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Cost-benefit Analysis Elements for Green Building Concepts in Architectural Projects

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Abstract. Cost-benefit analysis is an approach used to determine a project's costs and benefits, including architectural projects that apply the green building concept. Through the application of cost-benefit analysis, it can be seen how much additional costs must be incurred as well as how many additional benefits from an architectural project if implementing the green building concept. This article aims to identify the cost and benefit elements when the green building concept is applied to an architectural project. The literature study results show that the cost elements are generally divided into soft costs and hard costs. As for the benefit elements, they can be grouped into environmental benefits, social benefits, and economic benefits related to energy savings.

Keywords: *cost-benefit analysis; green building; architectural projects; cost elements; benefit elements.*

1 Introduction

Cost-benefit analysis (CBA) is known as an analysis of the rate of return and the principles are the same as the procedures followed in the evaluation of investment projects ([1]). In addition, CBA is also known as a systematic and analytical process for comparing benefits and costs in evaluating a project or program which is often social in nature. CBA is the basis for government decision-making and is established as a formal technique for making informed decisions about the use of community resources [2]. CBA is often used to verify the economic viability of public projects because it is often difficult to ascertain the economic impact of public projects. CBA can also be said to be a framework that helps predict whether a project will improve social welfare in the future [3].

As we know that green building is a process of creating buildings and supporting infrastructure that can reduce the use of resources, a healthier environment for its inhabitants, and minimize negative impacts on ecosystems, both local, regional and global ecosystems [4]. In addition, the World Green Building Council [5] defines green buildings as buildings that, in their design, construction or operation, reduce or eliminate negative impacts and can create positive impacts on the climate and environment.

Green building design and development have become part of the global response to climate change and the depletion of natural resources. Indonesia as one of the most populous countries in the world is an important part of the global movement toward a sustainable future. There are three main factors in green building requirements that make them very important, namely health, energy saving, and climate change [6].

If referring to PUPR Ministerial Regulation No. 21 of 2021 concerning Assessment of the Performance of Green Buildings, green buildings mean buildings that meet building technical standards and have significant measurable performance in saving energy, water, and other resources through the application of green building principles according to their functions and classifications in every maintenance [7].

2 Research Method

The methodology used in this paper consist of several stages, including:

1. Systemic literature review and collection of research examples related to the application of green building concepts and cost-benefit analysis.
2. Grouping literature into several sections, such as Application of Cost-Benefit Analysis in Architectural Projects with the Green Building Concept dan Elements of Cost-Benefit for the Application of the Green Building Concept in Architectural Projects.
3. Explanation of the results of the literature review.
4. Drawing conclusions.

3 Application of Cost-Benefit Analysis in Architectural Projects with the Green Building Concept

Discussion of the application of cost-benefit analysis in architectural projects with a green building concept is more related to housing which is carried out to be able to see the increased costs and benefits obtained, as in research conducted by [8]–[12]. However, research on office buildings has also been conducted by [13], [14].

Research by Bradshaw et al., 2005, looks at the cost-benefits of green affordable housing in the United States. The cost data used in this study consists of total development costs, costs from the LEED category along with other components and systems, savings costs based on the LEED category, operational costs, material replacement/renovation costs, and NPV (net present value). The results of the study show that green affordable housing is financially feasible in the long run. Although indeed with the current system to assess the financial feasibility of green affordable housing is too burdensome for initial capital costs. 14 of the 16 case studies studied demonstrated project benefits exceeding project costs over the life of the building 30 years, with an average NPV of over $15,000 per unit [9].

Then Williams and Bourland, 2010, conducted research related to affordable green housing in the United States. The results show that the total development cost is around 9-18% above the cost for conventional affordable housing. The average cost increase as a result of green features was 2.4% (median 2.9%). Experience from the company and a growing number of affordable housing developers and homeowners increasingly demonstrates that certain green methods and materials have lower initial costs than conventional construction practices and can help offset any gradually higher costs associated with other green features in projects [12].

Furthermore, Deniz et al. in 2018 conducted a study on affordable homes with energy-efficient designs in Philadelphia, which has the highest poverty rate in the USA. It compares the estimated cost of the baseline design with the proposed good-performing design alternatives. Design alternatives with good performance have higher estimated costs. However, the payback duration of the improvements gained and reduced utility costs are also considered in the analysis to enable affordable prototyping. In the final stage of the analysis, the solar panels were reduced from 20 to just 11. The results show that the prototype investment has a payback period of more than 16 years with fewer ongoing operating costs than a typical house [10].

