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Technologies used by Green Buildings in Haryana State

Kanika[1], Kiran Singh[2], Kusum Rana[3], Manju Dahiya[4]

Assistant Professor, Department of Home Science, Pt. C.L.S. Government P.G. College, Karnal, Haryana, India[1]

Professor and Head, Department of FRM, I.C. College of Home Science, CCS HAU, Hissar, Haryana, India[2]

Associate Professor, Department of FRM, Directorate of Extension Education, CCS HAU, Hissar, Haryana, India[3]

Professor, Department of EECM, I.C. College of Home Science, CCS HAU, Hissar, Haryana, India[4]

ABSTRACT:A green building is one which uses less water, optimizes energy efficiency, conserve natural resources, generate less waste and provides healthier space for occupants. The present study has been designed with an effort to rediscover the India ethos by studying the green building rating system of India i.e. GRIHA. The present study was conducted in Haryana state. Secondary data regarding the number and ratings were collected and compile and out of which GRIHA rated buildings were selected purposively for case study on green technologies used in green buildings. Results regarding the status of green buildings reveals that total number of green buildings in Haryana state were ten out of which only four green buildings were rated by GRIHA. The technologies used in buildings were having main focus on; reduction of energy consumption; uses of low energy material; sustainable site planning; and reduction of water consumption.

KEYWORDS: Green buildings, GRIHA (Green Rated Integrated Habitat Assessment),Haryana state.

I. INTRODUCTION

One of the most inspiring definitions of green building articulated in the book, 'Natural Capitalism' is that 'a green building should create delight when entered, serenity and health when occupied and regret when departed. sustainable building or green building is an outcome of design philosophy which focuses on increasing the efficiency of resource use – energy, water and materials- while reducing building impacts on human health and the environment during the building's lifecycle, through better sitting, design, construction, operation, maintenance and removal **(U.S. environmental protection agency, 2009).**

Traditional to contemporary times, India have been using these technologies widely, still there is an urgent need to improve the energy efficiency to meet ever increasing energy demand of the country. The Green Rating for Integrated Habitat Assessment (GRIHA) in national rating system of India. It has been conceived by the energy and resource institute (TERI) and developed jointly with the ministry of new and renewable energy (MNRE) India.This also resulted in the development of various standards to remove the ambiguity surrounding green building design **(Kibert 2005)**. As stated by **(Hoffman 2003)** poor indoor air quality affects the health of the employees and resulted in enormous loss of the nation's commerce.

It is a documented fact that occupant's wellbeing and performance are affected by various aspects of the buildings exposure to daylight and views, air quality, temperature, odor, noise, ergonomics, design of the built environment **(HeschongMohane Group 1999, Kolleeny 2003, Madavi and Unzeitig 2005, Leather et al. 1988)**. Further, more, since people spent most of the time indoor and the IEQ (indoor environmental quality) has an impact on occupants (EPA and U.S consumer product safety commission 1995), it is beneficial to get feedback from the users themselves **(Zagreus et. al. 2004).** This has important implications since occupant comfort and comfort related behavior can impact a building's energy and environmental performance, particularly in green buildings.Though green building is interrupted in many different ways, common opinion that they should be designed and operated to reduce overall

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impact of built environment on human health and the natural environment by; efficiently used energy, water and other resources, reducing waste, pollution and environment degradation (**Callan 2006).**This study, therefore, attempts to understand the technologies used in green buildings as per GRIHA rating system with the following specific objectives:

1. Status profile of green buildings in Haryana state.
2. Assessment of the technologies used in green buildings.

II. RELATED WORK

GRIHA is India's National Rating System for Green buildings. It has been developed by TERI (The Energy and Resources Institute) and is endorsed by the MNRE (Ministry of New and Renewable Energy). It is based on nationally accepted energy and environmental principles, and seeks to strike a balance between established practices and emerging concepts, both national and international.GRIHA attempts to quantify aspects, such as:
Energy / power consumption (in terms of electricity consumed in kWh per square meter per year)

1. Water consumption (in terms of litres per person per day)
2. Waste generation (in terms of kilograms per day, or litres per day)
3. Renewable energy integration (in terms of kW of connected load)
4. Control and reduce /optimize the same to the best possible extent

GRIHA assesses a building out of 34 criteria and awards points on a scale of 100. In order to qualify for GRIHA certification, a project must achieve at least 50 points.

