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What does it cost to convert a non-rated building into a green building?

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ABSTRACT

The increasing demand for natural resource exploration and exploitation has generated greater attention on the impact on the environment of such actions. One solution to mitigate the negative impacts is to regulate it through government agencies and legal requirements thereby promoting sustainable construction. More recently, a variety of environmental and green building rating tools have been developed to assist construction of green buildings. It helps in making decisions that best fit the sustainable goals (i.e. social, economic, environment). This paper outlines potential benefits of Indian government green buildings. Findings of this paper show that the average increase in the initial cost of green buildings is 3.10% for those with three stars rating and 9.37% for those that are five stars rated buildings. It is worth investing in such acts to safeguard the environment.

1. Introduction

Today the world is facing major environmental problems in the shape of climate change, waste accumulation, ozone layer depletion, etc. (EPA, 2016). The construction sector consumes tremendous energy, natural resources and, as a consequence, it increases pollution levels globally. The construction industry accounts for 10% of global gross domestic product (GDP) and has both direct and indirect impacts on climate change and the environment. Greenhouse gas (GHG) emissions from the construction industry approximate 23% (Erlandsson & Borg, 2003; Nelms, Russell, & Lence, 2005). The different phases of a building life cycle emits an excessive quantity of CO_2 to the atmosphere through the production of building materials, construction of buildings, the renovations, and the rehabilitations at later stages, up to the final demolition. Researchers have concluded that the selection of low environmental impact construction materials has a significant saving on CO_2 generated (Gonzalez & Navarro, 2006). The building uses energy throughout its lifecycle. The environmental, social, and economic indicators are three pillars of sustainable development, which is a globally emerging sector, and a highly active industry in both developed and developing countries.

In India, the urban population has grown at an annual growth rate of 1.15 percent between 2001 and 2011, from 27.4 per cent to 30.9 per cent (Indian Express, 2015). Due to this rapid urban expansion, the country has experienced an increase in construction activities which has imposed pressures on the environment and resources. Infrastructure investments play a major role in determining future resource intensity. A green building comes under the umbrella of sustainable development which inflicts minimum impact on the built environment throughout its lifecycle. The green building footprints have increased from 20,000 square feet in 2004 to 3 billion square feet footprints in 2015. The current target sits at than 10 billion green building footprints by 2022 (Times of India, 2015). Incorporating green building practices into the construction of buildings is a solid financial investment. Green buildings are not only environmentally friendly, but they also have various other advantages. For example, the buildings offer greater comfort by creating a healthier indoor climate. This in turn increases the productivity of the workforce while also reducing incidences of absenteeism (GRIHA, 2015). Due to the environmental crises, construction patrons are demanding assurance of buildings' long-term environmental and economic performance and costs. The problem in progressing towards sustainable construction practices is that the environmental attributes i.e. energy saving costs, indoor environmental quality, etc. are invisible and appreciated only when the building is occupied and is in use. The construction supply chain of builders, developers, planners, manufacturers, design (structure, landscape, and energy) and construction teams now need to consider the extra construction cost of a green building and the payback period for all factors. The initial incremental cost of a green building strongly depends on the country's situation. In several developed countries like the United States of America (USA) and the United Kingdom (UK), renewable energy prices have decreased as energy–efficiency technology is well advanced (Alshamrani, 2017; Tatari & Kucukvar, 2011). However, in other countries, these technologies are not locally available, so prices

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are still high. Another factor that has a significant influence on initial incremental cost is government subsidies (Alexeew, Carolin, & Zia, 2015). Green building subsidies are common in many developing countries including India (Alexeew et al., 2015). Moreover, this study has found that the incremental cost of green buildings over conventional buildings is mainly due to energy efficiency measures (Alshamrani, 2017; Tatari & Kucukvar, 2011). Several conventional energy-efficiency methods such as the orientation of the building, the position of doors and windows, open window units, proper plantation of trees, use of bamboo in construction, etc., may reduce energy consumption by 20–30% (Kneifel, 2010). However, there are few published studies concerning the development of initial cost prediction models for green buildings, particularly in the provision of cost comparison of sustainable and conventional buildings (Alshamrani, 2017; Tatari & Kucukvar, 2011). This is crucial not only to help determine the initial incremental cost of a green building but also to consider costs and benefits calculated over the entire life cycle (from the cradle to the grave) of a green building (Cabeza, Rincón, Vilariño, Pérez, & Castell, 2014).

