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Financial Performance Assessment of Flat Buildings Using Life Cycle Cost and Cost–Benefit Analysis

Griselda Junianda Velantika[1*], Reguel Mikhail[2], Karina Melawati Eka Putri[1], Elok Dewi Widowati[1], Rizqi Alghiffary[1], Muhamad Fauzan Akbari[1]

[1]Faculty of Engineering and Science, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Jl. Rungkut Madya, Gn. Anyar, Kec. Gn. Anyar, Surabaya 60294, East Java, Indonesia

[2]School of Civil and Environmental Engineering, Nanyang Technological University, 50 Nanyang Ave, Singapore 639798

* griselda.junianda.ft@upnjatim.ac.id

Abstract. Buildings resulting from construction projects are durable assets and decisions related to construction projects have enduring impacts. In many cases, building owners prioritize only the initial costs, such as building design, construction, and equipment costs, while neglecting the future operation and maintenance costs. This research studies life cycle costing (LCC) analysis to evaluate the financial feasibility of urban housing. The LCC calculates all the costs incurred and benefits during the building's operation. The cost is generated from construction, operational, and maintenance costs. At the same time, the benefit breaks down into flat rental costs, retail rental costs, and parking costs. The costs incurred are estimated over 25 years, and the parameters of feasibility are net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR). The study generates negative NPV, BCR < 1, and 0.61% of IRR. It indicates that the project is not feasible. This research gives alternatives to make the project feasible. This study employed a trial-and-error approach to ascertain the viability of investing in flat rentals by systematically adjusting rental rates. Incremental adjustments to rental rates are tested by a series of rate hikes of 50%, 100%, 150%, and 200% using a trial-and-error approach. The project will become feasible if the flat rate increases to 150-200% of the initial rental rate.

Keywords: Life Cycle Cost Analysis, Urban Residential Feasibility, Net Present Value, Benefit-Cost Ratio, Internal Rate of Return

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1. Introduction

South Jakarta is a burgeoning urban center and one of the administrative cities of DKI Jakarta. The South Jakarta Central Administrative Statistics Agency forecasts that the population of the South Jakarta region will reach 2,379,683 inhabitants in 2021 [1]. South Jakarta has become one of the most densely populated cities in Indonesia. The burgeoning urban hub draws many individuals searching for job prospects. As a result, both domestic and international investors are building numerous residential structures and flats in the region.

A construction project, such as building construction, constantly progresses through several stages. Progresses through interconnected stages that exert influence. The processes do not operate alone but are interconnected. The many phases of a building project can be delineated in a project cycle. This standard phase of the project cycle is applicable worldwide, including in Indonesia. In Indonesia, this stage's progress has successfully established a robust building system, significantly influencing the

economic sector, particularly regarding investment [2]. The construction industry (CI) enhances the overall well-being of individuals, society, and nations by carrying out projects to create buildings and infrastructure that fulfill the socioeconomic requirements of the built environment [3]. Buildings resulting from construction projects are durable assets and decisions related to construction projects have enduring impacts. Building owners or investors often prioritize the purchase cost when deciding on building design, equipment, and energy systems while disregarding future operation and maintenance costs [3]. The expenses required for construction encompass the costs associated with planning and building and the periodic costs for maintenance and operation. Typically, only a tiny percentage, precisely 5-10%, of suggested investments are ever implemented [4]. Forecasting all the costs needed to be invested is necessary to determine the total cost. Evaluating all the costs associated with the development, construction, and maintenance of a building over its lifespan has always been a challenging endeavor for all parties concerned [5]. This whole cost estimation includes the analysis of life cycle cost. Life Cycle Assessment (LCA) approaches in the construction sector remain highly complex, with no documented precise methodology. Consequently, researchers must rely on their judgments [6].

