APPLYING COST-BENEFIT ANALYSIS TO SEDIMENT MANAGEMENT PROJECTS

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ABSTRACT
Reservoir is one of the most susceptible infrastructures to the impacts of global climate change, particularly to sedimentation. Sedimentation will progressively reduce the reservoir storage and in many cases threatens the economic life of the reservoir. Sediment management is one of the techniques adopted to enhance the usage and economic life of reservoirs. Most of the sediment management projects were conducted based upon the necessity to remove the sediment without considering the profitability of the project itself. Departing from economic analysis will cause some consequences to the project, such as project cost overrun and other budget-related problems. Thus, this paper discusses the application of Cost-Benefit Analysis (CBA) approach in determining the most feasible sediment management alternatives in Sutami Dam of the Brantas river basin located in East Java Province, Indonesia. A simulation model of five sediment management alternatives were developed in order to determine the feasibility of such projects using the CBA approach. The differences among these projects lie in the method of sediment disposal and the volume of sediment dredged. The analysis of the study was based on the measurable costs and benefits of sediment management. The most feasible project is Alternative 2 with a dredged sediment volume of 300,000m^3 per year using the off-stream sediment disposal method. This alternative also has the largest B/C ratio (1.21) and the maximum net benefit. A sensitivity analysis was also carried out to analyse the elasticity of each project on the basis that the discount rates and project duration are the sensitive parameters. The results of the CBA and sensitivity analysis indicate that the most sensitive element in the sendiment management project is the project costs. Any changes of the sediment disposal method and/ or the volume of sediment dredged will influence the project costs. A basic framework of the Cost-Benefit Analysis application in sediment management has been developed at the end of the study. This framework is able to simplify the use of Cost-Benefit Analysis in determining the feasibility of sediment management in reservoirs, particularly those located in Brantas river basin.

KEYWORDS

Sediment management, cost-benefit analysis, feasibility, costs and benefits

INTRODUCTION

Water is prerequisite for human life and welfare, as well as for the preservation of environment. The sustainability of water resources should be regarded as one of the important factors to be considered in any country's social economic development. Reservoirs are one of the important tools in maintaining sustainable development and management of water resources (U.S. Bureau of Reclamation, 2006). However, due to sedimentation, the sustainability of reservoirs is not guaranteed in the long term (Oehy & Schleiss, 2004). Sedimentation will gradually reduce the available storage and in many cases threatens the primary use of reservoirs in a time less than the expected lifespan (Yeoh, Loveless, & Siyam, 2004).

Sutami Dam (also known as Karangkates Dam) is the biggest reservoir in the Brantas river basin, one of the biggest river basins on the Java Island. Unfortunately, due to sedimentation, the last storage measurement undertaken in 2009 showed that the gross storage of the Sutami Dam has decreased by 48.24 percent from its initial gross storage and the effective storage decreased by 55.8 percent from its initial effective storage (Perum

Jasa Tirta I, 2010). The situation will increase the impact of global climate change on water resources such as flood and drought. Several sediment management approaches have been conducted to cope with this problem. However, most of these sediment management projects were conducted based on the necessity to reduce the sedimentation rate in reservoir without considering the feasibility of the projects. This can give rise to budget related problems or non-appropriate project selection.

Hence, the main question that arises is "How to determine the feasibility of reservoir sediment management approaches which is a non-monetary profit projects?" This paper attempts to apply the Cost-Benefit Analysis technique in determining the feasibility of reservoir sediment management projects.

AIM AND OBJECTIVES OF STUDY

The aim of the study underpinning this paper is to apply the Cost-Benefit Analysis technique as an economic approach in sediment management projects. Accordingly, the objectives of the study are as follows:

1. To determine the most feasible sediment management alternatives in Sutami Dam by using the Cost-Benefit Analysis technique.
2. To develop a basic framework for decision making analysis in determining the most desirable sediment management alternatives.

