

Table 9: Comparison of Rating points

LEED	Points	GRIHA	Points
Certified	40-49	One Star	25-40
Silver	50-59	Two Star	41-55
Gold	60-74	Three Star	56-70
Platinum	75-89	Four Star	71-85
Super Platinum	90-100	Five Star	86 or more

So to achieve certified level in LEED rating system for new construction minimum 40 marks are required and this may be strategically planned by claiming first 5 highest criteria, which include energy efficiency (15),Sustainable building material(8), Onsite renewable energy(6), water efficient plumbing fixtures(5), waste water treatment and reuse(5), Use of certified building material(5).

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While in case of GRIHA system, Energy Efficiency (13), Renewable energy Utilization (07), utilization of BIS waste (06) will satisfy requirement to achieve single star GRIHA rating.

LEED rating system has made few criteria as mandatory requirement to appear for rating which includes Local building regulations, soil erosion Control, Ozone depletion substance, Minimum energy efficiency, commissioning plan for building's equipment and systems, segregation of waste-post occupancy, minimum fresh air ventilation, and Tobacco smoke control.

IV. COMPARATIVE ANALYSIS

Comparative analysis of criteria used by both LEED and GRIHA systems indicate that LEED rating system have made mandatory requirements along with option criteria.

The GRIHA system is flexible in its approach where all criteria are available. This may sometime make LEED a more integrative system as compared to GRIHA as it fails to ingrate maximum number of criteria to achieve basic certification.

In both systems Energy efficiency is observed to have highest significance this is also in relation to national priority. Building material and its impact on environment is given second priority in LEED rating system while water use is second in GRIHA systems. Post occupancy energy analysis is given significance in the LEED system while GRIHA demands closer monitoring of occupant's feedback on comfort within built environment.

V. CONCLUSION

As urban development migrates to greener building practices, developing a more thorough understanding of these green rating systems is of critical importance to practitioners and academics. The work completed in this paper begins to help build a more robust body of knowledge through examining the differences and similarities between the green programs and identifying best practices. Second, the spatial analysis highlights the role of policy decisions in encouraging certain green rating systems in specific geographies.

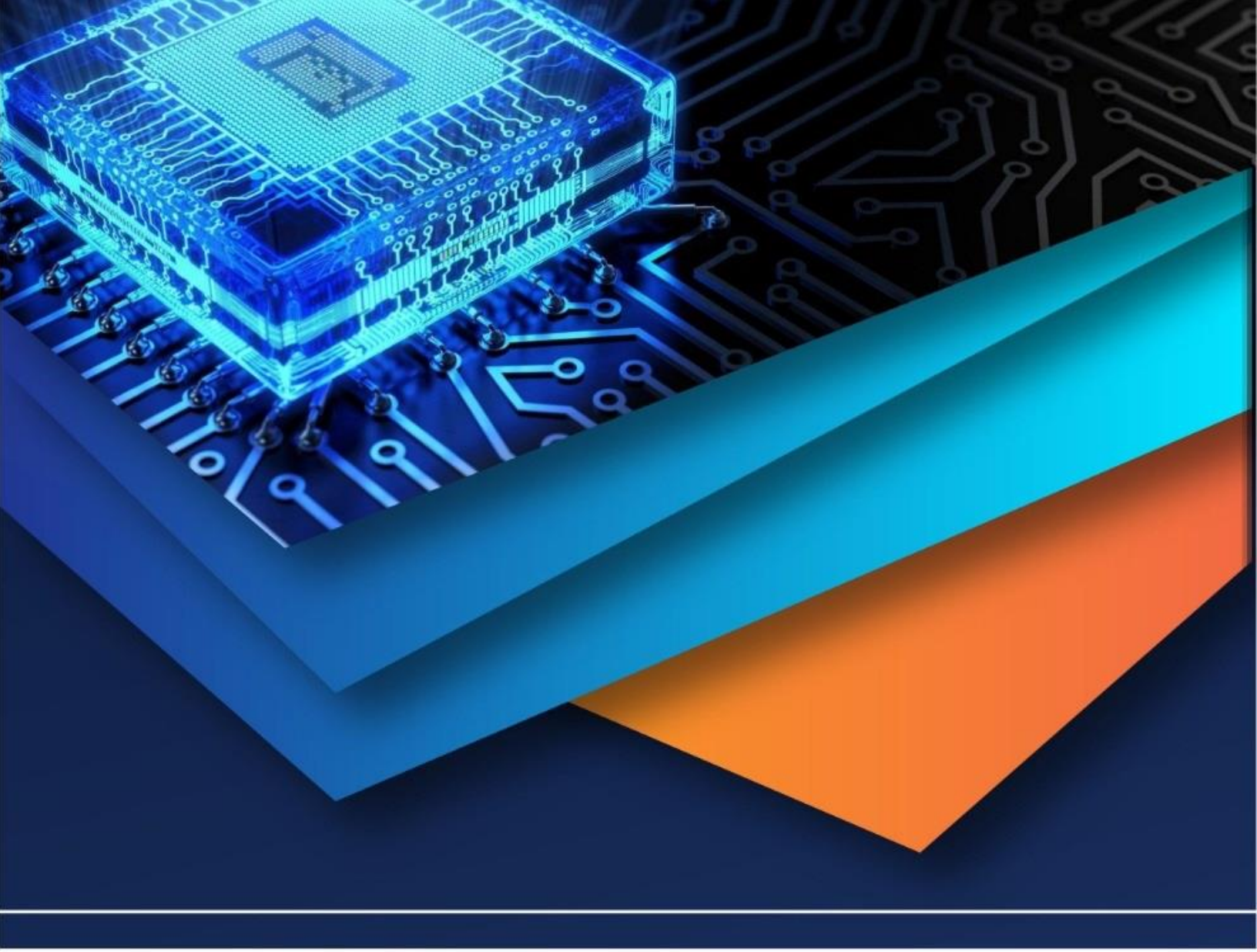
Specifically, the role of government mandates and/or incentives is clearly showcased in the locational variation between LEED-India and GRIHA developments. Finally, the lack of green development projects in certain areas of India clearly articulates the need for a more uniform policy related to sustainable development– if creating a more sustainable pattern of development is truly desired.

This study of comparison of criterion used for assigning green rating system to build environment will assist in formulating strategies and objectives to avail green rating under LEED-IGBC and GRIHA during planning phase of a new construction project. Also, careful evaluation of strategies to be adopted to achieve rating under specific criteria needs to be studied so that a particular strategy may help in availing multi criteria benefits. Also Post occupancy evaluation of each green rated project will further help in assisting impact of each strategy adopted. The future scope of the current study also expects analysis of effectiveness of rating awarded to a project on enhancement of building efficiency to handle sustainable objectives.

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