Economic Feasibility Analysis Development of Intake and Raw Water Pipelines in Kota Bangun Sub-District, Indonesia

S Marsudi1,*, R D Lufira1, S Sari1 and D Riadi1

1Water Resources Engineering Department, Faculty of Engineering, Universitas Brawijaya, Malang, 65145, Indonesia.

*Corresponding author: suwanto_m@ub.ac.id

Abstract. Increasing the population in Kota Bangun Sub-District, Kutai Kartanegara Regency, in line with the consequence that growing needs for drinking water and raw water for local communities become a top priority. Public complaints about the increasing difficulty of obtaining clean water seem to be an obstacle that the Regional Government has yet to resolve fully. The production capacity of PDAM Kota Bangun is currently only 30 liters/sec, which is far from sufficient for the needs of all people in the Kota Bangun Sub-District. Economic feasibility calculation analysis utilized the NPV, IRR, and BCR methods and sensitivity analysis to obtain the economic feasibility for the value of developing intake and raw water networks. The results indicate, with a reasonable life condition of 30 years, the construction of water networks in Kota Bangun is still economically feasible. Reasonable with the minimum requirement of BCR = 1, with sensitivity analysis on two scenarios, considerations of 30% and 20% leakage, and 30.55% and 25% administrative costs. The results of the research show that IRR = 17.70%. If the analysis conditions are that investment costs increase by 10% with Fixed Benefits, the payback period is 6.8 years.

keywords: clean water, economic feasibility, water system

1. Introduction
A major issue for human populations in semi-arid situations is the need for water for household utilization. On normal, an individual needs 200 L of water per day to meet their fundamental needs [1], [2]. The creators certified that 81 L per capita per day was adequate for one of the non-agricultural economies that utilized water effectively [3].

A water supply framework comprises a water source, water treatment in water treatment plants, and the customer's capacity and conveyance. This challenge is critical when considering cities with hundreds of thousands and, in some cases, millions of occupants, specifically providing millions of cubic meters of drinking water. This geopolitical circumstance requests wide speculation in the foundation. The foundation will become futile or uneconomical on the off chance that there are changes to climate designs.

The natural arranging handle in terms of water supply frameworks in cities in these locales is complex and not unimportant. This circumstance emerges due to the stochastic regularity of precipitation, a truth that's demonstrated by a few a long time with a bounty of water and others with long-lasting dry seasons [4]. This characteristic is exacerbated as precipitation arbitrariness is expanding due to worldwide climate alter [5].
Human life is inseparable from the need for water. Water is utilized for various purposes and primarily to ensure human survival, referring to clean water or drinking water. Clean water to be utilized must meet requirements of quantity and quality. Therefore, the provision of clean water needs to be conducted by both the government and the people themselves. Therefore, humans are always demanded to provide clean water to be utilized for a variety of purposes.

Various technologies are utilized to provide water for all facets of human life, despite challenging natural conditions. The increase in the population of Kota Bangun Sub-District of Kutai Kartanegara Regency has increased the need for drinking water for the people. Therefore, this becomes a top priority. Specifically, to support one of the Nawacita (Nine Agendas of Change) agendas, being “to achieve economic independence by moving the strategic sectors of domestic economy (No. 7)” in order to develop the nation.

Due to the difficulty of obtaining clean water, public complaints still appear to be an issue for the Regional Government of Kutai Kartanegara Regency. Therefore, the PDAM must increase the production capacity, with additional intake and transmission pipe networks, to supply the needs of all people in Kota Bangun Sub-District.

2. Materials and Methods
In developing clean water sources, investment analysis considers the aspect of measuring the values of costs and benefits. There are various ways to measure the values of the costs and benefits of an investment. In this study, the criteria for the level of investment feasibility utilize the formulas of NPV, IRR, and BEP as the parameters to determine the policies taken by first calculating the time value of money at the time of the research.

A project is said to be economically feasible if it meets the indicators of economic feasibility. According to [17], these are the indicators that are often utilized in economic analysis:
- Benefit-Cost Ratio (comparison of benefits and costs)
- Net Present Value (difference between benefits and costs)
- Internal Rate of Return

Although the existing methods vary widely in implementation, they all share the same principle, which is the capital budgeting method to calculate the economic return as a series of discounted cash flows [10]. Allows you to review projects with different risk profiles; The riskier projects are discounted more, which does not imply setting an explicitly arbitrary threshold such as a minimum rate of return or a maximum payback period [11].