SCOPE OF THE STUDY

1. The scope of the study is Sutami Dam located in East Java Province, Indonesia.
2. Sediment management discussed in this study focus on the current sediment management approaches i.e. hydraulic sediment removal methods conducted in Sutami Dam.
3. The costs and benefits components discussed in this study are limited to tangible costs and benefits as follows:
   - Cost elements incurred from project costs, additional equipment costs, and additional land acquisition costs
   - Benefits resulted from the reservoir's flood mitigation, energy generation from hydropower plant, and water supply for irrigation, domestic/household and industrial purposes.

   Any intangible or indirect costs and benefits of the project, such as environmental effects or human losses, are omitted from this study.
4. The alternative approaches proposed in this study are simulation projects which are based on the variations of the method of disposal and the volume of sediment dredged.

SEDIMENT MANAGEMENT

Sediment accumulation is an inevitable phenomenon in all reservoirs. It will gradually reduce the available storage and in many cases threatens the primary use of reservoirs in a time less than the expected lifespan (Yeoh, Loveless, & Siyam, 2004). To maintain the life span of reservoirs and to preserve their functions, it is necessary to manage the sediment inflow to the reservoirs. Morris and Fan (1998) described the basic concept of sediment management by applying the sediment control strategies to manage both water and sediment inflow to the reservoirs.

According to Perum Jasa Tirta I (2010), the current sediment management applied in Sutami reservoir is the sediment hydraulic dredging method. The sediment dredged from Sutami reservoir is around 350,000 m^3 per year, using three (3) pump suction dredgers, with the ability to dredge not exceeding 12 m depth. The current dredger productivity is around 40,000 m^3 per month. The dredged sediment is disposed *off-stream* into the spoil bank, located in the Sutami Dam green belt.

COST-BENEFIT ANALYSIS

Cost-Benefit Analysis (CBA) is a method to analyse a proposed or previously enacted project, most of it related to public interest. The difficulty in determining the economic benefit of this kind of project is well documented. CBA may assign a monetary value to each input and output resulting from the project. The values of the inputs and outputs are then compared (Zerbe Jr & Bellas, 2006). The general purpose of CBA is providing a sound judgment in making decisions, at the same time ensuring the efficiently use of society's scarce resources. In CBA, all consequences of a project (either related to costs or benefits) are assessed in pecuniary units, and the project is analysed in terms of economic criteria (Dubgaard, Kallesoe, Petersen, & Ladenburg, 2002).

CBA can be represented as an operation in which there are a number of distinct steps as summarized in the following Figure (Zerbe Jr & Bellas, 2006).

