RESEARCH ARTICLE OPEN ACCESS

Application of DEATo Increase Greenness ofaBuilding

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ABSTRACT
Green building is a best alternative for Traditional buildings according to Environmental policy it is increasingly respected by the community. To achieve sustainable development, higher attention has been paid to economic and environmental impacts associated with construction and operation of structures. So, to rate these green buildings there are numbers of rating systems in India which helps to provide functional framework for evaluation of environmental performance and containing Sustainable Development into building and Construction process. In this research GRIHA, LEED and Eco- Housing these Indian green building assessment tools are studied. In this project we used DEA and AHP for finding the factors upon which we can invest so that we can achieve maximum greenness with limited available funds. AHP helps in finding the weights of each factor. It helps in analyzing complex decisions. The model selected for this project is the CCR model in this model output increases by the same proportional change of each proportional increase in the input. EMS is software which computes DEA efficiency measures. The output of the DEA model includes efficiency scores. The factors proposed for consideration before constructing a new building are 1.Energy performance, 2.Utilization of fly ash, 3.Use of regional materials, 4.Water efficient landscaping, 5.Thermal comfort, 6.Water use reduction.

Keywords : Analytical Hierarchy Process,CCR, DEA , Decision Making Units (DMU's) , Efficiency, Efficiency Measurement System (EMS)

Date of Submission: 27-10-2019 Date Of Acceptance: 16-11-2019

I. INTRODUCTION

Construction industry is forced to look for some new techniques to face the challenges in construction industry because of increased global competition. During last two or three decades construction industry faces the problem of Global Energy consumption. Approximately 40 % of Global Energy consumption in building related. While going for construction it affects the environmental balance because of large amount of water consumption and waste generation. Hence there is need to build environment friendly and energy efficient buildings. To minimize the total environmental impact a Green building is designed, constructed and operated.In turn, green building reduces building impacts on human health and the environment by implementing improved site location, design, construction, operation, maintenance, and removal encompassing the complete life cycle of building because they are using the recycled materials and using materials that are eco-friendly throughout.(www.grihaindia.org, Dec 10,2013)

Most zero-energy buildings use the electrical grid for energy storage but some are independent of grid. Energy is usually harvested on-site through a combination of energy producing technologies like solar and wind, while reducing the overall use of energy with highly efficient HVAC and lighting technologies. The zero-energy goal is becoming more practical as the costs of alternative energy technologies decrease and the costs of traditional fossil fuels increase. Some advantages of these buildings are as follow:

Integration of renewable energy resources
Integration of plug-in electric vehicles
Implementation of zero-energy concepts

The zero-energy concept allows for a wide range of approaches due to the many options for producing and conserving energy combined with the many ways of measuring energy (relating to cost, energy, or carbon emissions).

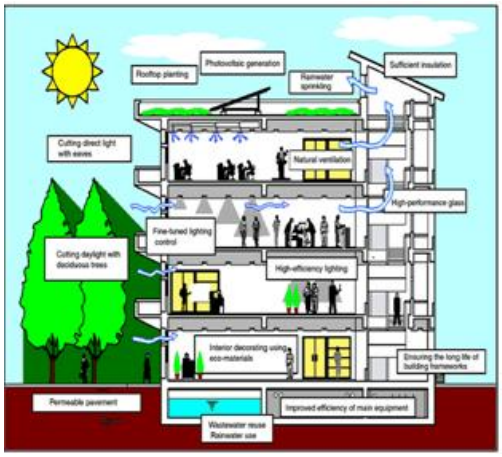

Fig..1.Provisions made for Improvement of Green Buildings

Therefore, there is a need to develop a cost model which increases green points in less cost. Data Envelopment Analysis (DEA) this is a linear programming-based technique for measuring the performance efficiency of organizational units which are termed Decision-Making Units (DMUs). This technique aims to measure how efficiently a DMU uses the resources available to generate a set of outputs . The DEA has following advantages: (1) It allows effective use of multiple inputs and multiple outputs (2) The weights of inputs and outputs are not needed by decision makers, (3) each DMU efficiency is compared to that of the best operating unit, rather than to the average performance. On the other hand, the main limitation of the DEA is that standard formulation of DEA creates a separate linear program for each DMU. This will be computationally exhaustive when the number of DMUs is large The remainder of this paper is organized as follows. First, the Indian green building rating systems are described. Second, the DEA technique is explained. Third, EMS software is applied for green building attributes. Finally, the results obtained are discussed.

