

Economic Feasibility Analysis Based on Reservoir Storage Capacity on the Construction of the Rongkong Multipurpose DAM

Elang Timur M. Patih Ragananda*, Ussy Andawayanti, & Evi Nur Cahya

Departemen Teknik Pengairan, Fakultas Teknik, Universitas Brawijaya, Malang

Abstract

The construction of Rongkong Multipurpose Dam located in North Luwu Regency, South Sulawesi aims to provide irrigation water, water supply, and increase electricity production capacity through hydropower with 6 construction sites under consideration. Economic feasibility analysis was carried out to obtain construction sites that have the best economic feasibility objectively. In this analysis, the parameters of Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Benefit-Cost Ratio (BCR) were calculated by considering the reservoir storage capacity in each sites. The result from this analysis shows that Site Tandung 2 is the location that has the best economic feasibility with reservoir capacity of 23,400 million m³ and Benefit- Cost Ratio (BCR) of 2.490.

Keywords: multipurpose dam, reservoir storage capacity, benefit-cost ratio, economic feasibility.

Received: 12 June 2023

Revised: 3 August 2023

Accepted: 27 August 2023

1. Introduction

Development of a region is carried out with the main objective as a form of effort in improving welfare and to realize social justice for all levels of society in the region. The implementation of development requires various studies and approaches that are objective and accurate, so that it can produce well-developed economic growth along with equitable distribution of infrastructure that reaches all levels of society. Infrastructure has a very strategic role in efforts to increase economic activity, expand the reach of community welfare, and equitable development (Ihum & Stephen, 2018).

Several empirical facts show that infrastructure development in a region goes hand in hand with economic development in the region. This occurs as a result of economic development that requires the availability of adequate infrastructure facilities and infrastructure. The existence of such infrastructure will encourage an increase in the productivity of various factors of production. On the other hand, improvements to existing infrastructure will also increase investment and economic growth in the region, resulting in increased employment (BPS, 2021).

One of the main challenges in Indonesia's current development efforts is to overcome the problem of inequality in infrastructure development that occurs in the inter-regional dimension. Unbalanced and uneven infrastructure development can lead to the failure of various efforts to reduce inequality in economic growth, which results in the emergence of welfare gaps between regions. This occurs as a consequence of development that is concentrated in certain regions.

Infrastructure development and economic development have a very close and interdependent relationship with each other. The inequality of infrastructure development that occurs will also have an influence on the gap and obstruction of economic development which leads to inequality of welfare between regions.

The agricultural sector in South Sulawesi Province has a very strategic role, where the agricultural sector can contribute 42% to regional gross income and is able to absorb more than 60% of the existing workforce (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2021). The Rongkong Multipurpose Dam construction plan is one of the Ministry of Public Works and Public Housing's strategic plan projects concerning the integrated development of water

* Corresponding author.

E-mail address: timur.elang1995@gmail.com

resources in South Sulawesi Province, more precisely in North Luwu Regency. The construction of the Rongkong Multipurpose Dam has the aim of increasing production yields on agricultural land, increasing raw water production to meet industrial and household water needs, and increasing electricity production capacity through hydropower (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2021).

The construction of the Rongkong Dam in North Luwu Regency, South Sulawesi Province requires substantial funding sourced from the State Budget (APBN) and loans sourced from the Asian Development Bank with 6 construction sites being considered as the Rongkong Dam construction site. To produce a more objective and detailed economic analysis of the overall situation of the Rongkong Dam construction project location, it is necessary to calculate the economic feasibility analysis based on the analysis of reservoir storage capacity at each location to determine the maximum estimated benefits compared and estimated costs incurred in the construction of the Rongkong Dam.

2. Methodology

This research was conducted at the Rongkong Multipurpose Dam construction project in the Rongkong River Basin, Sabbang District, North Luwu Regency, South Sulawesi with 6 (six) review location points shown in Figure 1.



Figure 1. Rongkong Dam Construction Site Plan

The data used are secondary data. Rongkong Dam technical plan data, hydrological data, Rongkong Dam construction affected area data, hydropower technical scheme data, and cost budget plan data are sourced from the Rongkong Multipurpose Dam planning consultant (cooperation between Associated Consulting Engineers Ace LTD Pakistan with PT Satria Bumistrata Service, PT Ika Adya Perkasa, PT Hilmy Anugerah, and PT Aria Jasa Konsultan). While the basic price standard data, agricultural data, and population data are sourced from the Central Bureau of Statistics (BPS) of South Sulawesi Province and the Central Bureau of Statistics (BPS) of North Luwu District.