Criterion for rating green buildings

Criterion	Description	Points	
Criterion 1	Site Selection	1	Partially mandatory
Criterion 2	Preserve and protect landscape during construction/compensatory depository forestation.	5	Partially mandatory, if applicable
Criterion 3	Soil conservation (post construction)	2	
Criterion 4	Design to include existing site features	4	
Criterion 5	Reduce hard paving on site	2	Partially mandatory
Criterion 6	Enhance outdoor lighting system efficiency	3	
Criterion 7	Plan utilities efficiently and optimize on-site circulation efficiency	3	
Criterion 8	Provide minimum level of sanitation/safety facilities for construction workers	2	Mandatory
Criterion 9	Reduce air pollution during construction	2	Mandatory
Criterion 10	Reduce landscape water demand	3	
Criterion 11	Reduce building water use	2	
Criterion 12	Efficient water use during construction	1	
Criterion 13	Optimize building design to reduce conventional energy demand	8	Mandatory
Criterion 14	Optimize energy performance of building within specified comfort limits	16	Partially mandatory
Criterion 15	Utilization of fly-ash or equivalent industrial/agricultural waste as recommended by BIS in building structures	6	
Criterion 16	Reduce embodied energy of construction is reduced by adopting material efficient technologies and/or low-energy materials	4	
Criterion 17	Use low-energy materials in Interiors	4	
Criterion 18	Renewable energy utilization	5	Partially mandatory
Criterion 19	Renewable energy based hot water system	3	
Criterion 20	Waste water treatment	2	

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Criterion 21	Water recycle and reuse (including rainwater)	5	
Criterion 22	Reduction in waste during construction	1	
Criterion 23	Efficient Waste segregation	1	
Criterion 24	Storage and disposal of wastes	1	
Criterion 25	Resource recovery from waste	2	
Criterion 26	Use of low-VOC paints/adhesives/sealants	3	
Criterion 27	Minimize ozone depletion substances	1	Mandatory
Criterion 28	Ensure water quality	1	Mandatory
Criterion 29	Acceptable outdoor and indoor noise levels	2	
Criterion 30	Tobacco and smoke control	2	Mandatory
Criterion 31	Provide at least the minimum level of accessibility for persons with disabilities	1	
Criterion 32	Energy audit and validation	1	Mandatory
Criterion 33	Operation and Maintenance	2	Mandatory
Criterion 34	Innovation Points (beyond 100)	4	
	Total	104	

Project scoring

1. 50-60 points iscertified as a 1 star GRIHA rated building.
2. 61-70 is a 2 star GRIHA rated building,
3. 71-80 is a 3 star GRIHA rating building,
4. 81-90 is a 4 star GRIHA rated building and
5. 91-100 is a 5 star GRIHA rated building

III. METHODOLOGY

To collect the secondary data pertaining to number, location, built up area, year of construction, rating of green buildings were collected and compiled. A well prepared schedule was used for the collection of data through telephonic communication. The main source of exploration were GRIHA (Green Rating for Integrated Habitat Assessment), IGBC (India Green Building Council), (LEED- India) Leadership in energy efficiency and BEE (Bureau of energy efficiency). Further, the case studies were done on the GRIHA rated buildings for getting the information regarding technologies used in those buildings. List of future registered projects under GRIHA were also tabulated.

