

A REVIEW ON THE APPLICATION OF DEA TO INCREASE GREENNESS OF BUILDING

Miss. Vasudha Vasanttrao Shinde , Prof. S.S. Deshmukh

P.G. Student, Department of Civil Engineering, Trinity Academy of Engineering , Pune .

Associate Professor and H.O.D. Civil Engineering Department, Trinity Academy of Engineering , Pune .

Abstract : Green building is an best alternative for Traditional buildings according to Environmental policy it is increasingly respected by the community. After Agriculture industry Construction industry is the largest industry in India. Green Building is nothing but the Sustainable Development with use of Renewable Material and Reuse of Conventional materials also. 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. To assess the efficient green building attributes in terms of minimum cost Data Envelopment Analysis (DEA) is used. Hence, this paper mainly focuses on to maximize greenness of a building in limited fund availability with application of Data Envelopment Analysis (DEA) .

Keywords : *Green Buildings, Data Envelopment Analysis (DEA), Sustainable Development, Efficiency, Decision Making Units (DMU's) , GRIHA, LEED, Eco – Housing.*

1. 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.

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.

2. LITERATURE REVIEW :

2.1 The Use of Data Envelopment Analysis for Evaluating Building Energy Consumption in Terms of Productivity – David Carnes, TX Bruce D. Hunn, GA Jerold W. Jones

This Paper discuss the conceptual basis for considering building energy consumption in terms of the output of its occupants. It also discusses DEA a method of calculation of efficiencies with multiple outputs and multiple inputs. DEA method is applied to Texas State University Energy Consumption. According to author DEA delivers performance targets for less efficient entities based on the performances of the most efficient ones. The analysis in Texas State University Consumption was performed using an CCR 1 developed by center for cybernetic studies at the University of Texas at Austin. Final conclusion of author is that this method is suitable only for comparisons of facilities with same kind of activities. It removes the assignment of values to disparate sources of energy.

2.2 Comparative Study of LEED and GRIHA rating system - Mr. Ilyas Iqbal Sande, Prof. Mrs. N. S. Phadtare

In this Literature, author gives the comparative study between Green Building rating systems in India such as – LEED , GRIHA. Comparison between both of the systems can be done with their assessment method, performance criteria, scope and energy rating scales. Leadership in Energy and Environmental Design (LEED) System was developed by US in 1998. Green

rating for Integrated Habitat Assessment (GRIHA) in India was developed by building and construction authority Singapore in 2005. LEED India has been adapted from United States Green Building Council's (USGBC) in 2007. LEED mainly focuses on

- sustainable sites ,
- Materials and Resources ,
- Water efficiency ,
- Indoor Environmental Quality ,
- Energy and Atmosphere ,
- Innovation and Design Process ,
- Regional Priority .

Certification of LEED depends upon credit points which gives certification as Certified , Silver , Gold and Platinum. GRIHA Was developed by TERI and ministry of new and renewable energy , Government. of India jointly. GRIHA gives rating as one, two, three, four and five stars. To achieve all above case study is taken for Pimpri Chinchwad new town development authority at location location Akurdi in Pune. Comparison is depend upon factors such as

- Process ,
- Transparency ,
- Popularity ,
- Cost ,
- Criteria.

Conclusion of author is that both are the simple and effective rating systems and suggested for small contractors to achieve green agenda.

2.3 Study on the relative importance of green building attributes in Philippine Urban Setting Using Analytical Hierarchy Process - Diocel Harold M. Aquino, Christian R. Orozco, Alexandra Lauren C. Sy, And Hershey Kathlyn S. Yap

This paper focuses on study of the relative importance of green building attributes in Philippine urban setting. This is done with the help of Analytical Hierarchy Process (AHP) . This paper includes LEED i.e. International green building rating systems and BERDE locally developed rating systems based on LEED which can be served as a bench mark for this study. Different green building attributes are identified and evaluated by using AHP. This study uses field work approach- using survey and questionnaires and interviews. In this literature the most effective method used to concentrate judgment is that to make pair of elements and compare them as single property. Hence pair wise comparison gives determination of ranking criteria of rating systems by using AHP. Responses to the interviews and questionnaires are collected from

- Engineer ,
- Architects ,
- Urban Planners and
- End users.

After AHP calculations author concluded that energy efficiency is important for engineers and end users. While water efficiency for architects and for urban planner sustainability is priority.