The life-cycle cost (LCC) of a product or system refers to the overall expenses associated with its lifespan, including procurement, operation, maintenance, and eventual disposal [7]. The life cycle analysis approach has been proposed. It is widely used in the feasibility analysis of construction projects to reflect the complexity of the entire asset life cycle process [8]. These methods meticulously categorize all investments across the life cycle and provide a straightforward estimate of these expenses using a proportion coefficient. The life cycle cost model plays a crucial part in this process by serving as the foundation for determining the annual cash flow [9].

The construction sector consistently assures projects' practicality at the first planning phases [10]. Several prior research endeavors have concentrated on automating the process of defining requirements. Within these methods, establishing the necessary conditions was limited to a specific stage at the onset of a project, and the requirements were regarded as input to the design process, not subject to alteration. However, other sources have observed that the requirements often change and develop during the entire duration of the project [11].

The life cycle cost is strongly connected to a feasibility study. Feasibility studies are typically undertaken to justify investing in infrastructure projects. They play a crucial role in informing decisions regarding allocating public funds to infrastructure projects [12]. The economic analysis approach based on the life cycle cost model can accurately depict wind power projects' financial status and overall construction level, as shown by various economic assessment indicators. The monetary evaluation approach often uses NPV (Net Present Value), IRR (Internal Rate of Return), and PBP (Pay-Back Period) to assess the performance of project construction regarding cash flow, fund recovery speed, and predicted income within the established market conditions. [8]. Generally, life cycle costing has a close relationship with feasibility studies. This research studies life cycle costing (LCC) analysis to evaluate the financial feasibility of urban housing. This study examines the economic performance of a residential property in South Jakarta through life cycle cost analysis. It assesses the estimated cash flow during the period. The predicted cash flow is calculated for its feasibility parameters. Feasibility parameters are used to measure whether or not the building is feasible over a certain period. In this case study, the building is impossible due to the calculated NPV, BCR, and IRR. Therefore, this study also presents alternatives that can be used to determine the feasibility of buildings based on financial evaluation.

2. Research methods

This section presents many components of the methodology employed in this paper. This paper provides an overview of the LCC approach utilized in this research and highlights the critical data included in the calculation. The result of the LCC calculation used in the feasibility study. The primary objective of the LCC is to ascertain the most cost-effective solution among several alternatives. These

alternatives can only be compared under the same economic assumptions, research period, and service date. [13]. Feasibility studies for infrastructure projects encompass technical, Economic, and Environmental Feasibility Studies (EVTEA). The feasibility study method quantitatively assesses the costs and advantages of the proposed environmental changes and the project's social and economic aspects. [14]. This research method was carried out to estimate the life cycle cost over 25 years for the Flat building in South Jakarta. Determination for 25 year period based on the minimum service life of the building [15] [16] [2]. The life cycle cost is associated with the feasibility study of the Flat Building. The Flat has a total floor area of 43,522.52 m2 and a public, social, and parking area of 5,313.13 m2. This project has 23 floors of I Tower and 29 floors of U Tower U with 1216 units.

A step-by-step calculation is performed to ascertain the life cycle cost, encompassing the investment costs incurred from the initial stages of building planning to operational and maintenance costs. This involves determining the initial construction costs and calculating the operational costs, which include employee salaries, energy expenses (such as water and electricity), and land tax costs. The data on initial construction cost was given by the Contractor of the Flat Building. The operational cost data is obtained through calculations such as employee salaries based on Indonesia's government regulations and electricity and water costs based on estimated daily electricity and water consumption. In contrast, land and building costs are based on law number 28 of 2009 concerning regional taxes and levies. [17]All maintenance costs are calculated based on the Regulation of the Minister of Public Works and Housing Number 24 of 2008 concerning building maintenance guidelines. [18]. The initial construction cost, operational, and maintenance costs are part of the outcome (cost), while costs which are part of income (benefit) based on calculation refer to similar building approach in Jakarta, DKI Jakarta governor regulation Number 55 of 2018 and Number of 31 of 2017 [19][20].