IV. RESULTS

Status profile of green buildings in Haryana state

Table 1: status of green buildings

Sr. no.	Name	Certification level or rating
	GRIHA rated buildings	
1	Administration building of GAIL compressor station	☆☆☆☆
2	AkshayUrjaBhawan HAREDA	☆☆☆☆☆
3	S P Infocity	
	LEED rated buildings	☆☆☆
4	Fortis Memorial Research Institute	☆☆☆☆
5	ITC Maurya hotel	Platinum
6	IIRAD Institute	Platinum
7	IOCL- Admin building and learning center	Gold

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8	Orris spring homes	Gold
9	WIPRO	Gold
BEE rated buildings		
10	PEDA office complex	

Data in table 1 regarding status of green building pertaining to number of green buildings in Haryana, location, build up area, year of construction rating of green building according to different organization dealing with the green building rating system are shown. It was seen that four green buildings were rated by GRIHA,five green buildings were rated by LEED while BEE rated one green building.

Technologies used in green buildings

Table 2: General information of green buildings

Sr. no.	General Information				
	Parameters	**Administration building for GAIL compressor Station (case 1)**	**AkshayUrjaBhawan HAREDA (case 2)**	**S. P. Infocity (case 3)**	**Fortis Memorial Research Institute (case 4)**
1.	**Location**	Chhainsa, Faridabad, Haryana	Sector 17, Institutional Plot Number 1, Panchkula, Haryana	Manesar, Haryana	Sector 44, Gurgaon
2.	**Site area**	11161 m^2	3,900	29000 m^2	43,303 m^2
3.	**Built-up area**	2511 m^2	5,111 m^2	5417^2 m^2	65,961 m^2
4.	**Air-conditioned area**	801 m^2	1,208 m^2	2799^2 m^2	26,254 m^2
5.	**Non Air-conditioned area**	2,478 m^2	3,903 m^2	26180 m^2	44,612 m^2
6.	**Energy consumption reduction**	20.30 percent reduction in energy consumption compared to GRIHA benchmark	61.0 percent reduction in energy consumption compared to GRIHA benchmark	45 .0 percent reduction from GRIHA benchmark	33.0 percent reduction in energy consumption compared to TERI GRIHA benchmark
7.	**EPI**	66.95 KWh/ m^2/year	17 KWh/ m^2/year	156 KWh/ m^2/year	154 KWh/ m^2/year
8.	**Renewable Energy**	Rated capacity of solar PV installed on site is 4 KW	installed on site is 42.5 KW Rated capacity of solar PV	24 KW rated capacity of solar PV	Rated capacity of solar PV installed on site is 25 KW
9.	**GRIHA rating**	4 stars	5 Stars	3 Stars	4 Stars
10.	**Year of completion**	2013	2012	2013	2012

Data in table 2 shows the relative information about the four green buildings rated by GRIHA showed that case study one got 4 stars, case study two got 5 stars, case study three got 3 stars and case study 4 got 4 stars respectively, and were constructed during the years 2013, 2012, 2013 and 2012 respectively. The relative stars got by the building on an account of the 34 criterion laid out by GRIHA.

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Table 3: Technologies used in green buildings to benefit the natural environment

Strategy 1: Sustainable site planning			
Case study 1	**Case study 2**	**Case study 3**	**Case study 4**
Top soil was preserved during construction and re-used for landscaping. Construction activities were planned such that the excavation did not take place during monsoon to prevent soil erosion and soil runoff from the site. Dust screens were provided around construction area to prevent air pollution. Hard paving was minimized and the net paved area was only 18.83 percent of the total site area. Only native plant species have been used for landscaping.	The building is placed on north– south axis (+7°) in order to receive Sun light Most windows are placed on north-south facade of building. To keep the building naturally daylight. East and west oriented windows have easier sun control through shading devices. The south area at site has a wide spread landscaped area. The south face has solar chimneys to aid ventilation in non a/c spaces	Top soil stored and preserved for later use. Existing trees preserved and protected on site. Dust screens provided around construction area to prevent air pollution. Utility corridors designed along roads and pathways on site.	Top soil which was not very fertile was stacked, preserved, made fertile with the addition of manure and re-laid on the landscape areas. Consolidation of all site services along the transportation corridors minimizes the site disturbances. Surface parking is provided with 100.0 percent grass pavers reduce the heat island effect on site. Sufficient plantation done at the site reduces the noise levels considerably and enhances exterior environmental quality.

