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Economic Feasibility Analysis of Semantok Dam at Nganjuk-Indonesia

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ABSTRACT

Dam construction has a very large scale. Therefore, feasibility study must be done before the construction. This research objective is to analyze the cost, benefit, economic feasibility and sensitivity of economic feasibility of Semantok dam construction in 2014. Economic feasibility analysis of Semantok dam construction should be evaluated from the stages of needs identification, technical design appearance and profit or benefits of the project to general welfare of society. Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost ratio (BCR) are used to analyze the feasibility of Semantok dam construction. Analysis results show that the cost of Semantok dam construction is IDR 313,632,065,000. While the total benefits of Semantok dams development is IDR 85,480,052,457 with details of IDR 84,099,632,327 for Irrigation Benefit, IDR 580,420,080 for power plants and IDR 800,000,000 for flood control benefit. Analysis result also shows that Semantok dam construction economically feasible to be built, with economic analysis for Value Net Present Value> 0, namely IDR 194,775,172,969, Internal Rate of Return > 12% namely 19.79% and Benefit Cost Ratio > 1 namely 1.762. In addition, sensitivity analysis of Semantok dam by seven conditions show that benefits fell by 10%, costs increase by 19% and implementation is delayed for two years, having lowest feasibility level result with NPV = IDR 72,589,703,402; IRR = 14.14%; B/C = 1.29.

INTRODUCTION

Dam construction is one best solution to develop potential of water resources given the current imbalance of water resources. Water availability is likely decrease and water needs increase. One potential of dam development is Semantok Dam at Sambikerep village, Rejoso Subdistrict, Nganjuk District, about 25 km north of Nganjuk City. Semantok dam is chosen due fulfills the accessibility, topography or morphology, geology, engineering, and environment. Dam construction has the investment scale, which is very large. Therefore, feasibility analysis should be done before the dam development.

Feasibility Study of Semantok dam development was done by PT. Indra Karya in 2009. The study results show that NPV is IDR 197.110.000.000, BCR is 1.28 at 12% interest rate, and IRR is 14.46%, with construction costs of IDR 145,511,603,000. The construction value when compared to conditions in 2014 is not relevant. Period of 5 years changes the basic unit of wages, materials and tools price. Construction costs will cause changes to economic feasibility analysis.

Feasibility analysis of Semantok dam planning at Nganjuk was not yet known in 2014. Therefore, it needs a research to analyze the feasibility of Dam Semantok at Nganjuk using the Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit cost ratio (BCR).

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LITERATURE REVIEW

1. Project cost analysis:

Project cost budgeting is used to calculate the cost of material and labor based on analysis, as well as other costs associated with implementation of work or project. Real cost estimation is sum of each multiplication between volume at a unit price of work. Generally, it can be summed below (Ibrahim, H.B., 2007):

$$\text{RAB} = \sum (\text{Volume x Price per work unit})$$

2. Benefits analysis of project:

Income analysis is a study about all income (benefit). Income analysis is focused on determining the cost of revenues from various sources that viable and enough from economic and political policy or even for infrastructure losses that arise when the project is not implemented can be categorized as a benefit (income) (Kodoatie, R.J., 2005).

3. Feasibility analysis:

Feasibility analysis purpose is to get a decision to continue investment in projects that will be done (Husen, A., 2009). The feasibility analysis is expressed in size of public benefits that can be generated. The feasibility analysis takes into account the value of NPV (net present value), IRR (internal rate of return), and BCR (benefit cost ratio).

3.1. Net Present Value (NPV):

Project evaluation with Net Present Value method will evaluate the project by adding all income and expense and then converted into present value. If the project profit is greater than the expenditure, then the NPV will positive. Adversely, if the profit is lower than the expenditure then the NPV is negative. A project is feasible if it have positive NPV (Budikusuma, W., 2011).

Mathematically, NPV can be written below (Budikusuma, W., 2011):

$$NPV = \sum_{t=0}^{n} F_t (P/F, i\%, t)$$

Where:

Ft = amount of cash flow in year t

(Positive to negative for income and expenditure)

n = Project age

NPV at prevailing interest rates should have a price> 0. If NPV = 0, IT means the project exactly same as the value of investment returns. If the NPV <0, the project is economically and financially not feasible to build.