The idea of green rating of buildings has taken roots in India. Rating tools set benchmark for green measures for constructing and using buildings to make them sustainable and to reduce their negative impacts on environment. The DEA technique is used for measurement of efficiency of the factors which are used for making green building.DEA is a non – parametric method of measuring efficiency of decision making units (DMU's). To measure that how efficiency of DMU's uses the resources available generate a set of outputs DEA technique is used .Data Envelopment Analysis (DEA) is a technique used to compare the performances of several units. For the selection of Decision Making Units the main criteria is limited fund factor. It allow multiple use of multiple input and output .The weights of input and output are not needed by decision makers. To find out prominent green building cost attributes CCR model of the DEA is used to maximize the efficiency of DMU's is objective function of this model.

1.2 Objective of Work

1. To understand green building rating system and develop the difference between all of these(LEED, GRIHA And Eco- Housing).
2. To understand and implement maximization of greenness of building in limited fund by applying Data Envelopment Analysis (DEA).
3. To find out prominent green building cost attributes.
4. To find efficiencies of attributes (which are selected) by application of EMS 1.3 Software.
5. To implement the attributes which gives more green points in lesser cost.

II. GREEN BUILDING

Green building is also known as green construction or sustainable building is the practice of creating structures and using processes that are environmentally responsible and resource efficient throughout a building's life-cycle; from sitting to design, construction, operation, maintenance, renovation, and demolition.(www.igbc.in, Dec 10,2013)

Buildings have major environmental impacts over their entire life cycle. Resources such as ground cover, forests, water, and energy are depleted to give way to buildings.

A green building depletes the natural resources to the minimum during its construction and operation. The aim of a green building design is to minimize the demand on non-renewable resources, maximize the utilization efficiency of these resources, when in use, and maximize the reuse, recycling, and utilization of renewable resources. It maximizes the use of efficient building materials and construction practices; optimizes the use of on-site sources and sinks by bio-climatic architectural practices; uses minimum energy to power itself; uses efficient equipment to meet its lighting, air-conditioning, and other needs; maximizes the use of renewable sources of energy; uses efficient waste and water management practices; and provides comfortable and hygienic indoor working conditions. In sum, the following aspects of the building design are looked into in an integrated way in a green building.

- Site planning ,
- Building envelope design Building system ,
- Design (HVAC heating ventilation and air conditioning, lighting, electrical, and water heating) ,
- Integration of renewable energy sources to generate energy onsite,
- Water and waste management ,

- Selection of ecologically sustainable materials (with high recycled content, rapidly renewable resources with low emission potential, etc.),
- Indoor environmental quality (maintain indoor thermal and visual comfort, and air quality)

A green building is one which uses less energy, water and natural resources, creates less waste and is healthier for the people living inside compared to a standard building.

- Energy saving to the extent of 30 - 40 %.
- Enhanced indoor air quality.
- Higher productivity of occupants.
- Potable water saving to the tune of 20% - 30%.
- Enhanced day light & Ventilation.
- Green buildings have a smarter lighting system that automatically switches off when no one is present inside the rooms.
- Simple technologies like air based flushing system in toilets that avoids water use by 100%.
- Use of energy efficient LED's and CFL's instead of conventional incandescent lamp.