2.4 Enhancement of greenness of new construction using the DEA- Gayatri Sachin Vyas, Kumar Neeraj Jha and Dilip Kumar Arvindkumar Patel

Enhancement of Greenness of any new construction that can be done with DEA is the main finding of the author. What is the importance of green building and the factors on which greenness of any building increases that are find out firstly in this literature. Green building rating systems such as GRIHA, Eco – Housing and IGBC are studied in this paper. How Data Envelopment Analysis (DEA) assess the relative efficiency of green building attributes in terms of cost that is found out by author. Comparison between GRIHA, Eco – Housing and IGBC is made according to various factors such as sustainable site planning, sustainable building material, Energy, Water etc. Hence the DEA is used for efficiency measurement with available data. According to author the attributes which scores 100% and above are efficient and remaining factors are inefficient. EMS 1.3 software is used to find efficiencies of attributes. The final findings of this paper is that energy performance is most efficient attribute with an efficiency of 325 %.

2.5 Integrate an Embodied GHG Emissions Assessment Model into Building Environmental Assessment Tools - Y. Chena, S. Thomas Ng

According to author considerable portion of Green House Gas (GHG) emissions is from building sector because maximum use of energy is made by the buildings while constructed and operated.GHG emissions model integrated of BEA comprised of

- Product category,
- GHG auditing ,
- Benchmarking.

The author makes assessment of GHG emissions in existing BEA schemes. Author discusses the environmental and weightings in BREEAM , LEED, Green Star and BEAM Plus with materials and resources aspects. In the assessment model the buildings are assessed through the three steps such as being classified into product category, being carbon audited and being benchmarked. To study limitations of exiting BEA Tools on quantitative evaluation of building materials embodied GHG emissions this is the first finding of work. The study provides a mean to minimize Carbon footprints of building. It also helps the users to identify real green building facilities.

2.6 Objective building energy performance benchmarking using data envelopment analysis and Monte Carlo Sampling Seong-Hwan Yoon and Cheol - Soo Park

The study focuses on the benchmarking of building energy performance by using data envelopment analysis and Monte-Carlo sampling method. Most popular measures of building energy performance benchmarking is EUI (Energy Use Intensity). Lower EIU of any type of building gives better performance this assumption is considered in EUI but this will not be actually in all cases if many of building services are not concluded in it. So to overcome this limitation the author done in this report. Case study for privately owned office building and government- owned public office building is considered for study. According to author DEA can evaluate performance of each DMU's only when simple data input and outputs are provided. Efficiency scores of EUI's and DEA for both the buildings vs. 1000 peer buildings and the final conclusion is found out. Therefore to overcome the limitations EUI's the DEA is included with combination of Monto-Carlo sampling. Finally after the demonstration DEA is more suitable approach for building energy bench marking than EUI.

2.7 Development of Data Envelopment Analysis for the Performance Evaluation of Green Supply Chain with Undesirable Outputs - Amir Amini, Alireza Alinezhad , Sadegh Salmanian

According to author the conventional and common structure of DEA and DMU's operates as black box because they ignores the internal structure. DEA is used in multistep or multilevel process but lack of attention to process , supply chain and internal communication that are fundamental problems related to DEA. So the author aimed to find out the general dimensions of the multilevel process. Therefore the model suggested by author is not only provides a possibility to calculate the performance of overall network but also creates the analysis of performance for each of the sub- processes. This gives a new model in DEA by network structure that can analyze performance of building by considering undesirable factors. So in this way it can be helpful for manager to improve the performance of supply chain by making small change in inputs and outputs of inefficient sub-units.

2.8 Data Envelopment Analysis in Energy and Environmental Economics: An Overview of the State-of-the-Art and Recent Development Trends - Abbas Mardani , Dalia Streimikiene ,Tomas Balezentis, Muhamad Zameri Mat Saman, Khalil Md Nor and Seyed Meysam Khoshnava

The main aim of this paper is to provide the overview of the application of DEA models in the fields of environmental and energy economics. For the scholars and practitioners the study given an idea about the state of art of output and input indicators of DEA in the environmental and energy economics fields. The environmental factors are most important for micro – sitting efficiency that is the main findings of the paper. Joint management practices achieves the best and long term scale efficiency this is conclusion made by author. In different schemes and fields distribution of articles based on DEA models has been done in the literature. Comparison between distribution of papers / articles by journal and distribution of papers based on year of performance is made by author. Finally the conclusion of this paper is considered in light of many limitations.