Research conducted by Vyas & Jha, 2018 in India, shows that green buildings have advantages, both for business and the environment. Investment in green building is economically profitable due to reduced CO2 emissions. Financial analyzes conducted to evaluate the economic viability of green buildings prove to be financially attractive over their life cycle. Cost analysis of government of India green building projects shows that although green building construction costs are higher than conventional costs, they are in the range of 2-5% for 3-star rated buildings, and 5-17% for 5-star rated buildings when environmental aspects are considered. Payback periods range from 2.04-7.56 years for 3-stars and 2.37-9.14 years for 5-stars. Furthermore, it is also known that the life cycle cost of green buildings is positive, which means that the savings generated from green buildings can cover the additional costs of green buildings [11].

Ade-Ojo & Ogunsemi, 2019, conducted a study related to the prediction of green affordable house financing in Nigeria from several aspects such as site design, water quality and conservation, energy and environment, indoor air quality, and materials. The results of the study show that these aspects make green buildings more expensive when compared to conventional buildings. However, this can be predicted and assessed through three approaches. The first approach sees that green building features are only considered as an additional 'task' compared to the decision-making process. The second approach is to examine existing cost predictions and budgets. the final approach is to compare the costs of similar projects as alternatives [8].

Research from Latief et al., 2017, discusses how to optimize the premium cost of 12 new office buildings that have been green building certified based on the GREENSHIP assessment system in Indonesia. The results of the study found that three main aspects affect the premium cost of new green buildings in Indonesia, namely energy efficiency and conservation, site management, and material sources and cycles. The platinum and gold levels have insignificant differences in energy and water savings when compared to the silver-to-gold levels. The silver level has the fastest return period among the existing levels. However, investors or developers prefer gold-level green buildings because of a medium premium cost with energy savings and medium to high water savings [13].

Furthermore, Ross et al., 2007, assessed the investment in green office buildings that are certified green buildings. The benefits are calculated based on energy consumption savings (electrical energy savings kWh x per unit tariff for the baseline and what is cost efficiency. The additional cost of implementing the green concept is $ 111,143.68 for a discount rate of 5.72% and a 10-year return scenario. Then calculate the NPV (net present value) seen from the cash flow of the resulting energy savings. The results obtained are that the NPV is 29,841.24. A positive NPV implies the financial feasibility of the project. For IRR (internal rate of return) seen from whether the IRR value is greater than the discount rate, if yes, then the decision is financially feasible. In the case studied by Ross et al., it can be seen that the IRR is 11.83% which is greater than the discount rate (5.72%). In general, it can be concluded that the application of the green building concept is financially feasible (NPV ≥ 0 and IRR ≥ 5.72%) [14].

4 Elements of Cost-Benefit for the Application of the Green Building Concept in Architectural Projects

The application of the green building concept from several works of literature is stated to have a high cost. This additional cost is referred to as an incremental cost, which is an additional investment cost, which can increase in green building projects compared to ordinary buildings [15]. In general, increased economic benefits are considered as dominant benefits, meaning that economic benefits are directly brought to investors and consumers. Green building has great profit potential [16]. Wu and Ma, then divide the incremental cost components into indirect costs and direct costs, as shown in Figure 1.

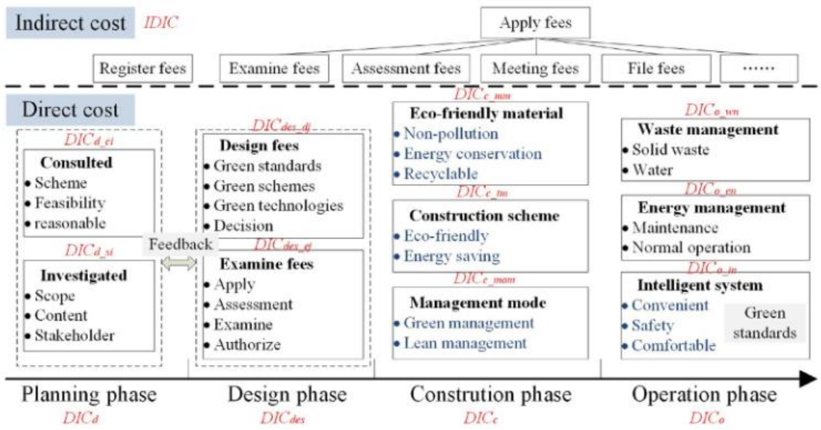

Figure 1 Indirect Cost and Direct Cost Element Components [12]