3.2. Internal Rate of Return (IRR):

Internal Rate of Return is the interest rate returns with assumption that all positive and negative cash flow are invested on same project (at same rate). IRR is all funds of IRR project invested with interest rate, then the remaining funds at end of project life = 0 (Budikusuma, W., 2011).

Rate of Return (ROR) method is used to evaluate a project by calculating the interest rate that becomes income in a project to restore all of expenditure in project. The interest rate is called the interest rate of return or Rate of Return (ROR). ROR is obtained by equating the income and expenditure with Present Worth (PW) Method (Budikusuma, W., 2011).

PW method has ROR at i% where (Budikusuma, W., 2011):

$$\sum_{t=0}^{n} R_t (P/F, i\%, t) - \sum_{t=0}^{n} E_t (P/F, i\%, t) = 0$$

Where:

Rt = Income at t year

Et = expenditure at t year

n = Project age

PW ROR method is obtained at NPV = 0 (Budikusuma, 2011: 66).

Greater interest of a project will decrease the profit. The relation between interest rate at i% with NPV can be described in Figure 1 below.

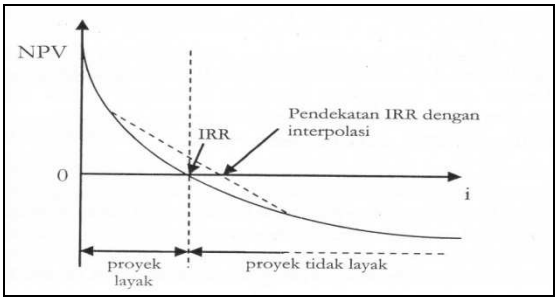

Fig. 1: Graph of relationship between NPV and IRR i

Internal rate of return (IRR) is the lending rate that generates NPV = 0. If IRR calculation is greater than the interest rate of loan, it can be said that investment will be worth it to do. If it is equal to interest rate, the investment is behind the invested capital, while if the IRR is less than the loan interest rate, it is not worth investment.

$$IRR = I' + \frac{NPV'}{NPV' - NPV''} x(I'' - I')$$

Where:
I' = Interest rates at positive NPV
I"= Interest rates at negative NPV
NPV' = positive NPV
NPV" = negative NPV

3.3. Benefit Cost Ratio (BCR):

BCR in simplest view is when the amount of all income minus all expenses (through comparison of specific economic) has a positive value, the activities are profitable, zero indicates break-even point and a negative indicates detrimental activity. One method used is the benefit-cost analysis (Kodoatie, R.J., 2005). "The government projects in this regard are the projects that are profit-oriented built either by central government or local governments" (Pujawan, 2008: 260)

Decisions making process in government projects are also through the systematic stages but not be based on profit generated by project. It more emphasis on benefits or general welfare to public.

Benefits in public sector projects defined as the favorable consequences of project on community, while the project cost is the cost incurred by government for the project (Budikusuma, W., 2011). As the name implication, the project evaluation by Benefit Cost Ratio method or commonly abbreviated as B/C Ratio is compare benefits and the cost. All benefits and all costs are spread over the life of income and expense that should be equated to first project value to present value. Therefore, the formula used is below (Budikusuma, W., 2011).

$$B / C = \frac{PV\,(Benefit)}{PV\,(Cost)}$$

The calculation results of B/C Ratio determine the project feasibility in accordance with following provisions [4]:

If B/C> 1 then the project was feasible.

If the B/C <1 then the project was not feasible.

3.4. Sensitivity analysis:

Sensitivity analysis is the study on how the programs offered can keep running even if there are unexpected changes. This analysis is the last checking of application program, method and assumption changes (Kodoatie, R.J., 2005).