The building's Life Cycle Costs (LCC) were evaluated using the approach outlined in the European Commission Delegated Regulation No. 244/2012 of 16 January 2012 [21]. The equation is stated below:

$$C_g(\tau) = C_I + \sum_j \left[\sum_{i=1}^{\tau} (C_{a,i_{(j)}} x\, R_d(i) - V_{f,\tau}(j))\right] \quad (1)$$

Where τ presents the period, Cg (τ) shows all the calculation costs over the period, CI is the initial investment for measure j, Ca,I (j) is the annual cost during year I for measure j, Rd (i) is the discount rate for year I, and Vfτ (j) is the residual value of measure j at the end of the calculation period.

The current outcome and income costs convert expenses to future expenses using the future value (FV) method, conducting net present value (NPV) analysis, and calculating life cycle costs. Consider the discount and inflation rates when converting current value to future value. The discount rate is obtained from the bank interest rate, while inflation data is obtained from Indonesia's Statistics.

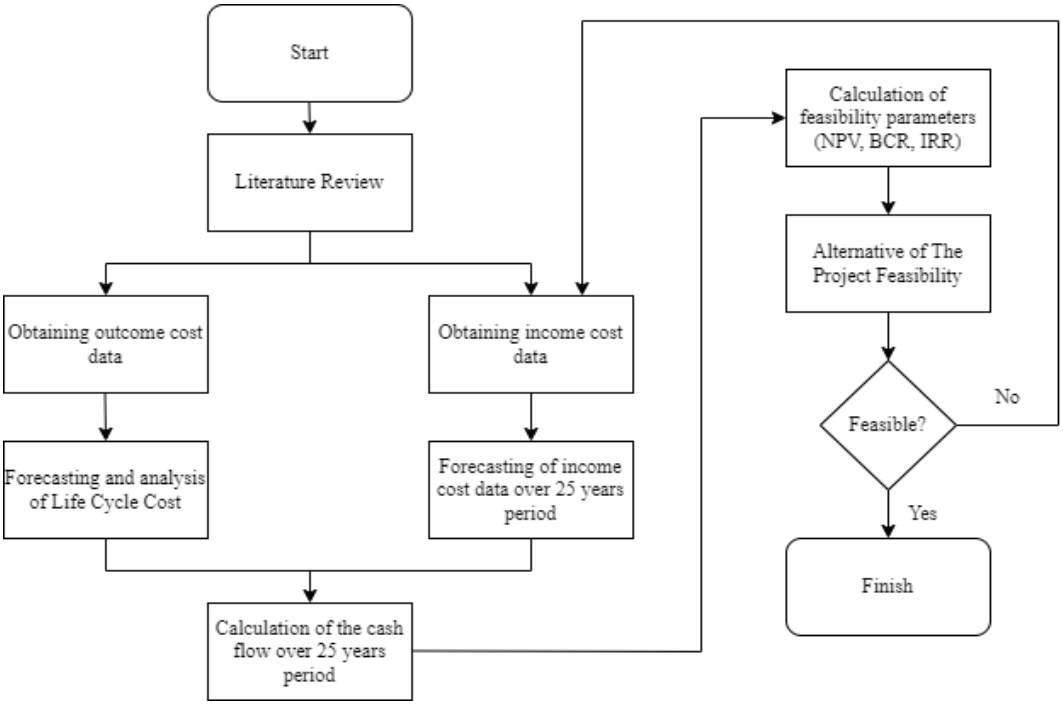

Figure 1. Research Flowchart

3. Results and discussion

3.1 Detailed Data of The Flat Building

The Flats Building in South Jakarta has two towers: I Tower, which has 24 stories, and U Tower, which has 30 stories. The building consists of a podium with parking on the basement floor up to the 6th floor. The second floor serves as a connection between the flats and a station, as well as shops, a prayer room, and F&B establishments on floors 3-6. I Tower dedicates its 7th floor to educational facilities, while U Tower's 7th floor houses 36 residential units. Tower 1 has residential units on floors 8–23, each containing 16 units. Tower U has residential units on floors 8–29, each containing 44 units. The Flats consist of 818 studio-type units, 265 units of 1-bedroom-type homes, and 133 units of 2-bedroom units, for a total of 1216 units.