Darko and Chan (2016) reviewed 36 articles and found that the cost is the second most reported barrier to green building adoption in the literature. The higher cost of constructing green buildings has become a major obstacle that makes it difficult to encourage stakeholders to adopt green buildings. Compared with conventional (non-green) buildings, green buildings cost more to construct, and the extra cost includes not only the higher purchase and acquisition costs of green building technologies (such as solar heating appliances and ground-source heat pumps) but also costs relating to installations that conform to design specifications and higher labour costs (Geng, Dong, Xue, & Fu, 2012). Many studies (Darko & Chan, 2016; Darko, Zhang, & Chan, 2017; Hwang & Tan, 2012; Mulligan et al., 2014; Nahmens & Reichel, 2013; Opoku & Ahmed, 2014; Potbhare, Syal, & Korkmaz, 2009; Samari, Ghodrati, Esmaeilifar, Olfat, & Shafiei, 2013; Shi, Zuo, & Zillante, 2012; Zhang, Platten & Shen, 2011) have discussed that anxiety about the high-cost premium of green buildings remains a prominent barrier to its widespread adoption. It is vital, to fully appreciate that the high cost of a green building is a real and major barrier that prevents stakeholders from adopting it. However, if real life cases are studied, the cost of green buildings may not prove to be a barrier. Darko and Chan (2016) ranked lack of incentives and support (from government) as third among the top five green building adoption barriers identified from the literature. In the US, the UK, and Canada, for example, the government provides various incentives (Qian & Chan, 2010) to drive the adoption of green building construction by stakeholders. Despite the importance of incentives, the progress in adopting green buildings is still lacking.

Ries, Bilec, Mehmet Gokhan, and LaScola Needy (2006) concluded that green buildings offer direct as well as indirect benefits. Indirect benefits of green buildings include the increase in productivity of a worker by approximately 25%; decrease in absenteeism; and decrease in energy usage by approximately 30% on a square foot basis.

A green building rating system measures the sustainability of a building. It provides an effective framework for evaluating the building's environmental performance and incorporating sustainable development into the building and construction processes. The innovation in thinking of sustainable construction and the approach was first initiated in 1990 in the United Kingdom with the advent of a sustainable building assessment system known as the Building Research Establishment Environmental Assessment Method (BREEAM). It represented the first successful effort at appraising buildings on a wide range of sustainable factors that included not only energy performance but also location, materials use, environmental impacts, contribution to ecological system health, indoor environmental quality, and water consumption (Kibert, 2013). BREEAM rated buildings initial incremental cost as high up to 2%, and a payback period of two to five years through savings in energy and water bills. The same research demonstrated that there is little or no additional cost for achieving 'pass' ratings (Abdul, 2014).

In the USA, the United States Green Building Council (USGBC) developed an American building rating system – Leadership in Energy and Environmental Design (LEED), in 2000. In LEED certified buildings the initial incremental cost ranges from 0.84 to 5% with a payback period of 3–5 years (Syphers 2003). Similar systems were developed in other major countries, for example, the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan (2004) and the Green Star in Australia (2006). In Germany, the German Green Building Council and the German government collaborated in 2009 to develop a building assessment system known as Deutsche Gesellschaftfür Nachhaltiges Bauen (DGNB), which is possibly the most advanced evolution of building assessment systems.

BREEAM, LEED, CASBEE, Green Star, and DGNB represent the cutting edge of today's high-performance green building assessment methods, both defining the concept of high performance and providing a scoring system to indicate the success of the project in meeting its sustainability objectives. Almost all developed countries show a similar increase in initial cost and payback period. Literature pinpoints economic benefits of sustainable buildings on four fronts:

- Minimisation of operating cost by reduction in electricity consumption.
- Reduction of maintenance cost by conducting complete functional testing of all energy using systems prior to occupancy.
- Increase of building value directly correlated to energy saving.
- Tax benefits offered by local, state or provincial and federal governmental authorities as an incentive for the implementation of green strategies.

These tangible benefits by the green building industry can be measurable (Poveda & Young, 2015).

1.1. Green building rating systems in India

In India, there are two main primary rating systems: the Green Rating for Integrated Habitat Assessment (GRIHA) and the Indian Green Building Council (IGBC). Recently Vyas and Jha (2016) developed a new green building rating system based on stakeholder's opinions. GRIHA was developed by The Energy Research Institute (TERI) in 2007 and recently revised in 2015. The GRIHA considers 31 criterions; the LEED-India considers 51 criteria and the newly developed rating system considers 34 attributes. The rating range for each rating system is as shown in Fig. 1. The GRIHA is a green building assessment rating system based on its predicted performance over the life cycle of the building (planning to operation). The stages of the building's life cycle that have been identified for evaluation are pre-construction, building's design, construction, and operation and maintenance (O & M). The issues addressed in these stages are as follows.

- The pre-construction stage includes intra-site and inter-site issues.
- The building planning and construction stage includes a reduction in resource demand, resource utilisation efficiency, resource conservation, resource recovery and reuse. It also includes the provisions for occupant's health and well-being. The main resources that are considered are water, land, green cover, energy, and air.
- The building O & M stage includes O & M of building systems and processes, occupant's health and well-being, and monitoring and recording of consumption, and also issues that affect the global and local environment.

The Indian Green Building Council (IGBC) was developed by Leadership in Energy and Environmental Design (LEED) in 2006 and was later changed to the IGBC in 2015. The distribution of green attributes of GRIHA, IGBC and the newly developed rating system by Vyas and Jha (2016) is shown in Fig. 2a–c respectively. In GRIHA,