"The sensitivity analysis is performed on the changing value of a parameter at a time to know how it would affect the acceptability of an alternative investment. The changed factors and the implication may affect the decision in engineering economics study as investment cost, cash flow, residual value, interest rate, tax rate and life of investment (Pujawan, I.N., 2012)."

Sensitivity analysis is used to determine the impact occurred if the variables assumed in investment analysis are changed. The end goal is to estimate the decision making. If the changes are assumed to be variables that will change the decision making, then it is said that decision was sensitive to changes in these variables. Sensitivity analysis is done by varying the amount that will determine the appropriateness of investment decisions (Budikusuma, W., 2011).

RESEARCH METHODOLOGY

1. Research location:

Physically, Nganjuk has a total area of 122,433 hectares. They are divided into three sections in according to soil type, ie 35% of paddy field, 27% of dry land and 38% of forest land. It is administratively divided into 20 subdistricts and 284 villages/wards. It is geographically located at coordinates between 111º 5' to 112º 13' east longitude and 7º20' to 7º 50 ' South Latitude.

Fig. 2: Map of Semantok dams planning

Nganjuk region is included in Brantas River basin with river area at Puncu Selodono. Nganjuk has 39 small and big rivers. Widas River is the longest river, 65 Km long and area of 32.50 km^2 with a debit streaming of 4.142 m^3/sec.

Semantok Dam plan is located in Brengkok River, Sambikerep Village, Rejoso Subdistrict, Nganjuk District, about 25 km in north of Nganjuk City.

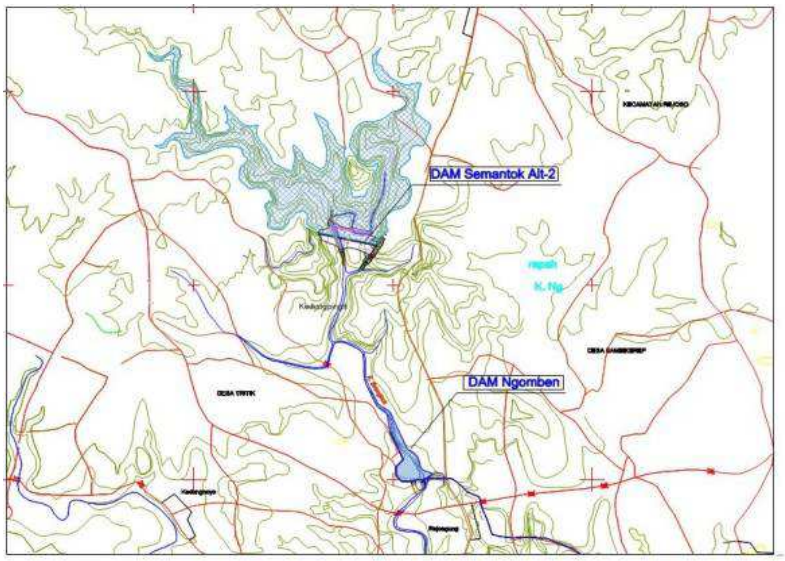

Fig. 3: Map of location plan and inundation area of Semantok dam

Determination of Semantok Dam has been at that location due fulfil the accessibility, topography or morphology, geology, engineering, and environment.

2. Stages of research:

The research stages can be seen in scheme below.

