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Evaluation of Green Building Parameters to Improve the Green Rating System of Existing Non-Rating Building.

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Abstract

There are various activities which are creating adverse impact on environment construction is one of them. Construction industries are having potential to reduce the environmental impact by constructing green building, net zero energy building etc. The various rating agencies have developed different tools for designing and development of green building. The present study consists of study of various green building parameters of non-rated building to convert into rated building. Total 21 parameters were studied out of these rainwater harvesting, use low flow fixture for efficient use of water and energy saving were studied in detail and discounted payback period method was used. The discounted payback period was calculated. Research reveals it is worth investment of Rs 4.58 lacs to upgrade the infrastructure and within 1.97 years the invested amount will get recovered and which will safeguard the environment.

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Introduction

Optimization of resources is a key factor in any type of construction project, resources optimization leads to making the project financially viable. Various factors such as energy, water, electricity, environment etc. play a key role in making buildings green by optimization.[1] studied the green building parameters and mentioned the importance of the design and development of the building.[2] mentioned challenges faced in scarcity of water and the use of roof rainwater harvesting is the effective way of tackling the issue of shortage of water. Rainwater harvesting not only fulfills the requirement for water but also creates awareness among the people regarding water management.[3] stated that construction sector will make a revolution by designing and constructing green buildings in global economy.[4] mentioned, over period of time in the building sector it is necessary to have a sustainable sector as it will have a great impact on the environment.[5] stated that energy is one of that important factor in green building design, the author mentioned in the United States around 18% of energy will be consumed by commercial building. The increase in

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demand for energy is creating challenge in design, also the difference between actual demand and design demand creating problems and is dependent on occupants usage and behavior.[6] studied and reviewed 925 articles on operating performance in green buildings, many researchers have given different definitions of green buildings and various rating systems have been formed by various countries to expedite green building development. The aim of developing green building is to protect the environment, reduction of pollution etc. which will create a conducive environment in the indoor spaces of buildings.[7] worked on carbon emission of office spaces, ISO 14040 helps to understand the carbon emission at various stages of building which includes use of the material, its process and manufacturing etc. The multiple linear regression models helps to measure the life cycle assessment.[8] attempted to convert non-rated buildings to green buildings and their impact on the costing part. Total project cost is obtained from CPWD, green building attributes cost, non-rated cost of construction and increase in cost of green building is calculated according to GRIHA and IGBC rating. The payback period, life cycle cost, the initial cost of green building are calculated. The concept of conversion of the non-rated buildings into rated found effective as far as cost and payback period is concerned.[9] stated the importance of tolls which assesses of green building. Various attributes are considered in the study which creates great an impact on environment, pollution, cost energy etc. These attributes are not applicable in all regions of India, the rating system will be definitely helpful in the design and development of new construction.[10] stated many researchers adopted various methods to make building green/sustainable, rainwater harvesting is one of the options to make building sustainable, the rainwater will get collected at one point through the roof and the collected water will be charged into boreholes to recharge the groundwater, also the collected water can be used for flushing purpose after providing the primary filtration treatment. This will help the usage of fresh water and also it saves the cost of electricity which is required for pumping.[11] surveyed regarding the barriers to the development of green buildings in Malaysia. A set of questionnaires was formed and data was collected, some observations are role of government, subsidy, incentive policies, loans with less interest for mortgages, exemption on taxation part etc. These are the major parameters that needs to be addressed to attract people to build the green building.[12] compared the cost of construction for conventional building and sustainable building, the initial cost of the building is measured by RS means, the building area, floor-to-floor height, number of floors, type of structure etc. are the input parameters and the model gives the accuracy of 94.30%.[13] commented on energy consumption, the construction sector is responsible for the consumption of natural resources as any type of building will consume energy in its entire life from construction phase to the demolition phase. It is necessary to understand the energy consumption pattern, at the initial phase during construction of building large amount of energy will be used for the construction of a the building, various operations, modifications etc. are known to be direct energy while indirect energy is required for the manufacturing of construction material.[14] studied the effectiveness of the use of motion sensor lights in buildings for energy saving and making the building sustainable. The electrical devices are installed in the toilets, devices consist of sensors which will detect the motion of humans and it will turn on and when this motion of human is stopped it will get turned off. These types of motion sensor lights are very helpful in passages, toilets, corridors etc. It has been noted the use of these lights will help to reduce the electricity energy between 30 to 40 % monthly. The study of the use of these lights in 10 toilets reduces emissions by around 19.03 tons/year.[15] mentioned about the strategies for awareness about green building, a questionnaire survey was carried out, analysis was done based on the responses received. It has been observed that professional training, awareness about the existing facilities available, media publicity, incentives schemes for adoption of green building technology for construction etc. are key factors for defining the strategies related to green building.[16] identified the various factors that influence the development of green buildings. In any sector if development starts to happen, automatically constraint starts coming up and these will influence the development. The author mentioned that providing incentive, guidance about the policies related to green building, publicity for green building technology, also providing subsidies and relaxation in taxes, the formation of schemes for rewards etc. are the influencing factors observed in China.