2.1Different Green Building Rating Systems In India

The idea of green rating of buildings has taken roots in India. This is in line with the global trend in which the rating tools set benchmarks for green measures for constructing and using buildings to make them sustainable and to reduce their negative impacts on environment. Based on the magnitude of green measures adopted, points are awarded to a building and, after appropriate weighting; a total score is ascribed to determine the rating of the building. This helps to convey the range of application of green measures in building construction.(N.S. Phadtare – 2015)

One of the reasons for interest in voluntary rating schemes is that the green buildings require a complex set of sustainability criteria related to a wide range of resource and material use which is often difficult to package as a single regulatory instrument upfront for enforcement. The advantage of the rating system is that it helps to disseminate green building practices outside the realm of regulations that are often impeded by structural and institutional barriers.
The different rating systems in India are

1. LEED
2. GRIHA
3.Eco-Housing

2.1.1LEED (Leadership in Energy and Environmental Design) :

Leadership in Energy and Environmental Design (LEED) is a voluntary national certification process that helps industry experts develop high-performance, sustainable residential and commercial buildings.It's a body, which is primarily allocated to rate various buildings whether that building qualifies or possesses the various environmental and occupant friendly parameters such as good indoor air quality, use of environmental friendly and alternate materials etc. various countries have separate bodies controlling the LEED.

In year 1998 the Leadership in Energy and Environment Design (LEED) green building rating system was introduced in US.LEED – India programmed has adapted from united States Green Building Council (IGBC) in India. IGBC has setup the LEED guidelines for India Core Committee with the objective of the LEED rating system for the Indian context. (N.S.Phadtare – 2015)
Few salient features of green building recommended by IGBC are as follows :

1. Effective use of soil and landscapes
2. Efficient use of water
3. Energy efficient &eco-friendly equipment
4. Effective control & building management systems
5. Use of renewable energy
6. Use of recycled/recyclable materials
7. Improved indoor air quality for health and comfort

2.1.2GRIHA(Green Rating for Integrated Habitat Assessment) :

GRIHA is an acronym for Green Rating for Integrated Habitat Assessment. GRIHA is a Sanskrit word meaning – 'Abode'. Human Habitats (buildings) interact with the environment in various ways. Throughout their life cycles, from construction to operation and then demolition, they consume resources in the form of energy, water, materials, etc. and emit wastes either directly in the form of municipal wastes or indirectly as emissions from electricity generation. GRIHA attempts to minimize a building's resource consumption, waste generation, and overall ecological impact to within certain nationally acceptable limits benchmarks.(www.grihaindia.org, Nov 1,2013)

GRIHA is a national rating system for Green buildings in India. Conceived by TERI and developed jointly by the Ministry of New and Removable Energy , Government of India, it is based on nationally accepted energy and environmental principal. Over 300 projects across India of varying scale and function are being built based on GRIHA guidelines.(N.S. Phadtare – 2015)

Some of the benefits of a green design to a building owner, user, and the society as a whole are as follows:
1. Reduced energy consumption 2. Reduced destruction of natural areas, habitats, and biodiversity3. Reduced air and water pollution (with direct health benefits)4. Reduced water consumption5.Limited waste generation due to

recycling and reuse6.Reduced pollution loads7.Increased user productivity8.Enhanced image and marketability.

2.1.3 Eco-Housing :TheEco-housing partnership was launched in September 2004 in response to the unchecked and resource intensive housing construction boom in India. Implemented by the International Institute for Energy Conservation (IIEC) with support from United States Agency for International Development (USAID) and the Global Development Alliance (GDA).

The eco-housing assessment tool was developed in 2006 for Pune City only. In 2009, Version II was introduced, and it is used in Pune and to some extent in Mumbai also. In Pune, it is popular in small to medium residential projects. (Vyas and Jha, 2016).The term eco – housing means environment friendly and energy efficient buildings, sustainable construction practices and healthy and productive indoor environment with lower natural resources use.