2.1. Benefit-Cost Ratio (BCR)
Benefit-Cost Ratio (BCR) is the ratio of the present value of benefits toward the present value of the costs. In general, the following is the formula for calculating the BCR [17]:

\[
BCR = \frac{PV \text{ of Benefit}}{PV \text{ of Cost}}
\]

Where:
- \( PV \) = Present Value
- \( BCR \) = Benefit-Cost Ratio

In evaluating the feasibility of a project with the BCR method, if the \( BCR > 1 \), then the project is said to be feasible; conversely, if the \( BCR < 1 \), then the project is not economically feasible to be developed.

2.2. Net Present Value (NPV)
The present values of the cost and benefit components are calculated based on the discount rate or interest rate that has been determined. The Net Present Value (NPV) is obtained by subtracting the present value of the benefit component by the present value of the cost component [17].
\[ NPV = PV_{\text{Benefit component}} - PV_{\text{Cost component}} \]  \hspace{1cm} (2)

Where:
\[ PV = \text{Present Value} \]
\[ NPV = \text{Net Present Value} \]

A project is said to be economical and feasible if the NPV is positive or NPV > 0. On the other hand, the NPV method also has strong limitations when used to evaluate innovation opportunities, that are often overlooked or underestimated. Critiqued by many researchers [12-15].

2.3. Internal Rate of Return (IRR)
The Internal Rate of Return is the interest rate that is obtained if the BCR value is equal to 1, or the value of the interest rate if the NPV is equal to 0. The IRR is calculated according to the net benefits and the total value for investment purposes. The IRR value is very important to be found in order to see how much the project can be financed by considering the applicable value of the interest rate of loans. The calculation of the IRR value is performed with the following formula [18]:
\[ IRR = I' + \frac{NPV'}{NPV' - NPV''} (I'' - I') \]  \hspace{1cm} (3)

Where:
\[ I = \text{interest rate giving a positive NPV value} \]
\[ I'' = \text{interest rate giving a negative NPV value} \]
\[ NPV = \text{difference between the present value of benefit and present value of cost} \]
\[ NPV' = \text{positive NPV} \]
\[ NPV'' = \text{negative NPV} \]

2.4. Break-Even Point
This analysis is utilized if the selection of alternatives is strongly influenced by a single factor that is uncertain, such as capacity utilization. The break-even point of the factor is to be determined so that the two alternatives are equally as good according to their economics. Knowing the break-even point will allow a better alternative to being determined at a certain value of the uncertain factor. The selection of investment alternatives will often result in different decisions if the level of production or utility of investments differs.

The break-even point in this study is utilized to determine how many years it takes for the invested capital to provide returns or when expenses subtracted by profits are equal to zero. Figure 1 shows the chart of the break-even point [16].

![Figure 1. Break-Even Point](image)
2.5. Payback Period
The payback period is the time needed to recover or return all costs that have been expended in the investment for a project. The payback period to be selected is the one by which the costs of investment can be recovered the most quickly; quicker return periods are better and most likely to be selected. These are the weaknesses of the payback period method [16]:
1. Ignorance of the time value of money
2. Ignorance of cash flow after the payback period

\[
\text{Payback Period} = \frac{I}{A_n} \tag{4}
\]

Where:
I : Required cost of investment
\( A_n \) : Net benefit that can be obtained annually

2.6. Present Value
The project's economic value is generally many years, where the future benefits and costs will vary. It takes a specific time, and all future benefits and costs are converted to that time (usually now) to compare the value of benefits and costs.

Approach to calculating the present value using the formula:

\[
P_v = \frac{1}{(1+n)^n} \tag{5}
\]

Where :
Pv: present value
R : interest rate
n : the time interval between now and the year in which costs are incurred or benefits arise

2.7. Sensitivity Analysis
The values determined for the state after the project, such as production, prices, and other matters, are still estimates. Thus it is possible that the actual circumstances that will not correspond to the estimated values. By performing sensitivity analysis, it is possible to obtain the impacts if the solid-state after the project is not the same as the calculated values. Sensitivity analysis is usually performed by changing one of the elements of the project, such as production yield, costs, or fees, after which EIRR calculates the value. By estimating the discount rate, the obtained BCR value will be close to or equal to 1. With this approach, it will be possible to find out whether a project is feasible or infeasible.