Review of Literatures

As stated by[6] 925 parameters were studied by referring 106 articles, the parameters such as energy performance, study of designed and operational energy consumption, indoor environment quality (IEQ), occupants satisfaction etc. were reviewed. It has been stated the IEQ of United states and China has a great difference between the designed Vs actual, there is difference in actual energy consumed and designed energy. It was mentioned the IEQ satisfaction level of occupants in green building was increased.[17] carried out cost benefit analysis as cost is the most important parameter in construction energy efficiency technology application method was used in the case study of China. It has been observed the project doesn't meet the market requirement as far as finance is concerned, if any kind of subsidy is provided then it would be possible to make it financially viable and the project will attract investor too.[18] discussed the green retrofitting of aged buildings which are non-rated buildings at Hong Kong region. Green retrofitting methods viz. motion sensor lamps, LED lights, Lifts in building shall have power regeneration system, rainwater harvesting and usage of grey water, water saving devices, solar system etc. This list will be helpful in retrofitting the building using sustainable, recycled, energy-efficient materials to make conventional building to green rated buildings. In addition to this the proper policies related to retrofitting with green material shall be formed by the concern authority.[19] studied the use of building information modelling (BIM) in retrofitting of building. The retrofitting consists of improvisation of energy and environmental performance, optimization of usage of water, improvement of comfort of occupants by providing ample amount of natural light by improving the air and noise quality etc. and these things must be financially beneficial to the owner.

Indian Green Building Council (IGBC) and Green Rating for Integrated Habit Assessment (GRIHA) are the main rating agencies in India. The forecasting the performance of building over the life cycle of building, which consists of pre-planning, planning, design, execution and operation and maintenance of the building. While IGBC contributes to new construction, existing buildings, school, retail etc. It gives a rating for buildings in Silver, gold and platinum. The Indian rating systems are focus on the environment (solid waste, wastewater, water etc.), energy, material, design, construction management, innovation, indoor environment and comfort etc.

Materials and Methods

To achieve the objective of conversion of non-rated building to rated building, extensive survey was conducted by visiting the site. The selected site was of private hostel building which was constructed in the year of 2000. The building consists of parking + three storied, total numbers of buildings are three, which will accommodate the around 180 students. The various existing parameters were noted as shown in Table1 viz. type electrical fittings, rain water harvesting, solar system, water recycling and its use, solid waste management etc. The rain water harvesting, energy saving light fittings and water efficient plumbing fittings are considered in the study. While, roof insulation and reflective paint was not considered as some part of the roof was covered with the solar system and remaining part covered with the fabricated shade. The selected building is having existing hot water system and Solar panels/ photovoltaic (PV) panels. Regarding waterless urinals, these are not considered in the study as each room consists of EWC hence separate urinal is not required. While building is having only two common washrooms for visitors/staff which consist of only two urinals and replacing these urinals are not going to have great impact on the saving of resources, so waterless urinals is not considered in the study. Due to availability of existing composting facility recycling waste storage and efficient landscape irrigation system these parameters (Sr no 18 and 21) is not considered in the present study. The list of green building measures were prepared according to (IGBC 2016) and (GRIHA 2015).

The various parameters along with percentage for green building as per GRIHA and IGBC are shown in Fig 1 and 2 respectively.