3.1 The Life Cycle Cost of Flat Building (Outcome)

Life Cycle Cost (LCC) is a comprehensive approach to assessing the financial impact of owning, operating, maintaining, and disposing of an asset by including all associated expenses. The term refers to the whole discounted expenditure associated with acquiring, operating, maintaining, and disposing of an asset during a specified time frame [22]. In this research, the life cycle cost includes construction, operating, and maintenance costs. Construction costs are only incurred once at the start of construction, while other costs, such as operational and maintenance costs, are incurred periodically every year.

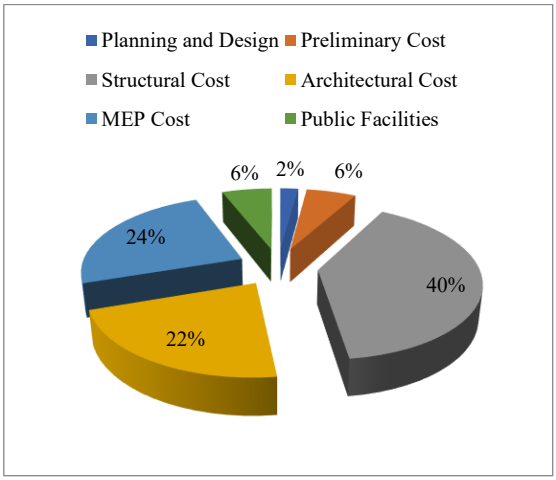

Figure 2. The percentage of initial cost

The initial cost of a flat building includes design and planning costs, preliminary work, structural work, architectural work, MEP work, and public facility work. The VAT used is 10% because the construction work was conducted in 2017.

The operational cost includes staff salary, water and electricity, and tax. The flat is overseen by a staff team, including security guards, cleaners, and administrative officers, who handle day-to-day operations. The staff is 15, including six security guards, five cleaners, and four administrative officers, who handle routine operational chores. Rahman, Maryani and Elmadhania, (2018) they built a simulation of the checking procedure at security posts to assess the workload of security officers. The determination of 6 security guards was based on their research. The simulation includes one, two, and three security officers. To achieve the highest level of security, which is 100%, it is necessary to have three security personnel stationed at each post. A security level of 90% can be achieved under regular workload situations with two security officers. Nevertheless, employing only one security officer will result in a security level that is below 50%. To fulfill these requirements, six security guards must cover the three security positions in the flats. While for cleaning, there are five cleaning staff members, with each floor assigned a specific number of people. The demand for administrative officers can be determined based on the available space in the flat, which includes the building management room (Building Management) with the head manager, assistant, and two personnel members. Therefore, a total of 4 administrative employees are required.

The electricity requirements in Flats are determined by collecting data on electricity consumption per unit. There are 1216 units in Flats, and each unit utilizes electricity with a power rating of 900 VA. The tariff category for social purposes is significantly high at a voltage of 900 VA, specifically Rp. 925/ KWH.

As per the provisions of Law Number 28 of 2009, specifically Regional Taxes and Regional Levies, the Rural and Urban Land and Building Tax is imposed on land and buildings that are owned, controlled, and utilized by individuals or entities, except areas used for plantation, forestry, and mining business activities. The tax base is determined by calculating the fraction of the whole land area, including the building base area and the land area outside the building base. The flats have a land area of 12,163.88 square meters and a building area of 43,522.52 square meters. The total operational cost is listed below.