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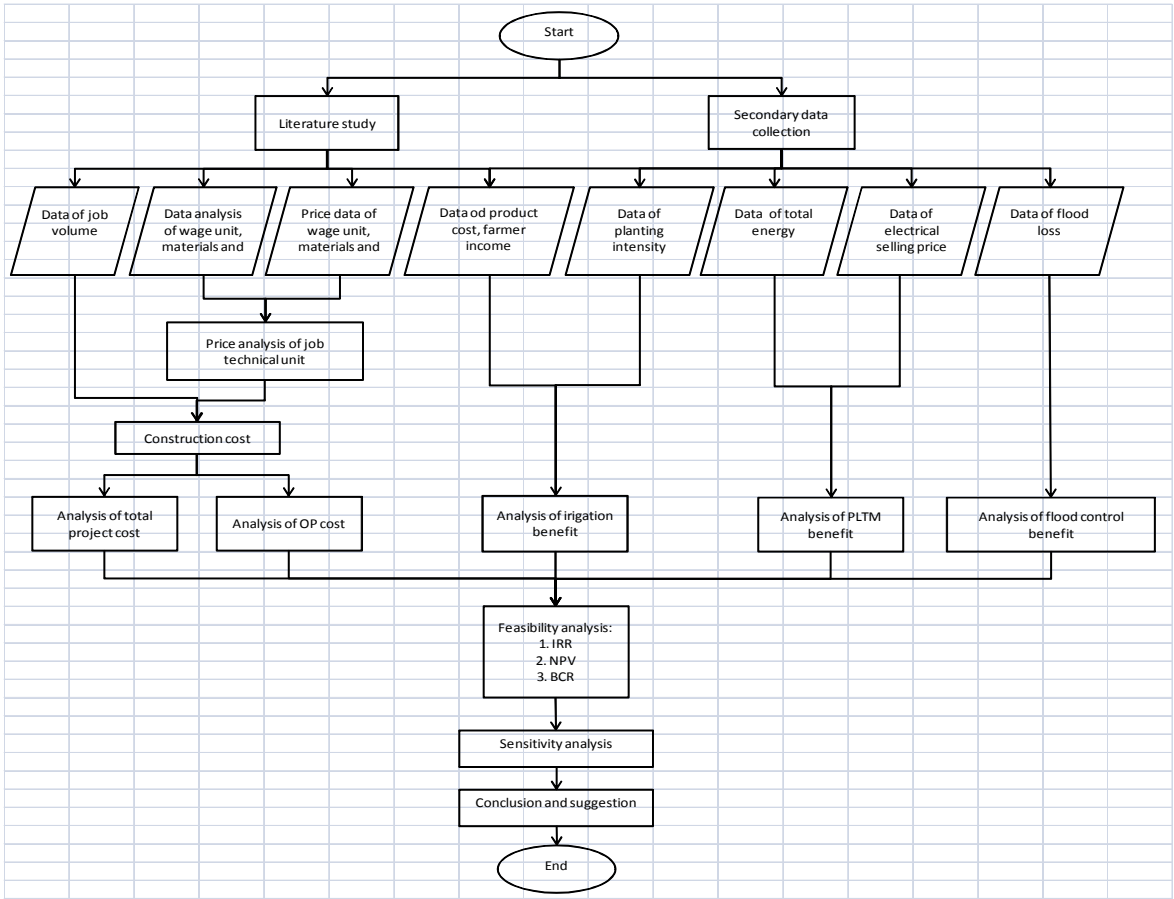

Fig. 4: Scheme of research stages

RESULTS AND DISCUSSION

1. Analysis of construction cost:

Analysis of total project cost is expenditure required to complete or implement overall construction. They are include direct costs) based on analysis of unit price of technical jobs and indirect costs. Total cost of Semantok Dam project Construction is presented in Table 1.

Table 1: Direct and indirect cost of Semantok dam development at Nganjuk

No.	Item	Total cost (IDR)
A	Mobilization and demobilization	211,680,000
B	Preparatory work	3,948,508,300
C	Construction work	210,120,359,599
C-II	Cofferdam and main dam	152,167,520,545
C1	Digging work	22,413,344,351
C2	Drilling dan Grouting	3,761,774,000
C3	Embankment work	106,671,461,000
C4	Instrumentation work	18,226,875,400
C5	Hardening of crest dam	1,094,065,794
C-II	Spillway	34,069,107,547
C6	Soil work	7,518,954,175
C7	Concrete work	26,379,388,476
C8	Spillway Bridge work	170,764,896
C-III	Intake and waterway	23,883,731,507
C9	Soil work	81,123,951
C10	Intake and penstock work	4,635,026,768
C11	Diversion (Conduit) work	19,167,580,788
D	Hydromechanical	5,331,889,839
E	Irrigation network	1,951,269,048
F	Facility building work	1,865,500,000
G	Electric power work	1,158,750,000
H	Electrical	287,492,169
I	Total of construction cost	224,875,448,955
11	Administration cost (4% of direct cost)	8,995,017,958