In order to examine sensitivity from the results of economic analysis, with consideration of several possibilities that may occur with the project results if there is the possibility that changes will occur in the bases of calculations for the costs and benefits of the project, there are some matters that need to be considered in the sensitivity analysis for a project:

a. Occurrences of cost overruns
b. Changes in the value of benefits
c. Delays of the implementation time of the project

For the purposes above, the sensitivity analysis for the Work on Intake and Transmission Pipe Networks for Raw Water of Kota Bangun Sub-District was reviewed through a variety of circumstances:

1. Normal Condition (Fixed Benefits and Costs)
2. Investment Costs Rise by 10%, Benefits Are Fixed
3. Investment Costs Rise by 10%, Benefits Decrease by 10%
4. Investment Costs Rise by 10%, Benefits Decrease by 10%, Project Delayed by 1 Year

Analysis Scenarios
Scenario 1:
- Leakage = 30%
- Administrative Expenses = 30.55%
Scenario 2:
- Leakage = 20%
- Administrative Expenses = 25%
3. Results and Analysis
The following are the utilized assumptions for conducting the economic analysis in the study:
1) The economic lifetime was established to be 30 years.
2) The rate of interest was established as 8-12% (by the agreement of BAPPENAS with international financial institutions on the minimum rate of return for projects of the Ministry of Public Works as the Directorate-General of Water Resources in Indonesia).
3) The estimated sale price of raw water per m³ was determined to be Rp. 4,527.00 per m³, being estimated to increase by 10% every 5 years.
4) Full development for the benefits of the structure is estimated to begin in the xth year.
5) In the current year, replacement of intake components (especially pumps) will be carried out.

3.1 Project Benefits
Benefits are the economic or financial advantages that are obtained from the revenue of water services prices subtracted by the operation and maintenance costs.

Revenue (benefit) from water services in this study was established by an alternative scenario of the raw water price being based on the rates that have been applied by PDAM Tirta Mahakam, where the price of water was calculated based on an economical price. The intent of the economical price is for costs required to construct intake facilities and their supplements for the provision of raw water and the completion or implementation of the project. The costs of investments included in this study are the costs required to construct intake facilities and their supplements for the provision of raw water and

| No. | Year | Capacity (liters/sec) | Production (m³) | Discharge Leaked (20%) (m³) | Discharge Value (Rp/m³) | Water Price (Rp/m³) | Earnings Prior to Tax (Million Rp) | Non-Tax Earnings (Million Rp) |
|-----|------|----------------------|----------------|-----------------------------|------------------------|-------------------|--------------------------------|-----------------------------|
| 0   | 2020 | 50.00                | 1,576.800.00   | 315.360.00                  | 1,576.800.00           | 4527.00           | 7138.17                         | 7138.17                     |
| 1   | 2021 | 61.28                | 1,995.571.44   | 399.114.13                  | 1,995.571.44           | 4527.00           | 9033.95                         | 9033.95                     |
| 2   | 2022 | 63.77                | 2,011.091.38   | 402.218.32                  | 2,011.091.4           | 4527.00           | 9104.21                         | 9104.21                     |
| 3   | 2023 | 64.54                | 2,028.632.37   | 404.989.63                  | 2,028.632.4           | 4527.00           | 9135.39                         | 9135.39                     |
| 4   | 2024 | 65.50                | 2,046.313.94   | 408.006.40                  | 2,046.313.9           | 4527.00           | 9165.50                         | 9165.50                     |
| 5   | 2025 | 65.49                | 2,052.304.55   | 408.006.40                  | 2,052.304.6           | 4527.00           | 9165.50                         | 9165.50                     |
| 6   | 2026 | 65.21                | 2,068.526.85   | 408.006.40                  | 2,068.526.9           | 4527.00           | 9165.50                         | 9165.50                     |
| 7   | 2027 | 65.11                | 2,084.859.15   | 408.006.40                  | 2,084.859.2           | 4527.00           | 9165.50                         | 9165.50                     |
| 8   | 2028 | 65.02                | 2,091.725.35   | 408.006.40                  | 2,091.725.4           | 4527.00           | 9165.50                         | 9165.50                     |
| 9   | 2029 | 65.00                | 2,098.591.57   | 408.006.40                  | 2,098.591.6           | 4527.00           | 9165.50                         | 9165.50                     |

