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COST AND BENEFIT ANALYSIS OF SHIFTING TO GREEN ENERGY IN HOUSE

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Abstract : Buildings are the largest consumer of energy and a major source of greenhouse gas (GHG) emission. This incurs a large sum of money to society. It is evident that incorporating green features in buildings can substantially save energy and water consumption, and reduces GHG emissions; however, it is perceived to be costly both by public and private sectors. Often, the investment decisions are made considering the initial cost of the project. Therefore, the purpose of this research is to identify the costs and potential benefits of green buildings over the life cycle of the project using Cost Benefit Analysis (CBA), which performs an economic assessment in project appraisal that helps investors and policymakers in better decision making. The study involves a case study of a public office building from Nepal, which is located at Dumre- Bhansar New Town. The existing building is retrofitted with green components such as solar panels and rainwater harvesting for energy efficiency and water efficiency. The results show that investing in green buildings reduce the life cycle cost of the project, and therefore generates value for money in public investment in the long run. A policy recommendation on subsidy helps in scaling the project to private sectors especially residential buildings. The most important contribution of this study lies in identifying the costs and benefits of green building and introducing the concept of life cycle cost using CBA, which increases awareness and removes barriers in implementing green technologies. This paper also acts as an introductory guideline for project appraisal and formulating policies for the Government of Nepal

***IndexTerms* : Green Building, CBA, life cycle costs, Sustainable Development Goals.**

I. INTRODUCTION

Developing green buildings is an important strategic way to realize sustainable development, save resource and energy, and protect environment. In order to promote the healthy development of green buildings, many countries issue green buildings evaluation standard, such as BREEAM of the UK, CASBEE of Japan, GBTool of Multinational Cooperation and LEED of the USA, which all aim to evaluate the "environment performance grade" of green buildings [1–3]. In 2006, China issued "Evaluation Standard for Green Building (ESGB)", which is the first multi-objective and multi-level comprehensive evaluation standard of green building "environment performance grade" in China [4]. In 2008, China began to implement the green building evaluation label system. There are 10, 20, 82 new buildings acquiring green building evaluation labels in 2008, 2009 and 2010, respectively [5]. By the end of 2012, there are total 742 new buildings acquiring green building evaluationlabels in China, and total building areas had reached 75.43 million m2 [6]. This shows that the development of green buildings have kept rapid momentum in China. However, compared by the new building areas of nearly 2 billion m2 each year, the development scale of green buildings is still very small in China. Analyzing the international existing green building evaluation systems, it can be found that these evaluation systems do not involve the economic evaluation of green buildings. For instance, BREEAM, LEED, CASBEE and ESGB do not contain such economic evaluation. Although the GBTool system, as an evaluation framework, proposes to evaluate cost benefits, it does not provide specific evaluation contents and methods. Currently, many people's awareness about green buildings is not enough comprehensive and accurate, they think that green buildings require high investment and high cost, and do not want to develop or purchase green buildings, which hinders the development of green buildings in China. Hence, it is very necessary to construct the theoretical method system of green building cost–benefit analysis from a technical and economic point of view, which has important theoretical value and practical significance for the healthy development of green buildings

Literatures review

1. Analysis on economic, environmental and social benefits generated by the green building technology application. For instance, Nalewaik and Venters think green buildings can bring tangible and intangible benefits; besides, with the increase of resources and energy's price, cost saving of resources and energy willmake green buildings generate significant economic benefits. Ries et al. takes new green plant as a case, and analyzes quantitatively economic and environmental benefits brought by the green plant, which mainly includes increasing working efficiency and human health, decreasing energy consumption, operating andmaintenance costs; Specifically, the case study shows that working efficiency is increased by 25%, and energy is saved by 25%. Kats thinks that the benefits brought by green buildings include saving energy and water, decreasing waste discharge, increasing indoor environment quality, employee's satisfaction and work efficiency, as well as decreasing health costs, equipment operation costs and maintenance costs.