METHODOLOGY

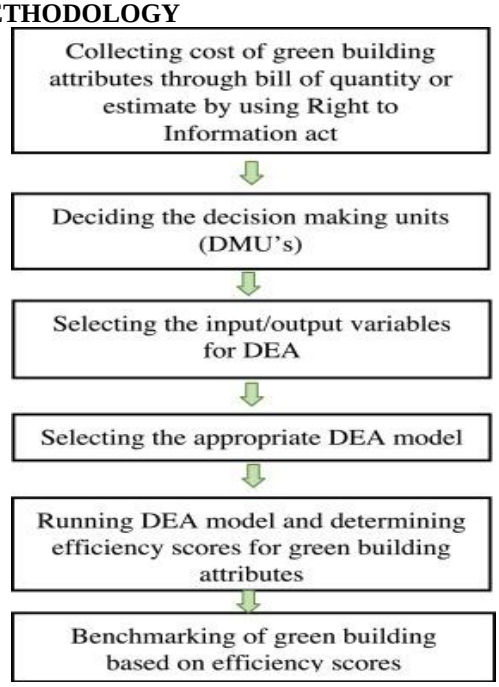

Fig. 2. Flow Chart / Methodology of work

3.1 Data Envelopment Analysis

Data envelopment analysis (DEA) is a technique used to compare the performances ofseveral units. These units in the context of services can be various service organizations like banks, hospitals, schools etc. This technique is used in places where a relativeperformance of different units is to be compared and evaluated.

• DEA can be used to analyze the performance of several units to set a benchmark.

• The analysis can be used to discover the inefficient operations or units even for themost profitable organizations.

• DEA has an advantage over other analysis techniques as it can handle complexrelation between multiple inputs and multiple outputs and the units are non-commeasurable.

• DEA techniques are based on linear algebra and are related to linear programmingconcepts. The technique is similar to mathematical duality relations in linearprogramming.

Data Envelopment Analysis is a relatively new data-oriented approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs.

Data Envelopment Analysis (DEA) is a mathematical method based on productiontheory and the principles of linear programming. It enables oneto assess how efficiently a firm, organization, agency, or suchother unit uses the resources available (inputs) to generate aset of outputs relative to other units in the dataset.DEA is a common non-parametric frontier model for studying multi-input and multi-output systems.

3.2 Advantages of DEA

1. DEA can handle multiple inputs and multipleoutputs. Inputs and outputs can have verydifferent units.
2. DEA provides a single comprehensive measureof performance.3. It doesn't assume any specific functional formrelating inputs to outputs.
4. DEA provides valuable information for lessefficient DMUs on how to improve. For each inefficient DMU, DEA also provides a peer bestpractice group for reference purposes.

3.3Steps followed in the DEA Process :

1. The amount involved in each factor is calculated.
2. The amount required to satisfy all the pre requisites is calculated.
3. The factors which are satisfied along with the pre requisites are listed and the possible points are calculated.
4. The points acquired makes the building certified.
5. The remaining factors which require fewer amounts and can achieve possible points are noted.
6. And these factors are selected as the DMU's; these DMU's selected are same as results of the AHP process.

The variables are selected as DMU's are find out from the collection of data from site. Cost of each factor is considered and total money required for Pre requisites is calculated. The variables are selected for

DEA with the reasons of their exclusion is given. The inputs and output variables are calculated in DEA and according to use of DEA model CCR Model efficiencies are measured. Then finally the Excel sheet is prepared for application of EMS software

3.4 Pre requisites

Pre requisites are those factors that should compulsorily be satisfied in order to get the building certified. The amount calculated and shown in the Table 1 are the difference amount between the costs of the normal conventional building to the green building. These costs are given by the Indian Green Building Council (IGBC). By satisfying all these factors of the pre requisites we can achieve 40 points as per the LEED that is a certified green building.

Table 1. Pre requisites

FACTORS	COST(Rs)
Sustainable sites	
1. Construction activity prevention	
a. Temporary seeding	25 Rs per sqft
b. Permanent seeding	35 Rs per sqft
c. Mulching	60 Rs per sqft
Water efficiency	
1. Water use reduction	25000 to 30,000 Rs
Energy performance	
1. Commissioning of building energy	5000 Rs
2. Minimum energy performance	5000 Rs
3. Fundamental refrigerant	20,000 Rs
Materials	
1. Storage and collection of recyclables	3000 Rs
Indoor environment	
1. Minimum indoor air quality performance	20,000 Rs
2. Environmental tobacco smoke control	2500 Rs

Total money required to be for Pre requisites is around 90000 Rs.