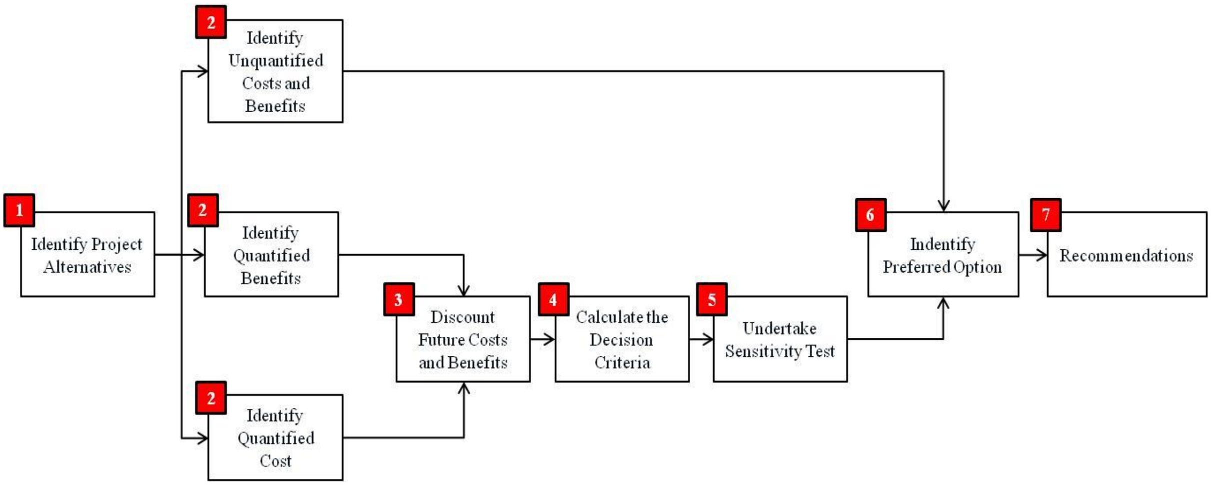

Figure 1 Basic Steps in Cost-Benefit Analysis

METHODOLOGY

The study is divided into three (3) stages of analysis: (i) sediment condition analysis, (ii) sediment management analysis, and (iii) CBA. Sensitivity analysis is also conducted in order to determine the most feasible project, based on its elasticity to certain economic parameters. In order to simplify the scope of this study, several assumptions were made to fulfill the requirements in the analysis processes.

1. Sediment condition analysis

   The analysis focused on the sedimentation problem in the study area. The analysis examined the change of sedimentation condition based on the differences between the initial dam data and the current data. This examination produces the annual sediment inflow in Sutami Dam, and used as the basis of determining the proposed volume of sediment to be removed in the project alternatives.

2. Sediment management analysis

   In order to obtain the optimum sediment removal project, five (5) alternatives of hydraulic dredging projects were simulated and analysed. The differences among these alternatives lie in the sediment disposal method and the volume of sediment dredged. The alternatives are summarised in Table 1.

Table 1 Summary of Project Alternatives

Project	Dredging Operation		Costs/Losses Incurred	Benefits Gained
	Volume (x 1000 m^3)	Disposal Method		
A_1	-	-	(increment benefits)	-
A_2	300	off-stream disposal	project costs	increment of reservoir benefits
A_3	300	riverine disposal	(project + additional dredging projects in	increment of reservoir benefits

Project	Dredging Operation		Costs/Losses Incurred	Benefits Gained
	Volume (x 1000 m^3)	Disposal Method		
			downstream Sutami Dam) costs	
A_4	= annual sediment inflow	off-stream disposal	(project + additional equipment + land acquisition) costs	increment of reservoir benefits
A_5	= annual sediment inflow	riverine disposal	(project + additional dredging projects in downstream Sutami dam + additional equipment) costs	increment of reservoir benefits

3. Cost-Benefit Analysis

This stage discusses the use of CBA to analyse the feasibility of five (5) alternatives simulated in this study and to determine the most appropriate alternative. Basically, this method will determine the economic parameters of each alternative (B/C Ratio and Net Benefit), and comparison is made to define the most “favorable” alternative.

As the basis for recommendation, a sensitivity analysis was carried out to analyse the elasticity of each project to certain sensitive parameters. In this study, the sensitivity analyses were conducted on the basis that the discount rates and project duration are the sensitive parameters. The sensitivity analyses are be carried out at: (i) the discount rates of 8, 10, 12 and 15% respectively, and (ii) the project duration of 5, 10 and 15 years. At the completion of the sensitivity analyses, the assessment of the results were based on the sensitivity ranking, whereby the most stable project (in terms of the B/C ratio and net benefit) will be recommended as the most feasible project.

The research processes is summarised in Figure 2.