The research implementation process is divided into 4 (four) stages of analysis, namely: cost calculation analysis, reservoir storage capacity and discharge analysis to fulfill the operational functions of the Rongkong Dam, benefit calculation analysis, as well as economic feasibility analysis and sensitivity analysis. The cost calculation analysis is used to calculate the costs incurred in the compensation scheme and the Rongkong Dam construction process at each review location. In the analysis of reservoir storage capacity and discharge to fulfill the operational functions of the Rongkong Dam, the calculation of the maximum volume of reservoir storage of the Rongkong Dam at each review location and the calculation of the water discharge required for irrigation water supply, raw water supply, and hydropower operations. Benefit calculation analysis is used in calculating the benefits of the agricultural sector, raw

water supply, and electricity supply through hydropower. In the economic analysis and sensitivity analysis, calculations are carried out on the parameters of Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period (PP), and Benefit-Cost Ratio (BCR) at all review locations by considering scenarios where the value of profit is reduced by 10% and the condition of extending the construction period of the Rongkong Dam for 1 year. In the cost calculation analysis, the following sequence of calculation steps is carried out:

- The first step is to calculate the compensation fee for areas affected by the construction of the Rongkong Dam (for housing units, house land area, rice field land area, and garden land area) based on Government Regulation No. 19 of 2021 concerning the Implementation of Land Acquisition for Development in the Public Interest.
- The second step is to calculate the construction cost for each item of construction work with adjustments based on the value of the regional inflation rate (2.04%)[(BPS, 2021).
- The third step is the calculation of indirect costs consisting of: administrative cost, supervisory consultant cost, contingency cost (10%), and tax value (2.65% based on Government Regulation No. 9 Year 2022 regarding Income Tax on Income from Construction Services Business).
- In the fourth step, the compensation fee, construction cost, and indirect costs are summed up to obtain the total cost of the Rongkong Dam construction at each review location.

to fulfill the operational function of Rongkong Dam starts from the calculation of the volume of the Rongkong Dam reservoir storage at all locations so as to obtain the maximum reservoir storage capacity of the entire location. Reservoir volume calculations are carried out starting from the riverbed elevation to the highest elevation of the reservoir at each location located at the top elevation of the spillway.

Then proceed with calculating water requirements for raw water supply needs, irrigation water supply, and for hydropower operations. Calculation of water requirements for raw water supply is carried out based on the population growth rate in North Luwu Regency which is calculated using the Exponential Method shown in Equation 1 (Pradany et al., 2020):

$$P_n = P_0 \times (e^{r \times n}) \tag{1}$$

Where:

- P_n = Total population in year n
- P₀ = Initial population
- e = Euler number (2.718)
- r = Percentage of population growth rate (%)
- n = Review year period

The calculation of irrigation water requirements is carried out based on the method established by the Ministry of PUPR in the Planning Criteria for the Planning Section of the KP - 01 Irrigation Network in 2013. Calculation of water requirements for Rongkong Dam hydropower operations is carried out based on the hydropower turbine installation scheme and the design discharge required for its operation.

In the analysis of the calculation of benefits, the calculation of benefits from the agricultural sector, the provision of raw water, and the provision of electricity through hydropower. The calculation of benefits from the provision of electricity through hydropower uses the basis of the Minister of Energy and Mineral Resources Regulation No. 19 of 2015 concerning the Purchase of Electricity from Hydropower Plants with a Capacity of up to 10 MW by State Electricity Companies, where each 1 kWh of electricity is priced at 9 US cents).

In the economic feasibility analysis and sensitivity analysis, calculations are carried out on economic feasibility parameters that will be observed for changes using a scenario where the profit value is reduced by 10% and the condition of extending the construction period of the Rongkong Dam for 1 year. Net Present Value (NPV) is the value of the difference between costs and profits based on the interest rate applied. The calculation of the Net Present Value (NPV) value is shown in Equation 2 (Blank & Tarquin, 2012):

$$NPV = \sum_{t=0}^n \frac{(C) \times t}{(1+i)^t} - \sum_{t=0}^n \frac{(Co) \times t}{(1+i)^t} \tag{2}$$

Where:

- NPV = *Net present value*

- (C)_t = Income value in year t
- (Co)_t = Expenditure value in year t
- i = Interest rate applied (%)
- t = Year - t

Based on Equation 2, the classification of project feasibility based on Net Present Value (NPV) is obtained:

- If a positive (+) NPV value is obtained, the project is declared feasible.
- If the NPV value is negative (-), then the project is declared unfeasible.