12	Consultant cost (5% of direct cost)	11,243,772,448
13	Unpredicted cost (3% of direct cost)	6,746,263,469
14	Price escalation (8% per year)	33,259,556,283
J	Total of indirect cost	60,244,610,158
J1	Project cost before tax (B+C)	285,120,059,113
J2	Tax (10%)	28,512,005,911
K	Total of project cost	313,632,065,024

2. Benefit analysis:

Benefit Analysis of Semantok Dam Construction show a favorable impact as a result, including the benefits of irrigation, micro power plants and flood control. Benefit of Semantok dam construction is presented in table 2.

Table 2: Benefit of Semantok dam construction

No	Benefit	Value (IDR)
1	Irrigation	84,099,632,327
2	Medium Electric Power	580,420,080
3	Flood control	800,000,000
Total Benefit		85,480,052,457

2.1. Irrigation benefit analysis:

The net benefit of water irrigation potential usage of Semantok Dam water is the amount of profit earned from sales of agricultural products reduced by costs required during the growing season. Semantok dam is expected to meet the irrigation area in Semantok, Ngomben Irrigation Area, Regional and Local Irrigation Rejoso Kedung Padang with alternative cropping pattern Paddy - Rice - Crops, with cropping intensity before the project is assumed that an increase.

Analysis of production cost calculation and farmer's income per hectare for each type of rice plants, soybeans and corn before and after implementation of Semantok Dam project show an increase trend. Total benefit of irrigation is IDR 84,099,632,326/year. Benefit Calculation for irrigation is presented in Table 3.

Table 3: Irrigation Benefit Recapitulation Per Year

Location	Wide (Ha)	Benefit (IDR)		Irigation Benefit / year
		Before project	After project	
Ngomben	122	8,423,844,210	27,024,627,480	18,600,783,270
Semantok	139	3,980,438,972	25,986,806,160	22,006,367,188
Rejoso	139	9,773,056,427	30,790,354,260	21,017,297,833
Kedungpadang	139	8,315,170,224	30,790,354,260	22,475,184,036
Total Benefit Per Year				84,099,632,326

2.2. Micro Power Plant benefit analysis:

Micro Power Plant benefits is calculated from total power per year. Statistic PLN (Indonesian State Electricity) of 2013 at May 2014 shows that total customer at end year 2013 are 53,996,208 higher than 2012. Electric selling is 8.44% of average per kWh for 2013 namely IDR 818/kWh. It is higher than previous year at IDR 728/kWh. Installed capacity at Semantok Dam is 180 kW and total energy resulted is 45% from installed capacity. Yearly power is 709,560 per kWh. Electric selling is IDR 818/kWh. The Semantok benefit is IDR 580,420,080 micro power per year, as shown in table 4 below..

Table 4: Micro Power Plant Benefit per year

No	Description	Unit	Value (IDR)
1	Installed Capacity	kW	180
2	Produced power	kWh	709,560
3	Electric price 2013	IDR	818

Source: Results Analysis

The prediction of the aerodynamic coefficients of the investigated projectiles shown in Figure1 was carried using the methods and the computer programme described above. The effects of forebody and afterbody shapes on the aerodynamics at supersonic speeds are analysed in this paper.

2.3. Flood control benefit analysis:

Flood control benefit is calculated from BPD Nganjuk. The flood loss for 2013 is IDR 800,000,000.

2.4. Feasibility analysis:

Feasibility analysis of Semantok dam can be shown below. Operation cost and maintenance are general cost estimation for every year to operate dam, building and support building maintenance to make dam operates rightly. It is decided as 1% from total cost of project. Operational cost is done at fifth year to fiftieth year and assumed 10% increase every five year, as shown in table 5 below.