3.5 Greenness factors

These factors are from the LEED which are to be considered for the construction of green building. In Table 2 the factors which can be satisfied with the limited funds are noted these are satisfied along with the pre requisites. In this table the cost entered is the difference amount between the normal conventional building to the green building and points obtained by each factor are also noted.

Table 2.Possible points with limited funds

Site selection

Item	points	Cost(Rs)
Site Selection	1	
Development Density and Community Connectivity 5	4	
Site Development—Maximize Open Space 1	1	
Storm water Design—Quantity Control 1	1	20,000
Storm water Design—Quality Control 1	1	
Light Pollution Reduction 1	1	

Water Efficiency

Item	points	cost
Water Efficient Landscaping 2-4	2	10,000
Innovative Wastewater Treatment and Reuse 2	1	10,000
Water Use Reduction 2-4	**3**	**30,000**

Energy and atmosphere

Item	points	cost
Optimize Energy Performance 1–19	13	20,000
On-site Renewable Energy 1–7	4	15,000
Enhanced commissioning	2	5000
Enhanced refrigerator management	1	40,000
Measurement and Verification 3	3	5000

Materials and Resources

item	Points	Cost
Construction Waste Management 1-2	1	10,000
Materials Reuse 1-2	2	-5000
Recycled Content 1-2	2	-8000
Regional Materials 1-2	1	
Rapidly Renewable Materials 1	1	10,000
Certified Wood 1	1	3000

Indoor Environmental Quality

Item	Points	Cost
Increased Ventilation 1	1	
Construction Indoor Air Quality Management Plan—During Construction 1	1	20,000
Construction Indoor Air Quality Management Plan—Before Occupancy 1	1	10,000
Low-Emitting Materials—Adhesives and Sealants 1	1	20,000
Low-Emitting Materials—Paints and Coatings 1	1	5000
Low-Emitting Materials—Flooring Systems 1	1	10,000
Indoor Chemical and Pollutant Source Control 1		
Controllability of Systems—Lighting 1	1	
Controllability of Systems—Thermal Comfort 1	1	
Thermal Comfort—Design 1	1	
Thermal Comfort—Verification 1	1	
Daylight and Views—Daylight 1	1	
Daylight and Views—Views 1	1	

3.6Selection of Variables For DEA

The following Table 3.shows the variables which are selected for DEA

Table 3. Selection of variables for DEA

Sr. N	**The possible variable**	**Whether considered for DEA analysis**	**Remarks/ reasons for exclusion**
1	Energy performance	Yes	In this if we invest the possible points obtained can easily increased
2	Water use reduction	Yes	Amount required is less and most of the cost is included in the pre requisite
3	Strom water usage	Yes	For efficient water use
4	Water efficient landscaping	Yes	Amount required is less and most of the cost is included in the pre requisite
5	Thermal comfort	Yes	It can be done during the design stage which includes less cost
6	Controllability of lights	Yes	It is related to the energy performance factor
7	Increased ventilation	Yes	It is done at the design phase with which more sun light is allowed
8	Low voc paints	Yes	In this the cost involved is less and the health of the occupant is related to this
9	Use of regional materials	Yes	This helps in cutting down the building materials cost
10	Utilization of flyash	Yes	This helps in saving money during the construction of walls

11	Rapidly renewable materials	Yes	These are eco friendly materials and very cost effective
12	Alternative	No	It depends on the locality
13	Alternative transportation (low emitting and fuel	No	This factorinvolves more cost
14	Green	No	This is not

3.7 Selection Of DEA Model

This research makes use of the CCR model of the DEA to find out prominent green building cost attributes. The mathematical form of the CCR model is given in Equations 1, 2, 3, and 4 .The objective function is to maximize the efficiency of DMU.

$$Z_o = \sum_{r=1}^{s} u_r y_{r0} \quad (1),$$

$$subject\ to \sum_{i=1}^{m} v_i x_{i0} = 1 \quad (2),$$

$$\sum_{r=1}^{m} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 1 \quad (3),$$

$$i = 1,\ldots\ldots m,\ j = 1,\ldots,n\ ,\ r = 1,\ldots\ldots,\ s \text{ and } u_r\ ,\ v_i \geq 0. \quad (4)$$