Internal Rate of Return (IRR) is a percentage value that shows the break even point of a project. The calculation of Internal Rate of Return (IRR) uses Equation 3 (Park,S, 2013):

$$IRR = i_0 + (i_1 - i_0) \times \frac{NPV_0}{NPV_0 - NPV_1} \quad (3)$$

Where:

- IRR = *Internal Rate of Return*
- i₀ = Interest rate when NPV is positive (+)
- i₁ = Interest rate when NPV is negative (-)
- NPV₀ = Positive Net Present Value (NPV) value (+)
- NPV₁ = Net Present Value (NPV) value that is negative (-)

Payback Period (PP) is the duration required in returning investment funds. The calculation of the Payback Period (PP) is calculated using Equation 4 (Giatman, 2006):

$$PP = \frac{\text{Investasi Awal}}{\text{Keuntungan setiap Periode}} \times \text{Periode Waktu} \quad (4)$$

Based on Equation 4, the project feasibility classification is obtained based on the Payback Period (PP) value:

- If the PP duration is less than the investment life, the project is declared feasible.
- If the PP duration is more than the investment life, the project is declared unfeasible.

The Benefit-Cost Ratio (BCR) is a comparison of the present value of profits and costs. The calculation of the Benefit-Cost Ratio (BCR) value uses Equation 5(Sullivan et al., 2012):

$$BCR = \frac{PV(B)}{PV(C)} \quad (5)$$

where:

- BCR = *Benefit – cost ratio*
- PV(B) = Present value of profit
- PV(C) = Present value of costs

Based on Equation 5, the results obtained determine the economic feasibility of a project based on the following classification:

- BCR value > 1, then the proposed project is considered economically feasible (accepted)
- BCR value = 1, then the proposed project is considered neutral or break even between costs and profits (break even point).
- BCR value < 1, then the proposed project is considered not economically viable (rejected).

While the formula for obtaining present value (PV) is shown in Equation 6 (Fraser & Jewkes, 2012):

$$PV = A \times \left[\frac{(1+i)^N - 1}{i \times (1+i)^N} \right] \quad (6)$$

Where:

- PV = Present value

- A = annual value
- i = Effective interest rate for each period
- N = Number of compounding periods (year)

3. Result and Discussion

The result of the cost calculation analysis is the overall total cost for the construction of the Rongkong Dam at each review location. A recapitulation of the results of this analysis is shown in Table 1. Based on the results of the cost calculation analysis, it is known that Site Binuang 2 is the location with the largest total cost value of Rp. 10,657,811,780,658, - with a dam of the Earth Core Rockfill Dam (ECRD) type. While Site Tandung 2 is the location with the smallest overall total cost value of Rp. 4,830,456,489,380, - with an Earth Core Rockfill Dam (ECRD) type dam.

The results of the analysis of reservoir storage capacity and discharge to fulfill the operational function of the Rongkong Dam for each review location. Based on the results of the analysis of reservoir storage capacity and discharge to fulfill the operational functions of the Rongkong Dam, it is known that the largest reservoir storage capacity is at Site Tandung 1 with a volume of 93.063 million m³ which is used in meeting water needs for raw water, irrigation, and hydropower of 2.781 million m³. While the smallest reservoir storage capacity is at Site Binuang 3 with a volume of 13.218 million m³ which is used in meeting water needs for raw water, irrigation, and hydropower of 1.124 million m³.

The results of the benefit calculation analysis of each review location. A recapitulation of the results of this analysis is shown in Table 3. Based on the results of the benefit analysis, it is known that Site Tandung 1 produces the largest benefit value with a total of Rp. 20,139,894,418,102, -. While Site Binuang 3 produces the smallest benefit value with a total of Rp. 12,638,993,912,513.