3.1.1. Capital (Investment) Costs
The costs of capital (investment) of a project may be interpreted as the expenses that are required for the completion or implementation of the project. The cost of investments included in this study are the costs required to construct intake facilities and their supplements for the provision of raw water and
transmission facilities to channel water from the intake to the water treatment facility. The components of the investment cost for the development of the intake can be described as the following:

1. Cost of construction of civil structures
2. Cost of procurement and installation of mechanics and electrics
3. The total cost of investment is Rp. 11,828,292,624.87

The following is the summary of total costs for the Work on Intake and Transmission Pipe Networks for Raw Water of Kota Bangun Sub-District:

| NO. | DETAILS | COST (Rp.) |
|-----|---------|------------|
| I   | Preparatory Work | 497,615,588.12 |
| II  | Procurement of Items for Plumbing, Civil Work, and Fuel Tank | 5,930,786,100.89 |
| III | Work on Jetty Structure | 773,268,986.08 |
| IV  | Work on Pump Housing | 437,208,858.06 |
| V   | Work on Bar Screen | 694,278,633.83 |
| VI  | Work on Plumbing | 523,696,061.89 |
| VII | Work on Trash Log | 428,232,145.75 |
| VIII| Work on Electrics | 1,555,566,055.67 |
| IX  | Work on Mechanics | 842,014,065.07 |
| X   | Work on Generator Housing | 145,626,129.51 |
|     | TOTAL | 11,828,292,624.87 |

3.1.2. Operational and Maintenance Costs
The costs of operation and maintenance that are included in this study are the costs required to perform routine daily, weekly, monthly, and yearly operations and maintenance, for the salary or payment of employees, electricity costs, procurement of fuel for the generator, or replacement of spare parts for maintenance according to the standard number of operational hours for the usage of mechanical and electrical equipment.

The results of calculating the budget plan for the operation and maintenance of intake and transmission pipe networks for one year, with the scenario of 75% electricity usage from the power company and 25% electricity generation, indicate a total cost of Rp. 4,308,897,000.00 (Table 3).

3.1.3. Results of Sensitivity Analysis
Based on the boundary conditions and the above parameters, the following are the results of sensitivity analysis and economic analysis:
Table 3. Operational and Maintenance Costs

| No. | Energy Costs | Maintenance Costs | Employee Salary | General Administration Costs | Total O&M Costs |
|-----|--------------|-------------------|-----------------|-----------------------------|-----------------|
|     | (Rp/m³)      | (Million Rp)      | (Million Rp)    | (Million Rp)                | (Million Rp)    |
| 1   | 631.00       | 994.96            | 233.00          | 1367.39                     | 2146.45         |
| 2   | 1259.21      | 2164.51           | 2716.51         | 2799.87                     | 7200.56         |
| 3   | 631.00       | 1269.00           | 468.58          | 2737.64                     | 2781.34         |
| 4   | 631.00       | 1280.31           | 472.76          | 2762.05                     | 2808.14         |
| 5   | 631.00       | 1804.57           | 666.35          | 3883.04                     | 3951.99         |
| 6   | 662.55       | 1909.60           | 705.13          | 4315.80                     | 4384.69         |
| 7   | 662.55       | 1904.61           | 710.67          | 4349.71                     | 4415.19         |
| 8   | 662.55       | 1939.69           | 716.24          | 4338.73                     | 4403.76         |
| 9   | 662.55       | 1958.86           | 723.32          | 4427.13                     | 4497.79         |
| 10  | 662.55       | 1970.19           | 727.50          | 4452.72                     | 4523.80         |
| 11  | 695.68       | 2084.75           | 769.80          | 4935.99                     | 5014.78         |
| 12  | 695.68       | 2101.01           | 775.86          | 4974.86                     | 5054.27         |
| 13  | 695.68       | 2117.72           | 781.98          | 5034.06                     | 5094.10         |
| 14  | 695.68       | 2905.45           | 1072.85         | 6879.16                     | 6988.97         |
| 15  | 695.68       | 2919.17           | 1077.92         | 6911.63                     | 7021.96         |
| 16  | 730.46       | 3089.18           | 1140.70         | 7682.45                     | 7784.77         |
| 17  | 730.46       | 3113.54           | 1149.69         | 7722.87                     | 7846.15         |
| 18  | 730.46       | 3137.97           | 1158.71         | 7781.48                     | 7907.73         |
| 19  | 730.46       | 3175.28           | 1172.49         | 7876.01                     | 8001.74         |
| 20  | 730.46       | 3187.80           | 1176.93         | 7969.85                     | 8032.04         |
| 21  | 766.98       | 3399.35           | 1214.30         | 8764.35                     | 8904.25         |
| 22  | 766.98       | 3426.21           | 1218.23         | 8833.32                     | 8974.33         |
| 23  | 766.98       | 3470.29           | 1216.15         | 8903.13                     | 9045.25         |
| 24  | 766.98       | 3480.42           | 1221.42         | 9017.66                     | 9161.60         |
| 25  | 766.98       | 3494.63           | 1225.16         | 9043.99                     | 9188.36         |
| 26  | 805.33       | 3682.99           | 1395.96         | 10026.10                    | 10186.14        |
| 27  | 805.33       | 3711.87           | 1370.63         | 10104.72                    | 10266.02        |
| 28  | 805.33       | 3742.43           | 1381.54         | 10185.19                    | 10347.77        |
| 29  | 805.33       | 3792.69           | 1400.47         | 10324.73                    | 10489.55        |
| 30  | 805.33       | 3809.55           | 1406.70         | 10370.63                    | 10536.18        |