2. Study on incremental costs of green buildings technology application. Through comparative study on the costs of 33 green buildings and conventional buildings of the same type, Kats finds that the average incremental cost is only $3–5 per square foot, and the average cost increasing rate is only 1.84%. By collecting the construction cost data of 221 buildings (including teaching buildings, laboratories, libraries, community centers and so on) and comparing the unit construction cost, Morris finds that the difference of construction cost is very big even among the same type of buildings, which mainly depends on the type of property, no matter whether the green buildings get the LEED certification or not. Zhang et al.examines the costs and barriers in applying the green elements to the process of developing property projects, they find that the passive design strategies are comparatively inexpensive to apply as opposed to the active design strategies and the major barriers, the higher costs have hindered the extensive application of green technologies in China. By statistically analyzing the incremental costs of 18 projects participating the green building certification label (9 public green buildings, 9 residential green buildings), Sun et al. find that the major factors influencing on the incremental costs are: renewable energy application (48.20%), saving energy of envelope structure (23.20%), building intelligent (16.10%), indoor environment control (7.5%), water utilization and rainwater collection (2.60%). applies two indexes of "unit area incremental cost" and "incremental cost ratio" to analyze the incremental costs of green buildings, and gets that unit area incremental cost is 6.01$/m2 for one-star green building label, 16.28$/m2 for two-star green building label and 35.48$/m2 for three-star green building label, and that unit area incremental Table 2 Financial benefits of green buildings summary of findings (per ft2). Item Category 20-year NPV 1 Energy value $5.79 2 Emissions value $1.18 3 Water value $0.51 4 Waste value(construction only)-1 year $0.03 5 Commissioning O&M value $8.47 6 Productivity and health value (certified and silver) $36.89 7 Productivity and health value (gold and platinum) $55.33 8 Less green cost Premium $4.00 9 Total 20-year NPV (certified and silver) $48.87 10 Total 20-year NPV (gold and platinum) $67.31 cost ratio is 1.0% for one-star green building label, 2.2% for twostar green building label and 3.4% for three-star green building label.
3. The cost–benefit evaluation of green building technology application [8,9,19–24]. Ries et al. conducts a financial evaluation on the new green plant project utilizing three financial indexes ofthe net present value (NPV), breakeven period and B/C, which shows that investing new green plant is a correct decision from financial benefits aspect. Kats analyzes on the present value of incremental benefits and costs of 33 green buildings obtaining the LEED certification in 20 years of study period, which indicates thattotal financial benefits of green buildings are over ten times the average initial investment required to design and construct a green building, and energy savings alone exceed the average incremental costs associated with building green, and building green is cost-effective and make financial sense (see Table 2). Li and Tian constructs an incremental cost–benefit model of green buildings in the whole life cycle, proposes that the comprehensive benefits of green buildings in the whole life cycle can be reflected by two indexes, one is the NPV of comprehensive benefits, the other is the incremental cost–benefit ratio, and through case analysis, she draws a conclusion that green buildings have economic feasibility. In brief, the literatures above-mentioned mainly study on economic, environmental and social benefits of green buildings, and cost–benefit evaluation of green technology application on green public buildings and green plant buildings from the view of qualitative and quantitative point. However, there are a few of articles on the cost–benefit evaluation of green technology application on large-scale residential area in China. In this paper, taking the largescale green residential area in China as a study case, the authors would systematically carry out the cost–benefit analysis on energy efficiency technology application (EETA) on green buildings.