Table 1. Total Construction Cost of Rongkong Dam

Location	Dam Type	Total Construction Cost (Rp.)	Total Indemnity and Indirect Costs (Rp.)	Overall Total Cost (Rp.)
Site Tandung 1	Earth core rockfill dam (ECRD)	7.179.735.702.094	1.119.785.674.251	8.299.521.376.345
Site Tandung 2	Earth core rockfill dam (ECRD)	4.325.930.493.694	504.525.995.686	4.830.456.489.380
Site Tandung 2A	Concrete face rockfill dam (CFRD)	4.727.189.013.887	678.516.607.120	5.405.705.621.007
Site Binuang 1	Concrete gravity dam (CGD)	6.468.660.980.044	776.618.330.554	7.245.279.310.598
Site Binuang 2	Earth core rockfill dam (ECRD)	9.525.675.229.496	1.132.136.551.162	10.657.811.780.658
Site Binuang 3	Asphalt core rockfill dam (ACRD)	5.212.931.990.172	680.510.447.206	5.893.442.437.378

Table 2. Reservoir Storage Capacity and Water Demand Fulfillment Discharge

Location	Reservoir Storage Capacity (Million m ³)	Water Demand Fulfillment Discharge			
		Raw Water (m ³)	Irrigation (m ³)	PLTA (m ³)	Total (m ³)
Site Tandung 1	93,063	212.115,485	156.958,241	2.412.720,000	2.781.793,727
Site Tandung 2	23,400		127.845,683	1.620.000,000	1.959.961,168
Site Tandung 2A	48,295		135.149,087	1.836.000,000	2.183.264,572
Site Binuang 1	30,581		131.497,385	1.728.000,000	2.071.612,870
Site Binuang 2	75,198		153.323,382	2.149.200,000	2.514.638,867
Site Binuang 3	13,218		102.351,141	810.000,000	1.124.466,626

The results of the economic feasibility analysis and sensitivity analysis for each Rongkong Dam construction review site are shown in Table 4 through Table 6.

Table 4. Economic Feasibility Analysis of Rongkong Dam

Location	IRR	NPV (Rp.)	BCR	PP (Years)
Site Tandung 1	12,513%	5.188.740.815.342	1,727	5
Site Tandung 2	16,665%	6.192.077.508.869	2,490	4
Site Tandung 2A	15,775%	6.168.063.089.401	2,324	4
Site Binuang 1	10,466%	2.347.834.394.002	1,379	6
Site Binuang 2	6,942%	-1.359.284.253.966	0,851	7
Site Binuang 3	10,467%	1.970.079.774.390	1,385	6

Table 5. Sensitivity Analysis of Rongkong Dam 10% Benefit Reduction Condition

Location	IRR	NPV (Rp.)	BCR	PP (Years)
Site Tandung 1	10,830%	3.148.062.403.374	1,441	6
Site Tandung 2	14,744%	4.687.027.262.537	2,128	4
Site Tandung 2A	13,915%	4.559.346.467.844	1,978	5
Site Binuang 1	8,863%	790.950.960.058	1,128	6
Site Binuang 2	5,392%	-3.171.836.820.205	0,653	8
Site Binuang 3	8,898%	689.431.450.679	1,135	6

Table 6. Sensitivity Analysis of Rongkong Dam Construction Condition Extended by 1 Year

Location	IRR	NPV (Rp.)	BCR	PP (Years)
Site Tandung 1	10,840%	3.594.835.979.571	1,472	6
Site Tandung 2	14,246%	5.016.533.703.614	2,131	5
Site Tandung 2A	13,535%	4.911.548.987.303	1,988	5
Site Binuang 1	9,091%	1.131.805.440.326	1,171	7
Site Binuang 2	5,976%	-2.775.007.713.122	0,716	8
Site Binuang 3	9,118%	969.808.715.454	1,178	7

Based on the results of the economic feasibility analysis and the results of the sensitivity analysis shown in Table 4 to Table 6, it is known that the best location is at Site Tandung 2 with a BCR value of 2.490 for economic feasibility; 2.128 for 10% benefit reduction conditions; and 2.131 for construction conditions extended by 1 year. Meanwhile, Site Binuang 2 is the worst location with a BCR value of 0.851 for economic feasibility; 0.653 for 10% benefit reduction conditions; and 0.716 for construction conditions extended by 1 year. Based on the results of the analysis that has been carried out, a recapitulation can be made which is shown in Table 7 and Figure 1.

According to Table 7 and Figure 1, it is known that the total benefit value and reservoir storage capacity are interrelated, where the greater the reservoir storage capacity, the more optimal the benefits obtained. Meanwhile, the total cost value is influenced by the type of dam constructed and the work items that need to be carried out along with the compensation costs that must be paid and the indirect costs that are borne.