In Table 3 the relative information of the 4 cases regarding sustainable site planning revealed that in all the cases 1, 2, 3 and 4 top soil was preserved and further used for purpose and native plant species were used in landscaping. In case study 1 hard paving was minimized, in case study 2 the building was placed in north-south orientation to receive sun light and solar chimney was installed to aid ventilation. In case study 3 utility corridors were designed along with the road and pathways and in case study 4, consolidations was done on site services and surface parking was provided with 100.0 percent grass pavers.

Table 4: Reduction of water consumption in green buildings

Strategy 2: Reducing water consumption			
Case 1	**Case 2**	**Case 3**	**Case 4**
Around 68.8 percent of building water consumption was reduced by using low-flow fixtures. Around 40.67 percent reduction of landscape water consumption was reduced by planting native species of trees and shrubs and by using efficient	A 6.25 liter rainwater storage tank has been designed in the basement to collect water from the roof and courtyard. Percolation pits designed along the driveway to collect rainwater from the driveway, the overflow of which has been directed to the municipal sewer.	50 .0 percent reduction in building water consumption by use of low-flow fixtures. Reduction in water consumption during construction. 75.0 percent water recycled and reused within the complex. 50.0 percent reduction in	Low flow plumbing fixtures used to minimize the building water consumption reduction by 63.0 percent. Drip Irrigation system adopted on the site along with native plant species to cut short the landscape water consumption by 50.0 percent.

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irrigation systems.	ETP plant is installed to treat grey water collected from kitchen and toilet, the treated water is reused for horticulture. Solid waste is directed towards municipal sewer line.	landscape water consumption by planting native species of trees and shrubs and by using efficient irrigation systems.	100.0 percent treated water from sewage treatment plant is reused for cooling towers and irrigation purposes.

In table 4 the relative information of the 4 cases regarding reduction in water consumption in case study 1 68.6 percent building water was consumed around 40.67 percent water consumption was reduced during landscaping, in case 2 by using efficient fixture 70.0 percent annual water consumption was done, 6.25 liter rain water storage tanks were installed in the basement and ETP plant was installed to treat grey water and to reuse it. In case 3 50.0 percent of water reduction in consumption was done, 75.0 percent of water is recycled and reused in the building. In case 4 63.0 percent water consumption was reduced, drip irrigation system was installed on landscaping sites. 100.0 percent water was treated and reused.

Table 5: Reduction of energy consumption green in buildings

Strategy 3: Reducing energy consumption			
Case 1	**Case 2**	**Case 3**	**Case 4**
For achieving visual comfort: Window wall ratio (WWR) is limited to 30.0 percent for optimal day lighting in the internal spaces.ECBC compliant energy efficient artificial lighting design. External shading devices and efficient glazing have been installed. **For achieving thermal comfort:** Building envelope is ECBC compliant and helps in reducing the load in AC spaces and meets thermal comfort levels in non-AC spaces. ECBC compliant energy efficient variable speed centrifugal chillers of rated capacity 34TR are installed in the building. Lux and occupancy sensor-based controls are installed to reduce the energy consumption.	**For achieving visual comfort:** East and West windows are oriented south; these windows help the office spaces on those faces receive day light. Central court and single loaded corridor are provided for natural lighting. **For achieving thermal comfort:** The south face has solar chimneys to aid ventilation in some of the non a/c spaces. Misting is done in the courtyard to cool the ambient air. The achieved internal air relative humidity ranges from 60–75 per cent. Thermatek roofing tiles have been used to reflect maximum solar radiation back to the sky. Cavity walls with XPS foam insulation have been	**For achieving visual comfort:** Window wall ratio (WWR) limited to 31.0 percent for optimal day lighting in the internal spaces. ECBC compliant energy efficient artificial lighting design. **For achieving thermal comfort:** ECBC compliant energy efficient variable speed centrifugal chillers of rated capacity 800 TR installed in the building. Dimmers and occupancy sensors installed to reduce the energy consumption.	**For achieving visual comfort:** Ingress of daylight in Patient areas &Waiting areas. Landscape in sync with the Architectural spaces to provide visual comfort. **For achieving thermal comfort** Use of AAC blocks, Double Glazing & Roof insulation.