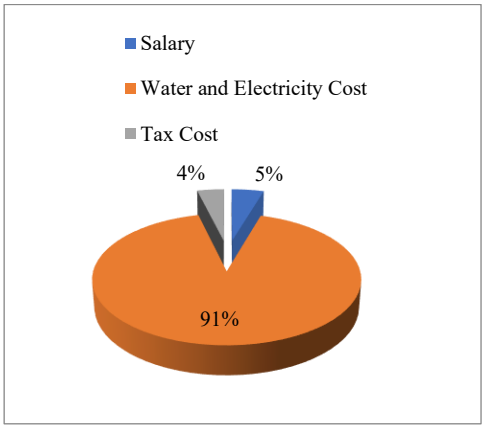

Figure 3. The percentage of annual operational cost

Maintenance costs pertain to the expenses incurred for maintaining and replacing utility building facilities. Repair costs refer to unforeseen and unplanned expenses that arise without the necessity of replacing building components. Replacement costs refer to the expenses incurred while replacing various components of a structure, which are decided periodically depending on their economic lifespan.

The data and volume of replacement components were acquired from the flat's cost estimation. The identification of components that necessitate replacement is determined by estimates for the maintenance and replacement of building components provided by Kirk (1995). Additionally, estimates for replacing building paint are based on Ministry of Public Works Regulation Number 24 of 2008, which outlines building maintenance and upkeep guidelines.

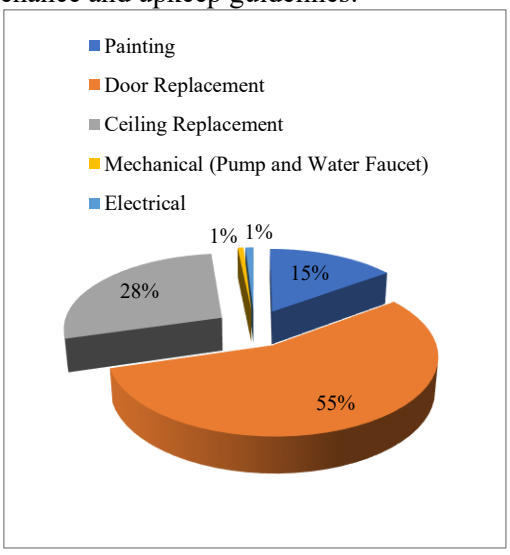

Figure 4. The percentage of annual maintenance cost

The expected maintenance and operational costs are calculated over 25 years, accounting for inflation. The inflation used is 3.35% (the average inflation rate for the city of South Jakarta from 2015 to 2023 by neglecting the Covid year based on the Statistics of Indonesia)

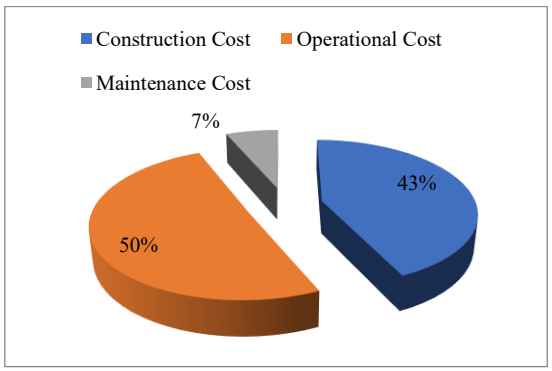

Figure 5. The life cycle cost percentage of a Flat Building in South Jakarta is projected to be over 25 years.

The studio-type residence is the smallest unit in the flat building, measuring 19 square meters. It includes one standard room, one bathroom, and a balcony. The largest dwelling in the Flat is a two-bedroom unit measuring 41 square meters. It has common room facilities, two bedrooms, one bathroom, and a balcony.

Construction costs consist of direct and indirect costs, while operational costs consist of salaries, tax, electricity, and water costs. Maintenance costs are incurred due to repairs or replacement of components that need to be replaced based on their planned life. Maintenance costs include painting and replacing doors, ceilings, and mechanical and electrical components. The maintenance cost is based on regulations of the Indonesian Minister of Public Works and Public Housing number 24 of 2008. All the maintenance and operational costs are projected over 25 years.