Table 7. Recapitulation of Rongkong Dam Economic Feasibility Ranking

Economic Feasibility Ranking	Location	Overall Total Cost (Rp.)	Overall Total Benefit (Rp.)	Reservoir Storage (Million m ³)
1	Site Tandung 2	4.830.456.489.380	14.853.664.779.955	23,400
2	Site Tandung 2A	5.405.705.621.007	15.876.770.546.886	48,295
3	Site Tandung 1	8.299.521.376.345	20.139.894.418.102	93,063
4	Site Binuang 1	7.245.279.310.598	15.365.217.663.420	30,581
5	Site Binuang 3	5.893.442.437.378	12.638.993.912.513	13,218
6	Site Binuang 2	10.657.811.780.658	17.888.471.352.083	75,198

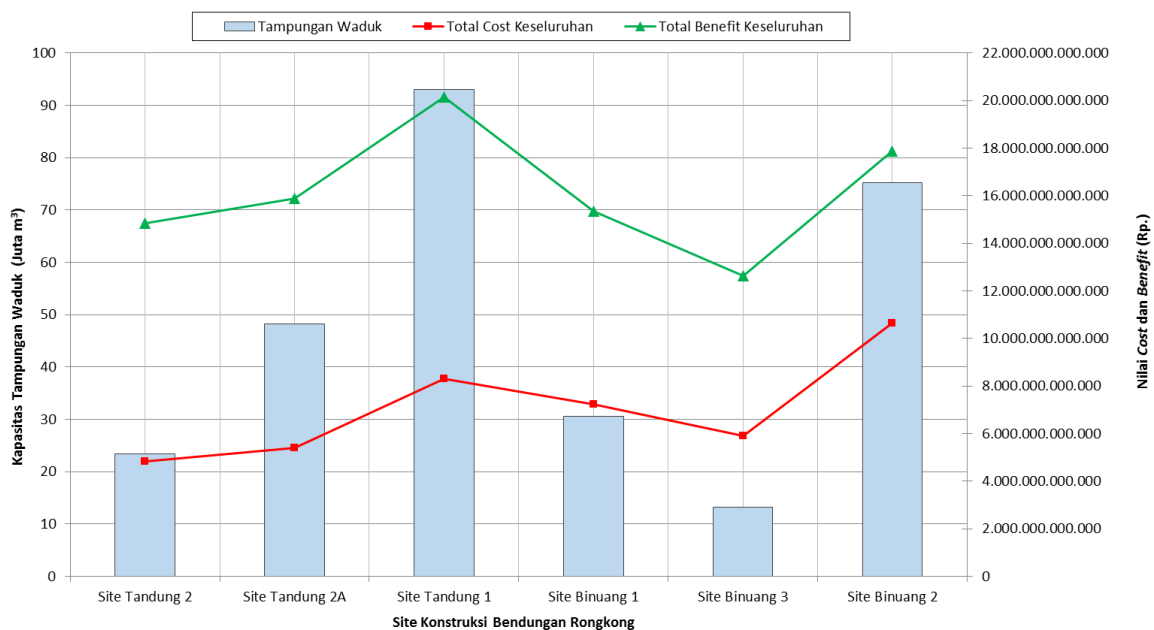


Figure 1. Graph Recapitulation of Total Cost, Total Benefit, and Reservoir Storage Capacity

4. Conclusion

According to the results of the analysis and discussion, the following conclusions were reached:

- Site Tandung 2 has the best economic feasibility results with a reservoir storage capacity of 23.400 million m³; Internal Rate of Return (IRR) percentage value of 16.665%; Net Present Value (NPV) value of Rp. 6,192,077,508,869, -; Payback Period (PP) duration for 4 years; and Benefit Cost Ratio (BCR) value of 2.490.
- Site Binuang 2 has the worst economic feasibility results with a reservoir storage capacity of 75.198 million m³; an Internal Rate of Return (IRR) percentage value of 6.942%; a Net Present Value (NPV) value of Rp. - 1,359,284,253,966, -; a Payback Period (PP) duration of 7 years; and a Benefit Cost Ratio (BCR) value of 0.851.
- The ranking order of the economic feasibility of the Rongkong Dam construction site is detailed as follows: (1) Site Tandung 2; (2) Site Tandung 2A; (3) Site Tandung 1; (4) Site Binuang 1; (5) Site Binuang 3; and (6) Site Binuang 2.

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