Table 4. Results of Sensitivity Analysis

| No. | Analysis | Scenario | Condition | BCR | IRR (%) | PBP (years) | Remarks |
|-----|----------|----------|-----------|-----|---------|-------------|---------|
| 1   | Economy  | 1        | 1         | 1.897% | 6.398   | Feasible    |         |
| 2   | 1        | 1        | 17.70%    | 6.849 | Feasible |
| 3   | 1        | 1        | 11.45%    | 11.101| Feasible  |
| 4   | 1        | 1        | 11.53%    | 11.465| Feasible  |

4. Conclusion and Suggestions

The results of the calculation of the operating and maintenance budget plan for the intake and transmission pipelines for one year, with the scenario of using the PLN electricity source by 75% and the generator power source by 25% being Rp. 4,308,897,000.00. Analysis Boundary Conditions with a leakage value of 30% and administrative costs of 30.55%. The economic life is set at 30 years. The interest rate is 8 - 12% (according to BEPPENAS' agreement with international financial institutions on the minimum rate of return for projects of the Ministry of Public Works, Directorate General of Water Resources in Indonesia). The estimated selling price of raw water per m³ is set at Rp. 4,527.00 per m³, and is estimated to increase by 10% every five years. Full development for building benefits is estimated from year X. Looking at the parameters set and analyzed, and the following results are obtained:

1. Normal Conditions (Fixed Benefits and Costs) obtained a minimum BCR 1, IRR 18.97%, Payback Period 6.398, Feasible.

2. Conditions Investment Costs Increase 10%, Fixed Benefits. The results obtained a minimum BCR 1, IRR 17.70%, Payback Period of 6.849, Feasible.
3. Condition of Investment Cost Up 10%, Benefit Down 10%. The results obtained a minimum BCR 1, IRR 11.45%, Payback Period of 11.101, Feasible.

4. Condition of Investment Cost Up 10% - Benefit Down 10%, Project 1 Year Late. the results obtained a minimum BCR 1, IRR 11.53%, Payback Period 11.465, Feasible.

From the results of the analysis for economic feasibility, the project is economically viable. However, suppose the basic assumptions of economic calculations for the economic feasibility analysis were similarly applied for the financial feasibility analysis. In that case, this project has financial feasibility that is not too great. This means that the project is compassionate toward suffering from financial losses if water leakage is still within a range of 30% and the general and administrative costs comprise 30.55% of the revenue. For the project to be financially healthy in management and ably managed in a sustainable manner, it is necessary to suppress the water leakage to 20% and save on general and administrative costs to 25%.

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