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	constructed in the east and west facade of the building.		

In table 5 the relative information of the 4 cases regarding reducing energy consumption for achieving visual comfort, in case 1 WWR (window wall ratio) was limited to 30.0, energy efficient lighting and external shading devises were installed. In case 2 center court yards were built with south oriented windows. In case 3 WWR was limited to 31.0 percent and energy efficient lighting were installed and in case 4 landscapes were sync with architectural spaces. Green building is one which uses less water, optimizes energy efficiency, conserves natural resources generate less waste and provides healthier spaces for occupants **(USGBC 2010)**. For achieving thermal comfort in case 1centrifugal chillers were installed and occupancy sensor were installed in case 1 and 3, in case 2 solar chimney was installed, misting is done in the court yard, Thermatek roofing tiles have been used and cavity walls with XPS installation have been constructed, in case 2 energy efficient centrifugal chillers were installed and dimmers and occupancy sensors were installed, in case 4 AAC blocks, double glazing and roof insulation were done.

Table 6: Installation of renewable energy technologies and use of low energy material in green buildings

Strategy 4: Renewable energy technologies installed			
Case 1	**Case2**	**Case 3**	**Case 4**
Solar panels have been mounted on the roof. Installed capacity of solar energy to meet space conditioning and internal artificial lighting loads: 4 KW. Solar street lights have been installed.	A 42.5 KW SPV plant (with 5 KW BIPV installed above the courtyard) has been installed. A Solar water heater of 600 liter capacity has been installed for cooking and bathing purpose.	Installed capacity of solar energy to meet space conditioning and internal artificial lighting loads: 24 KW and Installed capacity of solar energy to meet outdoor lighting loads: 5 KW. 120 units of electricity generated annually.	Solar Photovoltaic Panels for 25 KW are installed at site. Solar Water Heaters for 8000 liters are also installed to meet the surplus hot water requirement after heat recovery system.
Strategy 5: Use of low energy material			
Case 1	**Case 2**	**Case 3**	**Case 4**
Around 70% low energy material in flooring and 88.97% low energy material in doors and windows have been used in the building. Use of flyash bricks in the walling system. Around 30.0 percent OPC by weight is replaced with flyash in the structural concrete. Around 30.0 percent OPC is replaced by flyash for masonry and plaster mortar.	Door/window frames are made of Aluminium and UPVC. Bamboo flooring is done Low energy Armstrong mineral type false ceiling is done to minimize the use of hardwood. AAC block masonry along with XPS foam insulation is done in east and west facade of the building and fly ash brick masonry done in north and south facade of the building.	30 % OPC by weight replaced with fly-ash in structural concrete. Fly ash blocks used in block work for better insulation. 30.0 percent OPC replaced by fly ash for masonry and plaster mortar.	Autoclaved Aerated Concrete blocks are used for the construction of the hospital building. Cement with sufficient percentage of fly ash had been used for the construction. Low embodied energy construction materials and finishes have been used in the hospital interiors.

In table 6 the relative information of the 4 cases regarding renewable energy technologies in all the cases solar photo voltaic panels and solar water heaters were installed and last but not the least if we talk about use of low energy

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material in case all the four case use of fly ash bricks were used. In case 1 in addition 70.0 percent low energy material in floors, doors and windows have been used, in case 2 Aluminium doors and windows were used, low energy false ceiling and bamboo flooring was installed. In case 4 AAC blocks were used and low energy construction material and finishes have been used for interiors. The successful performance of green building depends not only on their designs but also matching technologies and management sophistication (**Cohen *et al.* 1999**).