The research conducted by Kaming et al. [2] regarding life cycle cost analysis for training buildings, there were quite significant differences in the proportion of operational costs. In a study conducted by Kaming, salary costs were more significant than utility costs. Meanwhile, in the current study, electricity and water expenses are much more significant than salary. This happens because the building which is the current research object is an apartment building. In the current study, most % of the costs, representing 50%, are allocated to operational expenses. Construction costs account for 43% of the total budget, while maintenance costs comprise 7%. This visual representation provides a clear overview of the cost distribution within the project. In terms of life cycle cost, the study by Kaming et al. [2] has the same percentage priority order as the current study. The most significant percentages are operational, construction, and maintenance costs.

3.2 Benefit of Flat Building (Income)

The benefit or revenue of the Flat Building is from flat rental fees, store rental fees, and parking fees. All the revenue will generate the investment. The cash flow is also predicted over 25 years period. As tenants grow, rental flats' profitability and return on investment increase.

The flat building rental rates are based on DKI Jakarta Province Governance Regulation Number 55 of 2018 regarding housing rates for rental flats with a tower building of at least six floors, the rate of which is Rp. 765,000,000 for type 36. The flat rental cost is obtained by multiplying the flat rental cost per square meter by the flat area. The flat rental cost obtained is projected over 25 years.

The retail rental rates reference the retail rental prices at other flats in South Jakarta and West Jakarta. Based on data from a property sales/rental agency, I found a retail flat in South Jakarta with an area of 8 square meters with a rental price of Rp. 25,000,000.00 per year and retail in West Jakarta flats with an area of 24 square meters with a rental price of Rp. 75,000,000.00 per year. It can be concluded that the retail rental fee is Rp. 3,125,000.00 per square meter each year.

Gubernatorial Regulation No. 31 of 2017, Article 5, Paragraph 2, specifies parking service rates. The parking charge is Rp. 6,000 for sedans, jeeps, minibusses, pickups, similar vehicles, and Rp. 3000

for motorcycles. On the second level, the flats have a designated motorcycle parking facility. The basement and parking spaces are on the first, second, and third floors. This Flats, a residential building, adheres to the Transit-Oriented Development (TOD) concept, ensuring a convenient connection to the station. This information suggests Flats, acting as a transit hub between the building and the station, has a 100% parking rental occupancy rate.

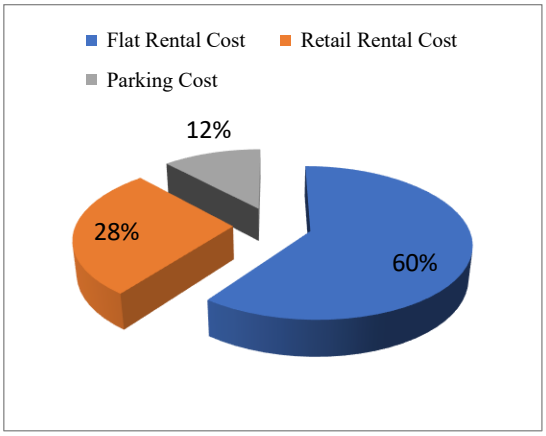

Figure 6. Income cost projected over 25 years period.

The most significant portion of the income is the total rental cost, accounting for 60%. This suggests that most of the overall rental income is from renting flats or apartments. The second most significant component is the retail rental cost, up to 28% of the total. This indicates that renting out retail spaces, such as shops or stores, contributes substantially to the overall rental income. The most minor portion of the total rental cost is allocated to parking, accounting for 12%. This suggests that while parking fees generate some income, they are a relatively minor component compared to the revenue from flat and retail rentals. Most of the income is in flat rentals, followed by retail rentals. Parking fees contribute the least to the overall rental revenue.