Table 1: Green building measure

S. No.	Green building measures	Available	Not available
1	Use of AAC block instead of brick masonry.		NA
2	Roof insulation and reflective paints on the roof.		NA
3	Use of 6mm reflective glass of window		NA
4	Provision of solar hot water system	A	
5	Low VOC paints		NA
6	Solar panels/photovoltaic (PV) panels	A	
7	Rain water harvesting		NA
8	Energy saving light fittings. (Use of CFL,LED)		NA
9	Green roof and wall treatment		NA
10	Water efficient fittings, sensors ,waterless urinals		NA
11	Liquid crystal display (LCD) light fittings		NA
12	Automatic light sensor		NA
13	Sewage treatment plant	A	
14	Solid waste management	A	
15	Onsite water Reuse		NA
16	Utilization of fly ash in the building structure.		NA
17	Use low energy material in the interior.		NA
18	Recycling waste storage		NA
19	Effective use of walls and roof (Protection)		NA
20	Use of UV reflected glass to prevent heat gain		NA
21	Water Efficient landscaping		NA

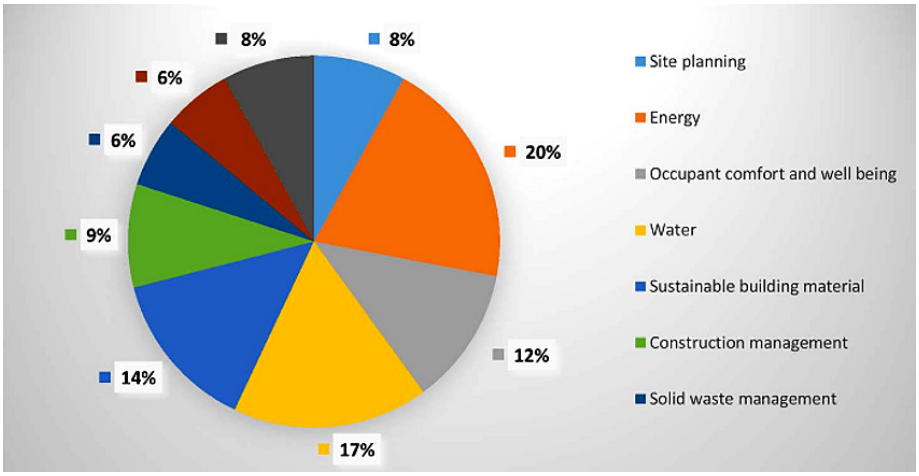

Fig. 1: Rating system - GRIHA

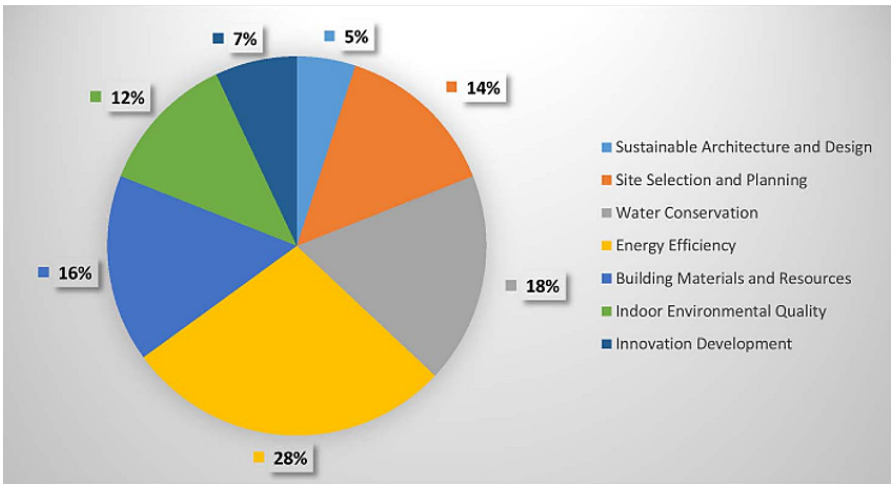

Fig. 2: Rating system - IGBC

Rainwater Harvesting

Due to the rapid development in infrastructure the need of water, electricity etc. increases day by day and the source of the water depleting day by day. It is challenge to cater the requirement of water, the various government agencies/ concerned authorities are facing the difficulties in providing the sufficient amount of water which is the basic need of human being. These agencies come up with the various solutions to save the water such as rain water harvesting is one of the solution. Many Municipal corporations made mandatory for implementation of rainwater harvesting, which can be done by collection of roof rainwater and collection surface rainwater.[20] stated about the scarcity of water in Jordan city, it is proposed to have roof rain water harvesting system to new and well existing building in the city, the 15.5 Mm^3/year of water can be collected from the roof by providing the proper system, the collection of water is around 5.6% of total domestic supply of water. It is mentioned the rainwater harvesting with water distribution system will helps to relief to fulfill the requirement at certain extent subjected to awareness amongst the citizens need create. In present study the building is having age of 24 years and rainwater harvesting system was not installed to all three buildings. The catchment area of three building is 1989.05 Sqm., buildings are having flat roof, average annual rain fall in taken 745 mm, which is obtained from Indian metrological department (IMD) as shown in Table 2, According to (IS 15797:2008) the runoff coefficient varies from 0.8 to 0.95 by considering the evaporation, infiltration and other losses if any. The total 11,85,474 liters water will get collected from the roof of all three building. As the building doesn't have rain water harvesting system, the water collection capacity per day in rainy season is around 9880 liters. The plumbing system is necessary to install for collection of water from roof to underground water tank. The details of building name, location and name of client are not revealed to maintain the confidentiality as per their requirement.

Table 2: Details of data related to rainwater harvesting

Description	B1	B2	B3
Type of roof	Flat	Flat	Flat
Catchment area (m^2)	636.17 m^2	641.37 m^2	711.51 m^2
Average annual rainfall (mm)	745	745	745