According to Northbridge Environmental Management Consultants, 2003, the costs of green building projects are divided into pre-construction and post-construction costs. Pre-construction costs include soft costs and hard costs. Soft costs are related to design, commissioning and documentation costs [17]. Meanwhile, hard costs are related to construction, materials, and building service costs [18]. Post-construction costs consist of operational costs from energy consumption, water use, maintenance, and management. Benefits accrue, including savings and financial benefits during construction and post-construction (such as higher property market values, higher rents, marketing opportunities resulting from social benefits, higher energy savings, less sick leave and higher productivity) [19].

Then Ross et al., 2007, looked at the costs of green building projects as seen from the construction costs (materials and labor wages), the design team (architects, HVAC engineers, energy commissioners, energy architects, light design, site planners, misc. fees), and LEED certification costs (LEED administration fees, fees from renewable energy credits) [14].

Fan et al., 2018, created a framework related to cost-benefit analysis in green building projects. from the interviews and literature review conducted, it was found that there are extra costs for green building projects which consist of actual costs and transaction costs. Actual costs consist of land costs, consulting fees, construction costs, and certification costs. Meanwhile, information search costs, research/learning costs, negotiation/coordination costs, approval fees, monitoring costs, and verification costs are included in transaction costs. Apart from extra costs, there are also extra benefits which consist of actual benefits and hidden benefits. Allowance for gross floor area, increase in the value of green buildings, energy savings, and water savings are included in the actual benefits. Then what includes hidden benefits include reputation/branding from the private sector, private sector competitiveness, job opportunities for the environment, health/productivity (indoor), and environmental benefits (outdoor) [15].

Abidin & Azizi, 2021, focuses on soft costs research on green building projects. There are eight elements of soft costs which are referred to as project preparation costs, consultant fees, green certification, pre-development charges, contribution fees, marketing costs, project overhead costs, and security of the funding [20]. Meanwhile Ade & Rehm, 2021., divides the cost element into two parts, namely hard construction costs and soft construction costs. Hard costs relate to tangible objects that need to be purchased to complete a dwelling, such as insulation, glass, etc. Meanwhile, soft costs include administration and audit fees, appraiser fees and additional design costs [21].

Furthermore, Long et al., 2021, looked at the increased cost of green building projects from primary and secondary indicators, as shown in **Table 1**. He explained that the increased cost of implementing green buildings is an investment [22].

Table 1 Incremental Cost Indicator [18]

Primary Indicators	Secondary Indicators
Energy saving and utilization	Energy-saving maintenance structure (energy-saving doors and windows and building floor cost)
	Energy-saving lighting system (cost difference between natural lighting and green lighting)
	Renewable resource systems (cost solar energy, geothermal energy, and wind energy)
Land saving and outdoor environment	Site utilization (increased cost of abandoned sites and underground space)
	Outdoor environment (cost of noise control, ground landscape design, three-dimensional greening)
	Pervious ground (cost increase caused by permeable paving method and permeable floor tile)
Water saving and utilization of water resources	Water-saving system (water source collection, reasonable discharge, etc.)
	Water-saving equipment (cost difference of water-saving faucet and water-saving sanitary ware compared with ordinary equipment)
	Water recycling (increased cost of clearing roads, toilet cleaning, air conditioning cooling water)
Material savings and utilization	Green building materials (increased cost of construction materials with little environmental impact and no pollution)
	Material recycling (cost increase to improve the utilization of building materials)
	Waste recycling (increased cost of waste treatment)

From the literature described above, it can be concluded that the cost elements in green building projects are divided into hard costs (related to construction, material, service, and operational costs) and soft costs (related to as shown in Table 2.

Table 2 Mapping Cost Elements in Green Building Architectural Projects

Cost Elements	Factors studied in research	Source
Soft cost/ non-construction cost	• Consultant fee • Design fee • Certification fee • Certificate fee • Documentation fee • Research fee • Marketing fee • Commissioning fee • Supervision fee	[14]–[17], [20], [21], [23]
Hard cost/ construction cost	• Material cost • Construction cost • Waste management cost • Labor cost • Operational cost • Service cost • Land cost	[14], [16], [18], [19], [21]–[23]

Furthermore, the benefit element in the application of the green building concept is important because it can be used as a reference for calculating benefits in a cost-benefit analysis. Ross et al., 2007, saw the benefits of implementing the green building concept through empirical evidence of saving energy consumption [14].