3.3 Financial Feasibility of the Flat Building

Net Present Value (NPV) is a financial metric used to evaluate the profitability of an investment or project. It is calculated by summing the present values of all cash flows associated with the investment, both incoming and outgoing, over 25 years. Calculating NPV includes identifying the cash flows, choosing the discount rate, calculating the present value, summing the present value, and subtracting the initial investment. The discount rate used in this research is 3.5%. Positive NPV indicates that projected earnings exceed the anticipated costs, suggesting the investment will likely be profitable. In contrast, negative NPV suggests that the projected earnings are less than the anticipated costs, indicating that the investment may not be profitable. The projected benefit over 25 years is Rp. 253,998,621,773.00, while the projected cost over 25 years period is Rp. 701,573,462,018.00. From the cost and benefit, it can be concluded that the NPV shows a negative value.

The Benefit-Cost Ratio (BCR), also known as the Cost-Benefit Ratio (CBR), is a financial metric used to evaluate the overall value of a project or investment by comparing the benefits to the costs. It is calculated by dividing the total present value of benefits by the total present value of costs. BCR > 1 indicates that the project's benefits exceed the costs, suggesting that the project is likely to be profitable or worthwhile. BCR = 1 indicates equal benefits and costs, suggesting that the project breaks even. BCR < 1 indicates that the project's costs exceed the benefits, suggesting that the project may not be

worthwhile. From the projected cost and benefit over 25 25-year period, the BCR is 0.36. It presents that the cost exceeds the benefit of this project.

The Internal Rate of Return (IRR) is a financial metric used to evaluate the profitability of an investment. The discount rate equals the net present value (NPV) of all cash flows from a particular project to zero. In other words, the IRR is the rate at which the present value of future cash flows equals the initial investment. IRR > required rate of return indicates that the investment will likely be profitable. IRR = required rate of return indicates that the investment will break even. IRR < required rate of return indicates that the investment may not be profitable. To determine the IRR, the method conducted in this research is trial and error. The cost uses the initial cost, such as planning and construction costs. The generated IRR is 0.61%.

3.3 Alternative of The Project Feasibility

An essential aspect of efficient project management is the identification and assessment of alternative options to enhance project feasibility. This not only aids in cost and resource optimization but also enhances the project's quality, performance, and sustainability. Projects can effectively navigate obstacles and modifications by employing a versatile and responsive strategy, guaranteeing sustained achievement. In this research, it carried out some alternatives to attempt to enhance the feasibility of the project. Conducting a thorough study is necessary to raise flat rental rates and maintain the profitability of the investment. This study employed a trial-and-error approach to ascertain the viability of investing in flat rentals by systematically adjusting rental rates. The simulation was carried out on an increase in rental rates because the rental rate component is the most significant component that influences cash flow income. Incremental adjustments to rental rates are tested by a series of rate hikes of 50%, 100%, 150%, and 200% using a trial-and-error approach. Given a 200% surge in rental rates, the investment's viability is established through a 25-year projection. The investment feasibility lies within the range of rental rate increases of 150 - 200%. Investors should take this into account when allocating their cash to flat buildings.

4. Conclusion

Life Cycle Cost (LCC) analysis is crucial in evaluating the expenses of constructing and maintaining buildings and structures. LCC is performed as part of feasibility studies. In the current study, most % of the costs, representing 50%, are allocated to operational expenses. Construction costs account for 43% of the total budget, while maintenance costs comprise 7%. Although limited studies have connected Life Cycle Cost (LCC) to the assessment of tangible project advantages using the Benefit-Cost Ratio (BCR), this study presents the financial feasibility using life cycle cost forecast over 25 years. The study generates negative NPV, BCR < 1, and 0.61% of IRR. It indicates that the project is not feasible. The project will become feasible if the flat rate increases to 150-200% of the initial rental rate. To ensure the effective implementation of the investment project, investors must establish the financing procedure accurately. The optimization of potential income is significant and affects the feasibility of the project. The modeling and simulation of potential income serve as a challenge for future research.

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