Where,

Z_0: the measure of efficiency for DMU_0 (the DMU under evaluation), which is a member of the set j = 1, . . ., n DMUs.

u_r: the output weight. It is determined by the solution of the model and is assigned to the observed r^{th} output.

v_i: the input weight. It is determined by the solution of the model and is assigned to the observed i^{th} input.

y_{r0}: the known amount of the r^{th} output produced by DMU_0.

x_{i0}: the known amount of the i^{th} input used by DMU_0.

y_{rj}: the known amount of the r^{th} output produced by DMU_j.

x_{ij}: the known amount of the i^{th} input used by DMU_j.

The CCR model of the DEA is used to identify green building attributes. The model yields efficiency scores between 0 and 1. A green building attribute can be used if its efficiency score is 1. This means that one can invest in the respective green attribute which has less cost and greener points.

The inputs and outputs of decision making units (DMUs) in conventional CCR model of data envelopment analysis (DEA) are the separate limited data, thus the relative efficiency among decision making units is evaluated at one point of the time axis. But in many real world applications, DMUs have the inputs and outputs which are the continuous functions of a time interval. In this situation, how can we get the relative efficiency of the decision-making unit evaluated? At present, the systematic research on this point is lacking. So in the present paper, we first develop the continuous CCR model which is a fractional function programming in DEA, when the inputs and outputs of decision making units are continuous CCR functions on the interval. Then we establish a linear function programming equivalent to continuous model for effecting computations. At the same time, we get the dual model of the linear function programming for simplifying the primal one. At last we get the dual theories and raise the definitions of DEA efficiency for continuous CCR model.

3.8.Efficiency Measurement System (EMS)

Efficiency Measurement System (EMS) is software which computes Data Envelopment Analysis (DEA) efficiency measures. EMS is used for the determination of efficiency scores of the greenness factors. The output of the DEA model includes efficiency scores and benchmarks.

3.8.1Steps for running the EMS 1.3 software

1. Preparing the excel sheet as per the EMS criteria.
2. Load the data in the EMS software.
3. Run the DEA model.
4. Save the results.

3.9 Preparing the input output data

The first and probably most difficult step in an efficiency evaluation is to decide which input and output data should be included. EMS accepts data in MS Excel or in text format. Additionally to "standard" inputs and outputs EMS can also handle "nondiscretionary" inputs and outputs (i.e., data which are not controlled by the DMUs). The next sections describe how the data files should be prepared for EMS. The size of your analysis is limited by the memory of your PC. I. e., there is theoretically no limitation of the number of DMUs, inputs and outputs in EMS. Although the code is not optimized for large scale data, we successfully solved problems with over 5000 DMUs and about 40 inputs and outputs. The first and probably the most difficult step in an efficiency evaluation is to decide which input

and output data should be included. The EMS accepts data in the MS Excel or in text format

Using MS Excel files EMS accepts Excel 97 (and older) files (*.xls). The input output data should be collected in one worksheet. Don't use formulas in this sheet, it should only contain the pure data and nothing else.

The following Table 4.shows the Input and Output Data for selected DMU's.

Table 4. Input and Output data for selected DMU's

DMU's	Cost (I)	Area (I)	Maintenance Cost (I)	Change in Greenness Points (O)
Energy Performance	20,000	1500	5000	13
Water use reduction	30,000	1500	1000	4
Storm Water usage	30,000	1500	1000	2
Water efficient lanscaping	10,000	1500	1000	4
Thermal comfort	10,000	1500	500	2
Controllability of Lights	12,000	1500	1000	1
Increased Ventilation	5,000	1500	500	1
Low VOC paints	20,000	1500	5000	2
Rapidly renewable materials	20,000	1500	3000	1
Use of Regional Material	-5,000	1500	1000	2
Utilisation of Fly ash	-10,000	1500	2000	2