Table 5: Operational Cost

No	Description	Cost (IDR)
1.	Total cost of project	313,632,065,024
2.	Operational cost (year 5th to 9th)	3,136,320,650
3.	Operational cost (year 10th to 14th)	3,449,952,715
4.	Operational cost (year 15th to 19th)	3,794,947,987
5.	Operational cost (year 20th to 24th)	4,174,442,785
6.	Operational cost (year 25th to 29th)	4,591,887,064
7.	Operational cost (year 30th to 34th)	5,051,075,770
8.	Operational cost (year 35th to 39th)	5,556,183,347
9.	Operational cost (year 40th to 44th)	6,111,801,682
10.	Operational cost (year 45th to 50th)	6,722,981,850

2.5. Net Present Value (NPV):

Project evaluation with Net Present Value methods can be shown below.

Determining the net benefits value until 50th year in according with construction.

Net benefit = Benefit value - (Investment value + Costs Operation and Maintenance); the detail calculations are below.

The net benefits of first year
= 0 - (62,726,413,005 + 0)
= 62,726,413,005
The net benefits of second year
= 0 - (87,816,978,207 + 0)
= 87,816,978,207
The net benefits of third year
= 0 - (90,953,298,857 + 0)
= 90,953,298,857
The net benefits up to 50th year
= 85,480,052,407 - (0 + 6,722,981,850)
= 78,757,070,556

Economic and financial of NPV = 0 means that the project returns exactly same as the investments value. NPV <0 means the project is not feasible to be built while the NPV> 0 means feasible to be built. The interest rates required by study are 12%. Analysis is carried out on each net benefit from first year up to 50th year and adds them up. Details of calculation is below

$$NPV = \sum_{t=0}^{n} F_t(P/F,i\%,t)$$

NPV = - 62,726,413,005 (P/F,12%,1) +-87,816,978.207 (P/F,12%,2) +
- 90,953,298,857(P/F,12%,3) + ... + 78,757,070,556(P/F,12%,50)
NPV = -56,005,725,897 +70,007,157,371 + -64,738,761,599 + 272,513,750
NPV = 194,775,172,969 > 0 (Feasible)

Net Present Value is IDR 194,775,172,969> 0. It means that Semantok dam construction is feasible based on Net Present Value calculation. Net Present Value is calculated with some rate of interest. It can be seen in Table 6.

Table 6: Net Present Value

Interest rate (%)	*Net Present Value (IDR)*
8	469,949,118,547
10	304,508,428,820
12	194,775,172,969
14	119,155,182,902
16	65,418,487,718
18	26,299,184,285
20	-2,713,147,43

2.6. Internal Rate of Return (IRR):

IRR is the interest rate at NPV = 0 or BCR = 1. Stages of analysis are below.

This analysis assumed that value of loan interest rate is 12. If the value of IRR> 12%, the project is feasible economically. IRR calculations are below.

$$IRR = I' + \frac{NPV'}{NPV' - NPV''} x(I'' - I')$$

Where :

I' = Interest Rate with positive NPV = 18%

I"= Interest Rate with negative NPV = 20%

NPV'= positive NPV = 26,299,184,285

NPV"= negative NPV = -2,713,147,483

$$IRR = 18\% + \frac{26.299.184.285}{(26.299.184.285 - (-2.713.147.483)} x(20\% - 18\%)$$

IRR = 18% + 1,79%

IRR = 19,79% > 12% (Feasible)

Calculation of IRR is 19.79%, higher than 12%. It means the Semantok dam construction is feasible. IRR calculation is shown in figure 5 below.

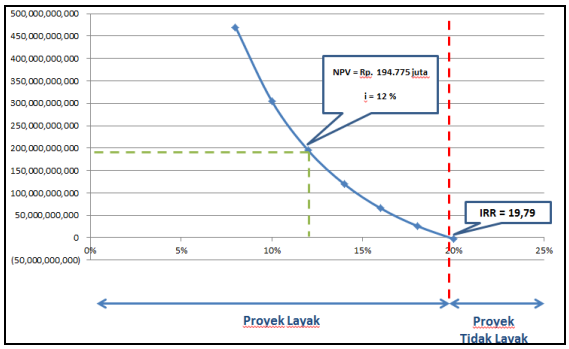

Fig. 5: Graph of IRR analysis

2.7. Benefit Cost Ratio (BCR):

Stages of analysis are follows. Comparing all income and expense. Income is all benefit of irrigation, power plants and flood control. The expenditure is cost of construction, operation and maintenance. Generally, it can be said that when the ratio B/C> 1 then the project could be accepted, if the B/C <1 then it cannot be accepted. Meanwhile, when the ratio B/C is equal to one, project conditions did not differ (indifferent) between acceptable or not.