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II. METHODOLOGY

1. Objective and Scope of the Project The objective of the project is to reduce the operating costs of public buildings and reduces GHG emissions. The scope of the project is to retrofit the existing building with PV solar panel (Hybrid) on its roof for energy efficiency and to install rainwater harvesting (RWH) technology to improve the water efficiency of the building. In this study, the installation period is considered as one year, and it is assumed that the project will generate cash flow after one year.
2. Cost and Benefit Items During an economic appraisal, it is a prerequisite to identify the most significant costs and benefits associated with the project. The costs and benefits items of PV solar panel and rainwater harvesting, identified within the scope of the study, are private cost, which includes capital cost and annual operating and maintenance. The benefits include private benefits and social benefits.
3. Aggregate Benefits and Costs Since the life of PV solar panel and rainwater harvesting is 20 years, the time horizon for CBA is set at 20 years from the start of the installation. The benefits and costs of the project are aggregated to lifetime for the economic assessment. The base year for discounting is considered as 2020. The social discount rate is calculated from the Social rate of time preference (SRTP) approach since it is suitable for public sectors that have no well-defined market value [22]. The SRTP is calculated as a maximum of Development Bond and Treasury Bill. As per the central bank of Nepal, the interest rate on development bond is 5% for 15 years and 4.28% for the treasury bill over 364 days [23]; so, the social discount rate is considered as 5%.
4. Calculate NPV, IRR, and B/C ratio The output of CBA is measured against standard parameters: NPV, IRR, and B/C ratio. All the costs including replacement cost and benefits are considered; however, salvage value is ignored since the NPV of salvage value is negligible. The NPV, IRR, and B/C ratio of the project are $14,997.51, 7.48%, and 1.252 respectively.
5. Sensitivity Analysis Sensitivity Analysis measures uncertainty during project implementation. It measures how the proposed intervention in green technology performs in the long run. Three factors are considered for scenario analysis: SDR, net benefits, and date as follows:
6. Social Discount Rate: The effect of SDR on NPV is observed by varying discount rates from 2% (Low) to 10% (High).

7. Net Benefits: The major benefit item is the power yield from the solar panel. During the analysis, the maximum expected power output was taken to quantify benefit; however, it is sensitive to the weather conditions. So, the monetary value of predicted benefits is varied by -10%, -20%, and, - 30% to study its impact on project feasibility.

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Suggestions:

The CBA shows that green building is beneficial to society, and it generates value for money. Besides, it aligns with sustainable development goals that help to make cities and communities resilient; so, there is a necessity for scaling it to private sectors. The question that needs to be addressed is how much subsidy is needed to make a project viable for the private sector such as a residential building in Nepal. To examine this, the private benefits and social benefits of a green building need to be identified properly. The private benefit considered in this study is energy-saving and water-saving while a reduction in CO2 emission is a social benefit, but the private sector does not account for social benefits in project appraisal. They are more concerned about the Revenue Expenditure (R/E) ratio. The R/E value for this project is 0.82 considering the worst-case scenario where the excepted power decreases by 30%.

IV CONCLUSION

Green building can save the substantial operating cost of building over the project life cycle; however, it is often criticized for having a high upfront cost compared to a conventional building. The knowledge of costs and benefits of green buildings is also limited among government officials and decisionmakers. Therefore, this study proposes CBA as an assessment tool for project appraisal of green building. The study carried out detailed costs and benefits of green building within its scope.. Furthermore, the subsidy framework helps in upscaling the green building concepts in the private sector. It is expected that the result of this study draws the attention of all stakeholders in better decision making. In summary, the CBA provides a proof-of-concept on the usefulness of intervention since it anticipates the world with and without the project and identifies potential costs and benefits along with cost savings and return on investment. The CBA methodology described in this paper also acts as a standard project appraisal guideline for any government intervention. This study has some limitations. Primarily, the present study considers only PV solar panel and rainwater harvesting; so, future work may consider other green components such as improving building thermal envelope and using water efficiency faucets. Then, the result and conclusion presented are from a case study of one public office building in Nepal. Even though results are promising, it should be validated on a larger scale. Finally, the current work has investigated the power consumption in the low scenario since most of the buildings in Nepal do not have proper heating and cooling system. The authors of this research are public officials from developing countries.

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