III. OUTPUT OF THE DEA MODEL

The following Table 5.shows the result of the DEA model

Table 5. Output of DEA Model

Sr. No 1	DMU's (2)	Efficiency score (3)	Ranking based on efficiency score (4)	Benchmarks (5)
1	Energy performance	325.00%	1	2
2	Water use reduction	100.00%	5	4
3	Strom water usage	50.00%	7	2 (0.20) 4 (0.30)
4	Water efficient landscaping	127.47%	4	6
5	Thermal comfort	100.00%	6	2 (0.08) 4 (0.42)
6	Controllability of lights	25.00%	9	2 (0.01) 4 (0.24)
7	Increased ventilation	50.00%	8	4 (0.25)
8	Low VOC paints	15.38%	10	1 (0.15)
9	Rapidly renewable materials	11.76%	11	1 (0.06) 2 (0.01) 4 (0.05)
10	Use of regional materials	200.00%	3	0
11	Utilization of fly ash	200.00%	2	0

Analytical hierarchy process helps in finding the weights of each factor. It helps in analyzing complex decisions. In this project by the AHP process we get conclusion that energy performance with weight 1.7005 is more important than the other factors. In the site selection sub factors preserve and protect landscape with weight 0.377273 is more important. From the efficient water use the sub factor water use reduction with weight 0.570716 is more important. In the material sub factors use of regional material is preferred with weight 1.725. From the Indoor environment sub factor thermal comfort with weight 1.702 is more important.

Data envelopment analysis helps in finding the efficiency of the factors which are selected based on the cost factor. The model selected for this project is the CCR model in this model output increases by the same proportional change of each proportional increase in the input. For the DEA process we used EMS 1.3 software for finding the efficiencies of the factors. Energy performance is most efficient factor with efficiency score of 325%.

IV. DISCUSSION

The Indian construction industry currently lacks any readily available cost model ofgreen buildings for the selection of attributes in limited funds. To judge investmentmodel, the industry currently relies on the segregated and a large number of reports ofthe different types of green building attributes (Johannes, 2015). As such, the DEAapproach is well suited to fill this gap and to assess where to invest. The DEAapproach presented in this paper can be utilized by a particular green buildingdeveloper to achieve more green ratings in a limited fund. Additionally, the proposedmethodology is deployable at the project level. Every project has multiple DMUs ofgreen building attributes. DMUs are ‘‘benchmarked" against each other in DEA.Consequently, developer will be able to identify their best performing green buildingcost attributes.

V. CONCLUSION

The data envelopment analysis helps in finding the efficiency of the factors which areselected based on the cost factor. The model selected for this project is the CCRmodel. In this model output increases by the same proportional change of eachproportional increase in the input. The EMS 1.3 software has been used for the DEAto find out the efficiencies of the attributes. Energy performance is found as the mostefficient attribute with an efficiency score of 325%. In this project we used Analytical hierarchy process and Data envelopment analysis for finding the factors upon which we can invest so that we can achieve maximum greenness with limited available funds. The factors proposed for

consideration before constructing a new building are 1. Energy performance, 2.Utilization of fly ash, 3. Use of regional materials, 4.Water efficient landscaping, 5.Thermal comfort, 6.Water use reduction. When a building satisfies all the pre requisites of the LEED then they should consider these factors to get more green points and can get a green rated building. All the factors proposed here are very economical when compared to the other parameters. By this project we can conclude that upon investing limited funds on the proposed factors we can achieve increased greenness. When a building satisfies all the pre requisites of the IGBC then they should consider these attributes to get more green points and thus get a green rated building. All the factors proposed here are very economical when compared to the other parameters. The limitation of the current study is that developed cost model includes only one case study in Indian context only. This study can be applied to green buildings in other developing counties.

Even though the cost model in this paper is based on data collected from the Indian construction industry, the methodology would suggest a much broader geographical applicability on cost model for green construction projects internationally. The next step for the research team is to develop a cost model for a number of case studies from different geographical and climatic region.

5.1 Future work

There is a good scope for the future work in this study. More responses can be collected from various green building related members; case studies of different green buildings can be taken and can be analyzed. The analysis done in this can study can also be done by using SB tool.

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