Grouping the benefits of implementing the concept of green building/sustainability into three major groups, namely environmental benefits/environmental benefits, social benefits/social benefits, and economic benefits/economic benefits has been carried out by several researchers [16], [22], [24]–[26]. The grouping of benefits is carried out based on sustainable building and construction or sustainable (green) construction so the benefit elements tend to be very broad [24]–[26]. Meanwhile, other research has focused more on architectural projects [16], [22].

Research from Long et al., 2021, saw that there are incremental costs and benefits to green buildings. The existing benefits are still divided into three main groups, namely environmental benefits, social benefits, and economic benefits. Energy savings, government subsidies, and material savings go into the economic profit. Meanwhile, social benefits are related to improving welfare and increasing income. Then the environmental benefits consist of reducing pollution, extending the life of the building, and reducing the occurrence of disease [22].

Wu and Ma, 2022, focus more on research on additional benefits that have an immediate impact when implementing the green building concept. Implicitly, there are benefits to society – society benefits (health, comfort, and waste reduction) and explicitly to water, energy, land, and materials which are included in the economic benefits. The results of the perceived benefits have an indirect impact on the environment (environmental benefits) such as reduced CO2 emissions and CO2 absorption as shown in Figure 2.

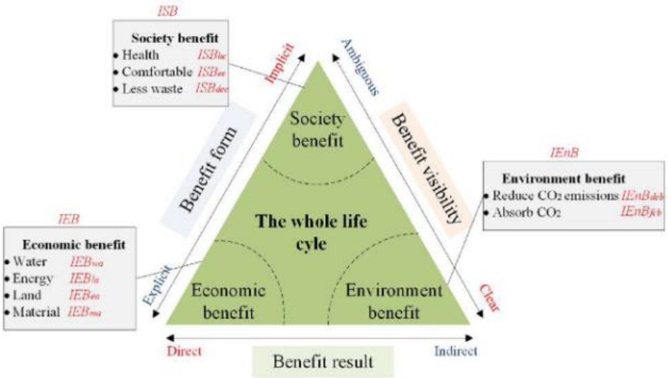

Figure 2 Benefits of Implementing Green Building [12]

Fan et al., 2018, divided benefits into 2, namely actual benefits and hidden benefits. Actual benefits relate to benefits that can be directly felt by the stakeholders involved, such as the GFA (gross floor area) concession, increasing the value of green buildings, saving energy, and saving water. While hidden benefits are benefits that are not directly felt but whose impact is still felt, some of them are reputation/image in the private sector, competition in the private sector, job opportunities for the community, health/productivity (indoors), and benefits for the environment (outdoors) [15].

Another benefit that is felt is the cost savings from reducing energy consumption in buildings. In addition, there are also indirect benefits that can improve health [27] The same thing was also mentioned by Assylbekov et al., 2021, who stated that green buildings can reduce negative impacts on the environment through water and energy efficiency. In addition, the application of the green building concept, especially water and energy efficiency, has the potential to reduce life cycle costs by around 40% [28].

Based on the literature related to the elements of benefit, it can be concluded that the benefits of implementing the green building concept are very broad. However, the majority of studies state that the perceived benefits are related to energy efficiency. Derivative elements of benefits related to energy efficiency can be seen in Table 3.

Table 3 Mapping Benefit Elements in Green Building Architectural Projects

Benefit Elements	Factors studied in research	Source
Environmental benefits	• Energy efficiency • Water efficiency • Reduce CO_2 emissions	[16], [22], [25]–[28]
Economic benefits	• Saving on energy consumption cost • Saving on water consumption cost • Saving on operational and management cost	[16], [25], [26]
Social benefits	• Improved air quality • Comfort and health • Waste reduction	[16], [24]

5 Conclusion

Implementing green building concepts in architectural projects will increase the investment cost, called incremental cost. But there is also the incremental benefit that the stakeholder of the project can get. One of the approaches that can be used to determine the incremental cost and benefit in the green architectural project is cost-benefit analysis. As per the literature review, there are cost elements, including soft cost or non-construction cost and hard cost or construction cost related. While for benefit elements, it can conclude into three groups, environmental benefit, economic benefit, and social benefit.

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