Rainwater Coefficient	0.8	0.8	0.8

Use of Water Efficient Plumbing Fixtures

Optimizing the usage water is the need of the day, the simple and small steps such as leakage detection, metering/sub metering to control the usage of water, routine and periodic maintenance of plumbing system etc. will helps to save the significant amount of water with the expenditure of nominal cost. Also there are certain steps viz. water saving products, replacement of old plumbing fixture and fittings, reuse of water etc. which helps to save the water but the initial investment in high.[21] In present study, the survey was carried out to understand the plumbing system. It has been observed the all taps which are fitted will discharge the water 9 liter/min, it has been measured with the amount of water discharged with the help of calibrated water collection plastic bag and water discharge per minute is measured. Low flow fixtures can help to reduce the consumption of water as these fixtures are having capacity to discharge 2.5 liter/min and 5.8 liter/min (Fig. 3). These three buildings are having total 283 numbers of taps, considering the low pressure at top floor (third floor) 5.8 liter/min fixtures can be fitted by replacing the existing 9 liter/min fixtures for 90 taps which are there at top floor. Similarly at first and second floor 2.5 liter/min fixtures can be fitted by replacing 9 liter/min to 193 taps. Overall saving in water is around 1542.50 liter/min, which is significant amount of saving in water, over and above there will be huge amount of saving in electricity which is required for pumping the water from underground to overhead water tank.

Fig. 3: Low flow fixture

Energy Efficient Electrical Fixtures

Detailed survey was carried out regarding collection of electrical fittings available at all locations as shown in Table 3. The building was designed to get ample amount of light and ventilation, being old building all the spaces are fitted with compact fluorescent lamp (CFL) electrical fittings.

Table 3: Details of electrical fittings

S.No.	Description	No of Fittings
1	4 seater room	108
2	3 seater room	108
3	Toilets	273
4	Passages	91
5	Gymnasium	05
6	Study room	14
7	Guest room	02
8	Store room	04
9	Guest room	30
10	Parking area	16
11	Garden area	06

[14]stated the importance of use of motion sensor lights in the building, the use of these lights which helps to reduction in electricity bill and large amount saving in energy. The reduction in monthly electricity bill was observed between 30 to 40% by use of motion sensor lights. In present study all the CFL's can be replaced with light emitting diode (LED) in the rooms, store room, offices etc. while the motion sensor lights can be installed at passages and toilets.

Results and Discussion

The rainwater harvesting, water efficient plumbing fixtures and energy efficient energy electrical fixtures etc. parameters are considered amongst the 21 green building measures mentioned in Table 1. The reason for selection of these green building measures is as the selected building is already constructed and which is in use, the design part and execution part was already over. To convert the non-rated building to rated building best possible green building measures with the minimum investment can be possible as far as financial feasibility. It is necessary to understand the initial investment required and payback period of the same.