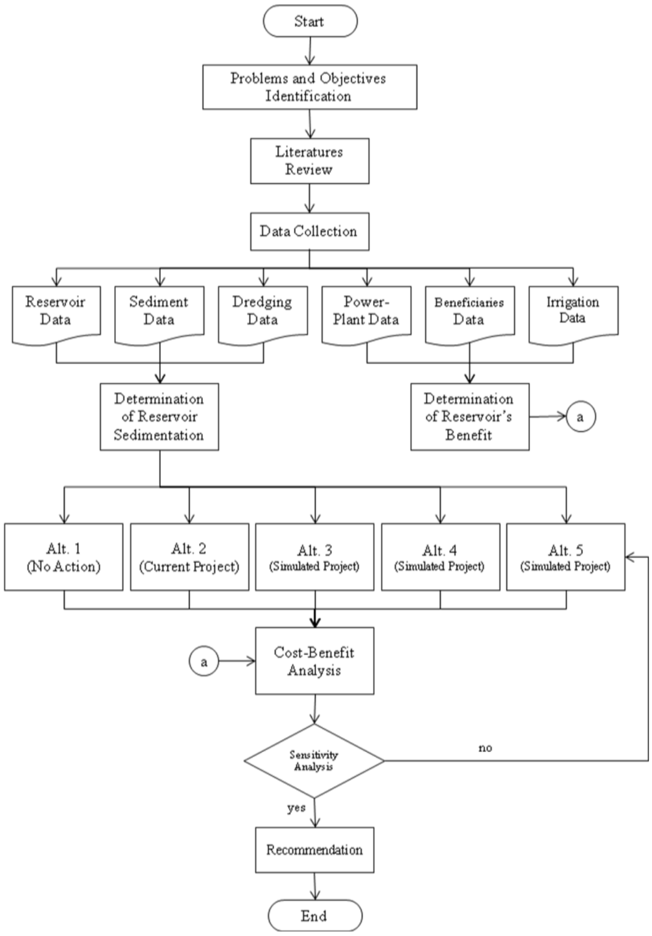

Figure 2 Research Flow Chart

FINDINGS

The recommendation for the most desirable project was based on the results of the CBA and sensitivity analyses as summarized in Table 2.

Table 2 Results of Analysis

No	Scenarios	Discount Rates	Project Durations					
			5 years		10 years		15 years	
			B/C Ratio	Net Benefit (x 10^6)	B/C Ratio	Net Benefit (x 10^6)	B/C Ratio	Net Benefit (x 10^6)
1.	Alternative 1	8%	-	- 4,624.9	-	- 8,543.7	-	- 11,222.5
		10%	-	- 4,873.9	-	- 9,052.8	-	- 11,798.0
		12%	-	-5,205.7	-	- 9,803.7	-	- 12,756.9
		15%	-	-5,870.5	-	- 11,431.0	-	- 14,938.7
2.	Alternative 2	8%	0.72	- 7,767.0	0.89	- 4,584.0	1.04	2,326.9
		10%	0.81	- 5,026.2	1.04	1,585.7	1.25	12,553.3
		12%	0.91	-2,182.5	1.21	7,780.3	1.40	18,565.8
		15%	1.10	2,319.9	1.52	17,280.8	1.95	38,915.6
3.	Alternative 3	8%	0.44	- 24,991.9	0.55	-31,183.8	0.64	- 30,813.8
		10%	0.50	-21,554.4	0.64	-23,063.0	0.77	- 17,855.9
		12%	0.56	- 18,069.0	0.75	-15,162.9	0.92	- 5,643.5
		15%	0.68	-12,695.1	0.94	-3,483.9	1.19	11,896.4
4.	Alternative 4	8%	0.25	- 90,658.0	0.31	- 122,116.9	0.36	- 138,433.5
		10%	0.28	-78,279.3	0.36	- 101,539.2	0.42	- 109,232.8
		12%	0.31	- 73.001.6	0.43	- 79,556.7	0.48	- 89,261.8
		15%	0.35	- 65,185.3	0.47	- 71,015.2	0.59	- 62,225.4
5.	Alternative 5	8%	0.19	- 128,842.1	0.23	- 184,893.2	0.26	- 217,946.8
		10%	0.21	-121,635.9	0.26	- 166,197.5	0.30	- 187,117.8
		12%	0.22	-114,674.8	0.29	- 149,034.2	0.34	- 159,950.1
		15%	0.25	- 104,572.3	0.34	- 125,485.1	0.42	- 124,194.1

The results indicate the performance of the sediment management project under different circumstances/scenario performed in CBA and sensitivity analyses. The performance of each project is shown in Table 3.