2.9 Productivity Analysis and Variable Returns of Scale: DEA Efficiency Frontier Interpretation - Juliana Benicio, João Carlos Soares de Mello

To find out or to analyze DMU's efficiency from the perspective of variable returns to scale this is the main objective of this paper. In this literature case study is prepared with variations in the efficiencies of DMU's according to methods used for analysis. For the study author uses CCR and BCC model of Data envelopment Analysis (DEA).Author produces the new model named as Concave frontier (F con)which is an Non – parametric algorithm and designed to ensure efficient frontier with increasing returns. Efficiency of the administrative sector in the higher education is taken as the case study. Comparative analysis between all the three methods i.e. CCR, BCC and F con is carried out according to DMU's .Final conclusion of author is that BCC model does not identifies efficient DMU's with increased returns to scale no longer. Comparatively concave border is able to identify DMU's with increased returns to scale.

2.10 Construction Project Success ranking through the Data Envelopment Analysis - Mazyar Zahedi – Seresht , Mohammadreza Akbarijokar, Shahrzad Khosravi, Hamidreza Afshari

Basic aim of this research is to rank the project success according to Data Envelopment Analysis (DEA). To rank Success of any construction project in its post delivery phase. Questionnaire survey is taken up by the author to achieve the above mentioned objective. The Criteria on which the further process of the report has to be done that are

- Time performance,
- Cost performance
- Quality.
- Customer satisfaction

This model is applied for 9 different projects which are having different importance. According to author success of any project is depends upon the success of that project after its closing phase. Measurement of project success is based on perspective of organization performing and directly involved in execution of a project. This analysis is used to improve success of project based on setting the input factors in future.

3. CONCLUSION :

The conclusion is made from the above discussion is that using the Data Envelopment Analysis (DEA) model we can find out the productivity analysis of a project and we can gives the successful project ranking after its closing phase. Performance evaluation of green supply chain it can be done with use of Data Envelopment Analysis. For energy performance benchmarking DEA plays a very important role in it.

DEA is a technique which is based on a linear algebra and it is also related to linear programming concepts. In short DEA can be used to analyze performance of different units to set a benchmark. It is also an advantage over other analysis technique because it can handles complex relation between numbers of inputs and numbers of outputs. DEA technique is also very similar to mathematical duality relations in linear programming.

REFERENCE

- 1) *The Use of Data Envelopment Analysis for Evaluating Building Energy Consumption in Terms of Productivity – David Carnes, TX Bruce D. Hunn, GA Jerold W. Jones*
- 2) *Comparative Study of LEED and GRIHA rating system (2015) - Mr. Iliyas Ikbal Sande, Prof. Mrs. N. S. Phadtare*
- 3) *Study on the relative importance of green building attributes in Philippine Urban Setting Using Analytical Hierarchy Process - Diocel Harold M. Aquino, Christian R. Orozco, Alexandra Lauren C. Sy, And Hershey Kathlyn S. Yap*
- 4) *Enhancement of greenness of new construction using the DEA(2016) - Gayatri Sachin Vyas, Kumar Neeraj Jha and Dilip Kumar Arvindkumar Patel*
- 5) *Integrate an Embodied GHG Emissions Assessment Model into Building Environmental Assessment Tools (2015) - Y. Chena, S. Thomas Ng*
- 6) *Objective building energy performance benchmarking using data envelopment analysis and Monte Carlo Sampling (2017) - Seong-Hwan Yoon and Cheol - Soo Park*
- 7) *Development of Data Envelopment Analysis for the Performance Evaluation of Green Supply Chain with Undesirable Outputs(2016) - Amir Amini, Alireza Alinezhad , Sadegh Salmanian*
- 8) *Data Envelopment Analysis in Energy and Environmental Economics: An Overview of the State-of-the-Art and Recent Development Trends (2018) - Abbas Mardani , Dalia Streimikiene ,Tomas Balezentis, Muhamad Zamari Mat Saman, Khalil Md Nor and Seyed Meysam Khoshnava*
- 9) *Productivity Analysis and Variable Returns of Scale: DEA Efficiency Frontier Interpretation(2015) - Juliana Benicio, João Carlos Soares de Mello*

10) *Construction Project Success ranking through the Data Envelopment Analysis (2014) - Mazyar Zahedi – Seresht ,
Mohammadreza Akbarijokar, Shahrzad Khosravi, Hamidreza Afshari*

11) <http://www.grihaindia.org>

12) <http://new.ysgbc.org/leed>

13) www.eohousing.in