Initial Investment and Payback Period

Regarding rainwater harvesting system, the water demand has been calculated according to the guidelines of NBC. Existing plumbing down take lines which are connected to drainage system, these lines are need to connect to the rainwater harvesting system. Table no. 4 shows the details of investment and saving cost. The costing of the water lines is calculated as per the market cost which is around Rs. 2,71,250 and one small primary filtration unit need to install before staring the water. The costing of the unit is around Rs. 22,000. The cost saving against the saving of water is calculated as per the water bills received from Municipal Corporation. The cost saving will be Rs.17 per cubic meter of water and per day saving in water in monsoon season is 9880 liters per day. Accordingly the Rs.168 will get saved per day and monthly saving will be Rs 5040.[2] concluded the effective rainwater harvesting has potential for water saving between 0.27% to 19.7%. In present study the water saving will be 26.27% per day.

Water efficient plumbing fixtures will helps to save the water, total saving in water is around 19,000 liters per day by installing the 2.5 liter/min and 5.8 liter/min low flow fixtures. The low flow fixtures have potential to cut down the water requirement by 50.53% per day during the monsoon season. The costing for the fixing the low flow fixtures is 50 per piece and total number of taps are 283 and total initial investment is Rs.14,150. Regarding electricity, the CFL lights of the rooms to be changed with LED tubes and CFL in the passages and parking are to be replaced with motion sensor lights. These lights will save the power consumption around 30 – 40%,[14] based on this average power consumption saving be 35%. The initial investment details are shown in Table no 4.

Table 4: Details of initial investment and saving details

S.No.	Description	Initial Investment (Rs)	Saving in Cost (Rs) Per annum
1	Rainwater Harvesting	2,71,150	60,480
2	Low flow fixture	14,150	1,16,280
3	Energy saving	1,72,740	1,26,072

Payback period is the span which is required to recover the amount invested in the project. The payback period is calculated using equation 1 and 2. Operation and maintenance cost, saving in cost

$$NCF = cashinflow - cashoutflow \quad ...(1)$$

$$nP = P/NCF \quad ...(2)$$

Where, NCF is net cash flow, interest component is take as 0 (i=0), P is present value, payback period *n*P in years obtained.

The total increase in cost of green building is Rs. 4,58,040/-, operation and maintenance cost is Rs. 43,608/-, saving in cost due to green building attributes is Rs. 2,59,224/-. Using equation 1, NCF is 2,59,224/- and *n*P is 1.76 yrs and if payback period is calculated based on the interest component of 12% (i=12%) then payback period will be 1.97 yrs which known as discounted payback period. Which indicates the money will get return in future at interest rate of 12%. The selection of discount is very crucial as it is depend upon availability of finance and its utilization in future. The interest for the study take as per the previous similar type of study carried out by.[18]

Conclusion

The present study helps to understand the benefits of green building and its impact on cost and environment. Outcome of the study stated the economic feasibility of selected parameters of green building. The construction cost of green building is higher than the non-rated building, the attempt was made to convert the non-rated building to rated building. For this total 21 green building parameters were studied at initial stage, considering the practical easiness in implementation in existing building three primary parameters viz. rainwater harvesting, saving of water by installing low flow fixture and

energy saving etc. were taken into account. For upgradation of infrastructure for converting non-rated building to rated building, one time investment cost will be required to made of Rs. 4,58,040/- against the investment made Rs. 2,59,224/- per annum will be saved. Discounted payback period of the green building will be 1.97 years. Which indicates the invested amount will be recovered in 1.97 years. Furthermore, initiative has been taken by municipal corporations, state government and central government for development of green building, also initiation is required regarding converting building to green rated building.

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This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement
This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions
- **Dr Sudhanshu Pathak:** Conceptualization, Methodology.
- **Mrs Aradhana Chavan & Mrs Mrunalini Shewale:** Writing and review original draft.
- **Mrs Rohini Khandelwal, Mrs Sukhada Shelar & Dr Sachin Mane:** Project administration, Supervision.

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