Table 3 Project Performance

No	Scenario	Performance
1.	Alternative 1	Due to the "do-nothing" scenario, there will be no extra benefit gained from this alternative. Thus, the analysis shows that the B/C ratios always zero and the benefits are negative.
2.	Alternative 2	The most feasible alternative, whereby the B/C ratio is 1.21 and the net benefit is positive. However, based on the sensitivity analysis, this project cannot be done in a short term period (5 years) because the benefits generated during that period cannot sufficiently recover the costs incurred.

No	Scenario	Performance
3.	Alternative 3	An extra project cost will be incurred due to the change of the disposal method (additional dredging works at d/s Sutami dam). Since the extra benefits gained still the same with alt. 2 (because of the volume of dredged sediment is the same), the B/C ratios are below 1.0 and the net benefits are always negative.
4. 5.	Alternative 4 Alternative 5	The project alternative 4 and 5 shows similar result, whereby the B/C ratios always below 1.0 and the net benefits are negative. This is because, the investments of new spoil bank and dredging equipment as well as the additional dredging volume have extremely increased the project costs; that cannot be sufficiently recovered by the benefits gained from the project.

BASIC FRAMEWORK FOR DECISION MAKING

The basic framework is a Microsoft® Office Excel® based template which integrates the calculations in the CBA steps. It is developed as a support tool for determining the most feasible sediment management project at other reservoirs. The basic guideline of using the template and the function of each button in the worksheets is shown in Figure 3.

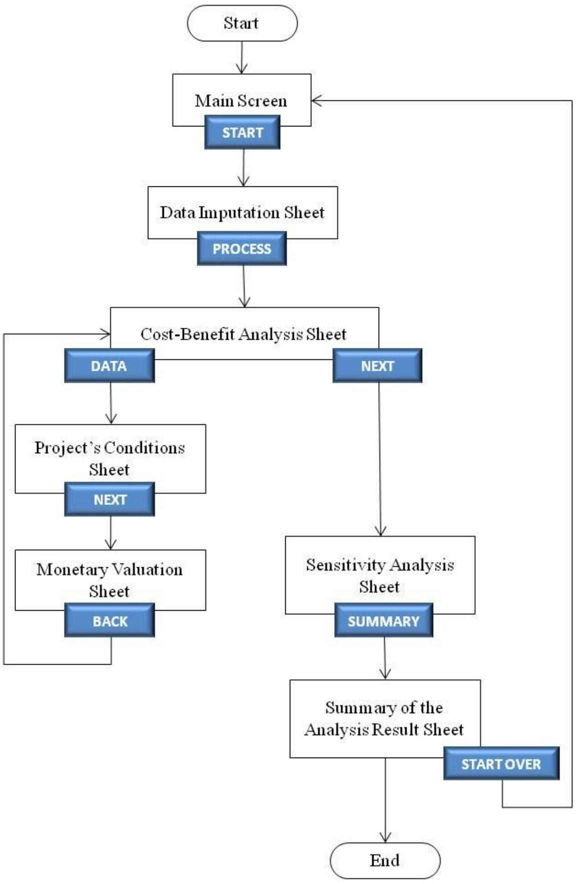

Figure 3 Basic Framework Guideline

CONCLUSION AND RECOMMENDATION

The analysis found that among those alternatives, the most desirable project is alternative project 2, where the dredged sediment volume is 300,000 m^3 per year using the off-stream sediment disposal method. This alternative has the largest B/C ratio (1.21) and the maximum net benefit (Rp. 7,780.3 million). The analysis also indicates that the changes in sediment disposal method and/or volume of sediment to be dredged will extremely raise the costs that cannot be sufficiently recovered by the benefits gained.

Although this study has been able to provide initial information about the desirability of sediment management project, however, more practical research of economic analysis on sediment management project is required before conclusive information can be made, particularly related to the identification of the intangible and indirect costs or benefits of the project.

The basic framework offers simplicity of CBA application in sediment management project. However, there are some limitations in developing this framework and it may reduce the accuracy of the result. Thus, recommendation for further study of CBA in sediment management is to enhance the accuracy of the framework as well as to expand the scope of the study.

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