Table 7: Registered projects of GRIHA in Haryana for future

Sr. no.	Project Title	Client Name	Location
1.	IGNOU regional centre	IGNOU	Sector - 12 Part-ii Karnal, Haryana
2.	The Lalit School of Hospitality	LalitSuri Educational and charitable trust	Food Craft Institute Complex, Badkhal Faridabad, Haryana
3.	Paras Trinity	ParasBuildtech India ltd.	ParasTrinity,Sector -63, Village Ullawas, Gurgaon
4.	Havanna heights	Ansal API	Kundli, Sonepat
5.	Fbn& Plexus production house	Rahul Kohli	Plot no.-47, Sector 27, Faridabad
6.	National Transmission Asset Management and ERP Centre	Power grid corporation of India Ltd.	400/220 KV. Village Pachgaon, Manesar, Gurgaon
7.	Rural Electrification Corporation World Headquarters	Rural Electrification Corporation	I-4 City Center, Sector – 29, Gurgaon
8.	EIL Complex	Engineers India Limited	Engineers India Ltd. R& D Complex Sector-16, Gurgaon
9.	ESENCIA	Ansal Properties & Infrastructure Ltd	Ansal Properties & Infrastructure Ltd Sec-67 Badshahpur
10.	Punjab National Bank IT – Headquarter & Staff College	Punjab National Bank	Plot No. 84, Sector 18, Gurgaon
11.	Administration Building & guest house for Solar Energy Centre	Solar energy centre Ministry of New &Renewable Energy	19th mile stone, Faridabad road, Gwalpahari, Gurgaon
12.	Central University of Haryana – Hostel Buildings	Govt. of Haryana	Central University, Village Jatpali, Mahendargarh
13.	GYS vision	Dignity Buildcon Pvt. Ltd	Sector-62 Urban Complex, Manesar, Gurgaon
14.	NHPC office complex.	NHPC limited	NHPC limited, sector-33, Gurgaon
15.	SrishtiArogyadham	Dr. Ramesh Saksena	Village Alipur, Sohna road
16.	Residential building	S. Gurumurthy	Nirvana country sector -50, Gurgaon
17.	Corporate office for Container Corporation of India Ltd	Container Corporation of India Ltd.	Plot No-33, Sector-32, Gurgaon
18.	Oriental Bank of Commerce	Oriental Bank of Commerce	Plot no. 5 Sec-32 Institutional area, Gurgaon

Results regarding future registered projects in Haryana under GRIHA in table 7 show that there were eighteen projects were registered. The project title, client name and location of registered projects are shown in table below. It was

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observed that maximum numbers of projects were registered in Gurgaon followed by Faridabad and Karnal district of Haryana state.

V. CONCLUSION AND SUGGESTION

Summarizing, the main sources of exploration of secondary data were GRIHA, IGBC, LEED- India and BEE. Ten buildings were found out to be green buildings out of them four were rated by GRIHA. Further, these four GRIHA rated buildings were selected for case studies, as per the case studies it was found that in all the four buildings top soil was preserved and further used for purpose and native species plants were used in landscaping. For reducing energy consumption in case 1 WWR was limited to 30.0 percent, in case 2 center courtyard was built in case 3 WWR was limited to 31.0 percent and in case 4 landscapes were sync with architectural spaces. In case 4 regarding renewable energy technologies solar photo voltaic panels and solar water heater were installed. In case 1 low energy material like flyash bricks were used in case 1 low energy material in door and windows were used and in case 4 AAC blocks were used and low energy construction and material were used. Green buildings show greater level of occupant's satisfaction and better ratings for perceived health and productivity compared to non-green buildings **(Brager et al. 2009).** The occupants of green building found to be having more productivity in their work. So, green building concept should be promoted and for the same government should provide some schemes/ funds.

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