The interest rate required in this study is 12%. Benefit Cost Ratio calculation is follows:

$$B / C = \frac{PV\,(Benefit)}{PV\,(Cost)}$$

$$B / C = \frac{IDR450.236.184.671}{IDR255.461.011.702}$$

B / C = 1,762 > 1 (feasible)

The value of benefit cost ratio is calculated with some interest rate. It can be seen in Table 7.

Table 7: Benefit cost ratio

Interest rate(%)	*Benefit Cost Ratio*
8	2.606
10	2.119
12	1.762
14	1.493
16	1.285
18	1.120
20	0.987

2.8. Feasibility analysis:

Feasibility analysis for Semantok Dams Development Semantok show that NPV (net present value) is IDR 194,775,172,969> 0, IRR (internal rate of return) is 19.79> 12, and BCR (benefit cost ratio) is 1.762> 1. It shows that economic feasibility of Semantok Dam construction is FEASIBLE to be developed.

2.9. Sensitivity analysis:

Sensitivity analysis is performed on by changing the value of a parameter at a time to know how it would affect the acceptability of an investment. Sensitivity analysis for Semantok Dam is based on seven circumstances. Table 8 shows recapitulation of sensitivity analyzes.

Table 8: Sensitivity result analysis of Semantok dam construction

No	Condition	EIRR	BCR	NPV (IDR)
1.	Benefit decrease 10%, Cost is constant	18.31%	1.586	149,551,554,502
2.	Benefit constant, Cost increase 10%	18.34%	1.613	171,115,674,994
3.	Benefit decrease 10%, Cost increase 10%	16.83%	1.452	126,092,056,527
4.	Cost and benefit are constant, Implementation late 2 years	17.31%	1.567	129,882,395,827
5.	Benefit decrease 10%, Cost is constant and implementation late 2 years	15.80%	1.410	93,989,842,840
6.	Benefit is constant, Cost increase 10% and implementation late 2 years	15.99%	1.433	108,482,256,389
7.	Benefit decrease 10%, Cost increase 10% and implementation late 2 years	14.48%	1.290	72,589,703,402

Source: Results Analysis

CONCLUSIONS

Analysis and discussion results can be summarized below.

The cost of Semantok Dam construction is IDR 313,632,065,000. (Three Hundred Thirteen Billion Six Hundred Thirty Two Million Sixty Five Thousand). The total benefits of Semantok Dams Development is IDR 85,480,052,457, - (Eighty Five Billion Four Hundred Eighty Million Fifty Two Thousand Four Hundred and Fifty Seven Rupiah). The details are follows:

- Irrigation Benefit: IDR 84,099,632,327 (Eighty Four Billion Ninety Nine Million Six Hundred Thirty Two Thousand Three Hundred Twenty Seven Rupiah).
- Power plant benefit: IDR 580,420,080 (Five Hundred Eighty Million Four Hundred Twenty Thousand and Eighty Rupiah).
- Flood Control Benefit: IDR 800,000,000, - (Eight Hundred Million).
- Semantok dam construction is economically feasible to be built.
- Net Present Value> 0, namely IDR 194,775,172,969.
- Internal Rate of Return Value> 12%, namely 19.79%
- Benefit Cost Ratio> 1, namely 1.762.

The sensitivity analysis of Semantok dam is reviewed by seven conditions. The analysis is presented in table 8. The benefit condition decrease 10%, costs increase 19% and implementation late 2 years (condition number 7) has a lowest feasibility with NPV = IDR 72,589,703,402; IRR = 14.14%; B/C = 1.29.

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